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FM 55-15
department of the army field manual


## TRANSPORTATION REFERENCE DATA

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## TRANSPORTATION REFERENCE DATA

FM 55-15, 23 February 1968, is changed as follows:

1. This change updates transportation reference information on Army motor transport units, motor transport operations, highway data, and planning data for motor transport.
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Insert pages, 3-1 through 3-92
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FM 55-15, 23 February 1968, is changed as follows:

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FM 55-15, 23 February 1968, is changed as follows:

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HEADQUARTERS DEPARTMENT OF THE ARMY Washington, D.C., 23 February 1968

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## CHAPTER 1

## GENERAL

## *1-1. Purpose and Scope

$a$. This manual is both a planning guide for staff and unit officers and a digest of operational data for use as a reference by operators and users of transportation.
$b$. This manual includes characteristics of typical transportation equipment and facilities and methods for estimating the capabilities of, or requirements for, transportation equipment, facilities, and troop units. Personnel and equipment data for the modes of transportation and for transportation terminals are presented as well as data for computing requirements for staff, supervisory, and control activities. Factors concerning administrative support requirements are included. It also contains report formats and examples of orders and standing operating procedures. Loading data for water, rail, motor, and air movements; tables on weights, measures, and conversion factors; and miscellaneous data of gen-
eral usefulness are included. Planning data contained herein may be modified as necessary to meet known conditions and requirements.

## 1-2. Application

The material presented herein is applicable to nuclear and nonnuclear warfare.

## *1-3. Changes and Revision

Users of this publication are encouraged to submit recommended changes and comments to improve the publication. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons will be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications) and forwarded direct to the Commandant, US Army Transportation School, ATTN : ATSTCD, Fort Eustis, Va. 23604.

## CHAPTER 2

## AIR

## *Section I. ARMY AVIATION IN THE TRANSPORT ROLE

## 2-1. General

The evolution of warfare has generated a need for greater mobility in support of the Army. Army aviation is an integral part of the transportation system designed to provide efficient and effective movement of personnel and cargo. Army aviation units provide airlift in support of requirements of the theater army, field army, corps and division. In addition, Army aviation units are capable of providing airlift in support of a unified or specified command, a military assistance advisory group or mission operating detachment, or a separate brigade operation. Because of the high mobility requirements of today's Army, considerable reliance is placed on the air mode of transportation provided by Army aviation units. These units are separated into two categories, divisional and nondivisional.
a. Divisional. Aviation elements which are organic to a division are authorized on the basis of each type division's requirement for constantly available aviation support. An airmobile division, which has a constant requirement for large numbers of aircraft, is authorized an aviation group. Each infantry and airborne division is authorized an aviation battation, and armored and mechanized divisions are each authorized one aviation company. Each armored infantry, mechanized, and airborne division is also authorized an air cavalry troop organic to the armored cavalry squadron. The airmobile division is authorized three air cavalry troops organic to the air cavalry squadron.
b. Nondivisional. To meet the varying requirements of subordinate divisions for aviation support, and to augment the organic aviation assets of other field army elements, separate aviation organizations are included in the
army field force structure. These separate aviation units are referred to as nondivisional aviation units. They normally include helicopter elements which are capable of performing airlift missions and of providing direct aerial fire support to subordinate divisions. Special purpose aircraft, such as medium lift helicopters and reconnaissance and surveillance airplanes are also included. These aircraft are normally assigned to a field army with further attachment to subordinate corps.

## 2-2. Organization

The table of organization and equipment (TOE) of each military unit prescribes its normal mission, organizational structure, and personnel and equipment authorization. Users who need detailed information on any specific aviation unit should use the TOE of that unit (see table 2-1) and FM 1-15.

## 2-3. Mission

The mission of Army aviation units is to provide airlift of personnel and cargo for combat service support and combat support operations as required. Missions assigned to an aviation unit are usually similar to the normal mission as stated in the TOE.
a. Objective. Missions are assigned to the aviation company with the objective of assisting in the accomplishment of the mission of the land force.
b. Authority. When the aviation company is placed in support of a ground unit, the ground unit commander assigns tasks to the aviation commander for execution. The aviation commander retains authority to issue orders to elements under his command as necessary to accomplish these tasks.

| Unit | toe | Miesion |
| :---: | :---: | :---: |
| *Light Airmobile Company Airborne Division. | 1-57G | To provide tactical air movement of troops and equipment in airmobile operations. |
| *Assault Helicopter Company | 7-77 | To provide tactical air movement of troops and equipment in airmobile operations. |
| Assault Support Helicopter Company. | $1-258 \mathrm{H}$ | To provide air transport of personnel and cargo for combat service support and combat support operations. |
| Assault Helicopter Company Separate. | $7-357 \mathrm{H}$ | To provide tactical air movement of troops, supplies and equipment within the combat zone. |
| Heavy Helicopter Company | 55-259H | To provide combat service support airlift for movement of heavy supplies, vehicles, aircraft and equipment, and as directed, to provide combat support airlift of combat units and air supply of units engaged in combat operations. |

Assignment<br>Aviation Battalion Airborne Division TOE 1-55.<br>Combat Aviation Battalion Inf-Div TOE 7-75.

To a field army, theater army support command, or other commands as required. Normally, attached to an Aviation Battalion, TOE 1-256.
To a field army or other commands as required. Normally, attached to a Combat Aviation Battalion, TOE 1-256.
To a Combat Aviation Group, TOE 1-252. Normally, attached to an Aviation Battalion, TOE 1-256.

Note. An asterisk indicates those TOE units without organic DS maintenance capability. This capability ia provided by the attachment of appropriate DS element as neeessary or mission essential.

## *Section II. COMBAT SERVICE SUPPORT

## 2-4. Airlift of Materiel

The airlift of materiel within the combat zone (CZ) is accomplished through employment of Army aviation and Air Force tactical airlift elements. Best utilization is attained by adapting to the situation the most appropriate airlift capabilities of each service to provide an air line of communications.
$a$. Intertheater airlift is an Air Force function. Air Force aircraft are used also for the airlift of materiel from rear areas, as from the communications zone (COMMZ) or field army area, to points as far forward as practicable. These airlifts use the throughput concept, under which shipments bypass one or more intermediate supply points.
b. Material delivered to overseas supply points on a wholesale basis by Air Force airlift or by surface modes can be further moved by Army helicopters to using units, or to supply points established for using units. The aerial resupply of land combat forces operating in
forward areas is accomplished primarily by Army aviation units, but Air Force elements may participate also in this function. In that situation, it may be necessary to attach the Air Force airlift elements to the land force.

## 2-5. Employment Considerations

Although optimum utilization of airlift would be attained by use of Air Force transport aircraft to move materiel from a COMMZ depot directly to the user, this is often impracticable in a tactical situation. There normally must be a point at which wholesale airlift is terminated and retail deliveries to the user are undertaken by Army aviation elements. Factors to be considered in determining the point at which wholesale airlift is terminated include the following:
a. Airfields. Suitable airfields must be available at points into which materiel is to be airlanded by Air Force transport aircraft.
b. Enemy Action. The enemy may be cap-
able of limiting or denying the use of forward areas for airlanding by transport aircraft.
c. Receiving Unit Capability. Combat units in forward areas have a limited capability to receive, store, protect, and redistribute materiel airlanded in wholesale lots by transport aircraft.
d. User Requirements. The user may be a unit of company size or smaller that requires resupply in retail quantities only.

## 2-6. Principles of Employment

The efficient employment of Army aviation is based upon the following considerations:
a. Economy of Utilization. Aircraft should not be used when surface means are equally effective. Since there are seldom enough aviation assets to satisfy all requirements of commanders, most aviation support is allocated on a priority basis.
b. Ready Availability. The ability to respond rapidly to demands for aviation support increases the value of this mode of transportation to supported commanders. Ready availability is obtained by locating aviation units as close as practicable to the supported units. Also the inherent mobility of aircraft permits support to be made available to units that are located throughout a wide area. Ready availability is also attained by intelligent scheduling of operational aircraft and by programing of required maintenance.

## 2-7. Operational Considerations

a. Air Density. Unlike surface modes of transportation, where the payload of a particular vehicle is relatively fixed, aircraft payloads are affected by air density. Denser air provides greater lift to an aircraft's wing or rotor blade, thus increasing the weight-lifting performance of the aircraft. Air density is affected by temperature, altitude, and humidity.
(1) Temperature. An increase in temperature causes a decrease in air density. The amount of air that occupies 1 cubic inch at low temperature will expand and occupy 2 or 3 cubic inches as the temperature rises. It is important to recognize that the payload of a par-
ticular aircraft can change, depending on the time of day when a flight is scheduled. Usually early morning temperatures favor operations and noonday heat causes a decrease in the efficiency of the aircraft.
(2) Altitude. An increase in altitude causes a decrease in air density. This factor is particularly important in operations conducted from areas high above sea level. It is' necessary either to decrease the aircraft weight or to increase the length of takeoff and landing strip.
(3) Humidity. An increase in humidity causes a decrease in air density: Air always contains some moisture in the form of water vapor, but the amount varies from almost'none to 100 percent. This water vapor is known as humidity. As humidity increases, water particles displace the air, causing a decrease in air density and reducing the performance efficiency of an aircraft.
b. Distance. The distance to be flown is particularly important in utilization of Army aviation transport because the allowable load is computed after the amount of fuel, plus reserve, is determined. Aircraft must carry less fuel with a relative reduction in distance flown when maximum payload is desired, and payload must be reduced when maximum distance is the important factor.
c. Weather. Weather conditions influence the operations of Army aviation elements. While low ceilings and limited visibility may restrict operations, such conditions may be used as an advantage in shielding the aircraft from enemy observation. However, adverse weather :generally reduces the efficiency of Army air transport operations. Although Army transport aircraft can operate under instrument flight conditions, commanders should establish weather minimums to preclude scheduling flights' that jeopardize the safety of aircraft and personnel. Weather minimums should be established commensurate with the experience of the pilots, type of aircraft employed, urgency of mission, navigational aids available, terrain along the flight route, and time of operation.
d. Enemy Situation. The location and capabilities of enemy forces should be considered before flight routes for Army aị transport op- .
erations are finalized. Every effort should be made to avoid areas where suspected enemy antiaircraft weapons or known enemy ground fire exist. Aviation units should have prearranged evasive-action flight plans in the event enemy aircraft are encountered.
e. Terrain. Terrain features must be considered with regard to their possible effects on each operation. Terrain influences the following :
(1) Location of takeoff and landing sites.
(2) Flight routes.
(3) Identification of prominent landmarks for navigational purposes.
(4) Location of navigational aids.
(5)-Location of emergency landing sites.
f. Flight Routes. Many demands for the use of airspace are generated during combat operations. The employment of aircraft of the Army and other services, artillery, drones, and missiles must be coordinated to insure adequate safety, proper identification, and efficiency of operations. Army aviation units are rèsponsible for making sure that flight routes are properly coordinated and approved by the appropriate air traffic control facility before combat service support or combat support operations are begun.
g. Communications. Combat service support and combat support airlift operations require that adequate communications be established before the beginning, of a mission. Voice communication is necessary among the following: Army airlift and command units, supported organizations, inflight aircraft, and takeoff and landing sites.

## 2-8. Support Requirements

Primary support requirements influencing the employment of Army aviation are the availability of petroleum, oils and lubricants (POL), ammunition, and aircraft naintenance support.
a. POL. Aircraft consume large quantities of fuel, POL items require special handling. Refueling facilities should be readily available.
b. Ammunition. The ammunition used in Army aircraft may be expended rapidly. This necessitates locating resupply facilities near the
area of operations to avoid the time penalty involved in lengthy flights to obtain supplies.
c. Aircraft Maintenance. The capability of aviation units in the performance of aircraft operations on a sustained basis is dependent upon efficient aircraft maintenance. Maintenance of aircraft begins with that performed by unit personnel and extends through direct support (DS) and general support (GS) to depot maintenance. To assure continuing availability of aircraft, close coordination is required between the aviation unit commander, the ground combat commander, and the supporting maintenance unit commander. Proper scheduling of aircraft is mandatory to prevent maintenance overload which can result in excessive down time for aircraft. For any large operation, personnel and aircraft from maintenance support units should be allocated for aircraft recovery and repair. Normally, airlift planners are concerned with aircraft maintenance support through the DS level categorized as follows:
(1) Organizational. Organizational aircraft maintenance is performed by personnel of the aviation unit. This maintenance includes the inspection, servicing, lubrication, and adjustment of aircraft components as well as the replacement of parts and minor assemblies within unit capability as prescribed by the maintenance allocation chart (MAC).
(2) Direct support. Aviation units possessing an integrated DS capability can perform this maintenance for their own aircraft. Those organizations listed in table $2-1$ have this capability; units not having it are dependent upon support elements for DS services. The major function of DS maintenance is the repair of end items or unserviceable assemblies for return to the using unit. Direct support elements also can install in aircraft certain components which an aviation unit's own personnel cannot install.
(3) Aircraft maintenance support elements. Aircraft maintenance support exceeding capabilities organic to the aviation unit is provided as follows:
(a) Divisional aircraft receive DS maintenance to include avionics and armament sup-

Figure 2-1(1). Payload versus range of Army helicopters.
port from their organic transportation aircraft maintenance company, within the maintenance battalion of the division support command (DISCOM). In the airmobile division, the DIS-

COM transportation aircraft maintenance and supply battalion provides aircraft DS maintenance including avionics and armament maintenance and repair parts support.


Figure 2-1(2. Payload versus range of Army airplanes.
(b) Nondivisional aircraft in the corps areas receive DS maintenance from the transportation aircraft direct support company located in the corps support brigade of the field army support command (FASCOM).
(c) Aviation units in the Army rear area receive DS maintenance from the transportation aircraft direct support companies located in the army rear support brigade.

## 2-9. Army Aircraft Payload Versus Range

a. General. Payload is the number of passengers and/or the amount of cargo that an aircraft can carry, usually expressed in pounds. As the distance to be flown is increased, the fuel required is increased and the payload is decreased. The payload varies with changes in altitude, temperature, air pressure, humidity, and wind.
b. Computations for Range versus Payload. Payload for various ranges may be approximated for Army aircraft by using figures 2$1(1)$ and 2-1(2). The data in these figures have been taken from the appropriate TM 55 -series
-10 aircraft operator's manual. The range includes a fuel reserve of one-half hour. Figures $2-1(1)$ and $2-1(2)$ are rapid references that should be used for general planning only. When cargo operations are to be planned over distances greater than 200 nautical miles, see the TM $\mathbf{- 1 0}$ series for detailed information.

## 2-10. Aircraft Characteristics

a. Army Aircraft Characteristics. Characteristics of Army aircraft are shown a.t tables . 2-2 and 2-3. Figures 2-4 through 2-18 illustrate selected Army aircraft. Figure 2-19 illustrates the detachable universal pod for the CH-54.
b. Air Force Transport Aircraft Characteristics. Characteristics of Air Force transport aircraft are shown at table 2-4 and figure 2-3.
c. Cargo Compartment Envelopes. Figure 22 illustrates the cargo compartment envelopes and access limitations of Air Force airexaft and selected Army helicopters.

Table 2-2. Army aircraft characteristics (helicopters)
(Located in back of manual.)

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|  | ${ }_{\text {coin }}^{\substack{\text { bein }}}$ | cover | 23014.5 | 435123 | L.071/65 | L, 1.51542 | ${ }^{1.4580227}$ | 1.15891226 | 1,09\% 24.4 | 1, $1.57 / 262$ | 4.046 | 4.0086 |  | 8, 8 001/1,35 | 8, 8.751 .1 .350 |
| ${ }^{\text {a }}$ (6) Sededemes | ${ }_{\text {kes }}$ | 100 | 1 | 100 | $\cdots$ | 10 | . | ${ }_{1} 10$ | 120 | 100 | $1: 10$ | 120 | 120 | \% | ${ }^{3}$ |
| (i) Cosees of freal | $\frac{m}{\text { mact }}$ | $\xrightarrow{2+30}$ | + +30 | $\underline{2+10}$ |  |  |  | 1+35 | +1+50 |  |  |  | 2.00 | $1+50$ | ${ }^{2+4}$ |
|  |  | L00720 | 120720 | L180/28 | S88,91 | 6sy101 | O6:1995 | ${ }^{\text {jo.ests }}$ | ${ }^{\text {Jober }}$ | ${ }_{\text {che }}$ | $\left.\right\|_{1,4807305} ^{50 .}$ |  | $\frac{3,6.60462}{}$ | 20.64636 | 20.696/613 |
| foromers: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | an yoperan one | components not |  | ace alcratc |  |  |  |  |  |  | Wae homm | cospeted |  |



Table 2-s. Army aircraft characteristics (airplane)
C)

| $\overline{\text { craratine wet (iv) }}$ |  |  |  |  | $\left.\begin{array}{\|c} \text { C-97C } \\ \text { (Strato- } \\ \text { freighter) } \end{array}\right)$ |  |  |  |  |  |  |  |  |  |  |  |  | (starithers) | ${ }_{\text {a }}^{\text {a }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| with Les ayup | w/ | w/a | N/A | w/A | */ | w/ | \#/A | w/ | n/月 | \%, |  |  | $\stackrel{13,000}{w / 4}$ |  |  | $\xrightarrow{412,720}$ | (12,500 |  |  |
| Nomal max. ewt | ${ }^{20,550}$ | 45,00 | 32,00 | ${ }^{60, \infty} \times 0$ | ${ }^{150,00}$ | 25, ,0e | 107,00 | 68,300 | 37,500 | 135,40 | 55,20 | 275,000 | 185,00 | 12l, 200 | 155,000 | 270,500 | 27L,000 | 315,000 | 28,000 |
|  | 28,550 | 55,00 | 33,000 | ${ }^{13, \infty}$ | ${ }^{166,000}$ | 269,000 | 121, $\times 0$ | 72,200 | 14,5000 | ${ }^{15} 5,00$ | $55,2 \infty$ | 180,000 | 129,500 | 124,200 | 17l, | 270,000 | 2ll, $0 \times$ | 315,000 | ${ }_{764,500}$ |
| max. 1arating nt (b) | 28,500 | 55, 00 | 33,000 | ${ }^{13, \infty}$ | 330,000 | 330,00 | 107,000 | 72,700 | 122,000 | 122,00 | ---- | 166,00 | 18,000 | ${ }^{212,200}$ | 133,000 | 20000 | 20,000 | 257,000 | 635,50 |
| (actu) (b, ${ }^{\circ}$ | 3,500 | 17,500 | u,1ヶ0 | $24, \infty \times$ | L0,00 | 10,600 | ${ }^{25,100}$ | 10,50 | 33,100 | 0,100 | 12,00 | $\infty$ | 59,00 | 25,00 | ¢9,00 | 77,30 | n,550 | 64, 65 | 265, 20 |
| Normal max. cargo payload (ACL) (lb) | 7,500 | 16, $\times 0$ | 7,500 | 13,00 | $27, \infty$ | 35,600 | 18,720 | 12,000 |  |  |  |  |  |  |  |  |  |  |  |
| Beargeecr max. troop aumaity | ${ }_{32}$ | so |  | ¢ | ${ }^{80}$ | 80 | ${ }^{70}$ | 62 | ${ }^{6}$ |  | ${ }_{6}$ | 17 | ${ }_{17} 17$ | 9 | 92 | ${ }^{19}$ | ${ }_{19}$ | 129 | ${ }_{205}$ |
| waterover larse) |  | 32 | 2 | ${ }^{4}$ | 56/86 | 8//80 | 80/0 |  | ${ }_{78 / 78}$ | ${ }^{78 / 8}$ |  |  |  |  | ${ }^{66 / 780}$ |  |  |  |  |
| Luttera cupectiv (no atemenema) | ${ }^{20}$ | ${ }^{24}$ | ${ }^{24}$ | ${ }_{3}$ | 5 | 54 | ${ }_{54}$ | ${ }_{35}$ | ${ }_{4}$ |  | ${ }_{50}$ | ${ }_{127}$ | ${ }_{127}$ | ${ }_{10}$ | \% | ${ }_{4}$ | ${ }_{12}$ |  |  |
| faratrops | ${ }^{26}$ | \%/A | ${ }^{27}$ | w/ | \%/A | v/A | y/A | 42 | m/ | \%/A | "/ | 112 | ${ }^{12}$ | ${ }_{6}$ | ${ }_{54}$ | v/a | \#/ | ${ }^{123}$ |  |
|  | 150 975 | Lel <br> 1,500 | ${ }_{1}^{12,60}$ | - ${ }_{200}^{101}$ | ${ }_{2}^{210}$ | - 212 | ${ }^{218}$ | ${ }_{15}^{154}$ | ${ }^{223}$ | ${ }^{223}$ | ${ }^{238}$ | 208 | ${ }^{203}$ | 280 | ${ }^{280}$ | 4.59 | 459 | ${ }_{4} 2$ | mo |
|  |  |  |  | 2,00 | 2,520 | 2,520 | 3,80 | 2,500 | 2,20 | 2,710 | 1,20. | 3,810 | 3,20 | 2,200 | 3,560 | 5,445 | 6,610 | 4,000 | 5,500 |
| per cu ft), 463 L or pallet <br> Center of gravity limits \& MAC |  | "/A | w/ | (10/1. | 15.5.53.0.0 | ${ }_{15}^{5} 5.53 / 4.0$ |  | $\xrightarrow{\text { \% } 20.4}$ |  |  |  | 28.0.03/4.0 | 18.014 .4 | come |  | cis | cin |  |  |
|  | (1-557.41 | 399.0.33.0 | 239.6-26, 2 | 3810 -ution. | 533.0 .516 .0 | 53, 0.530 .0 | 26.0.0-4.0.0 | 381.0.335.0 | 668.0588 .0 | 661.0664 .0 | 324.3-313.9.9 | 550.0.580.0 | 550.0.580.0 | ร9.0-537.0 | 526.9 .553 .1 | 839.0.877.0 | 832.0.087.0 | ${ }_{92} 2.7-972.0$ | wrat |
| rome | 4.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 1.34 | 4.5 | ${ }_{6} .0$ | ${ }^{6.0}$ |  |  |  | $4.0^{\circ}$ |  | 8.0 | 8.0 | $1.00^{\circ}$ |  |
| ${ }^{\text {ut }}$ | 2.0 | ${ }^{1.5}$ | ${ }^{1.5}$ | 1.29 | 1.5 | 1.5 | 1.29 | 1.5 | ${ }^{1.5}$ | ${ }^{2.5}$ | 2.0 | 2.0 | 2.0 | 1.5 | 1.5 | 1.5 | 2.5 | 1.5 |  |
| side | ${ }^{1.5}$ | 2.5 | 1.5 | 1.00 | 1.5 | 1.5 | ${ }^{1.0}$ | 1.5 | 1.5 | 1.5 | ${ }^{1.5}$ | 1.5 | 1.5 | 1.5 | 2.0 | 1.5 | 1.5 | 1.5 |  |
| Vertacal (4is) | ${ }^{2.0}$ | 2.0 | 2.0 | 2.147 | 2.5 | 2.5 | 2.67 | 2.25 2.25 |  |  | 4.5 | 2.0 | 2.0 | 2.0 | 4.5 | 2.0 | 2.0 | 2.0 | 2.5 |
| Vertical (down) |  | 4.5 | 4.5 | 2.47 | 2.5 | 2.5 | 2.47 | 2.25 |  |  | 4.5 | 2.0 |  | 4.5 | 4.5 | 2.0 | 2.0 | 2.0 | 2.5 |
|  | p3.5x.0.0 | $95.587 \times 6$ | 0.4.5x>0. 6 | Ss66.6 | 109.2.86.0 | 109.288 .0 | 122.0.987.73 | 10. 1 Les 6 | 106.5x7l. 5 | 20.5897. 5 | 10.0.086.0 | 136.0720.0 | 136.axata. 0 | 120.0008.0 | 20.0006.0 | 8.0xib. 11 | ${ }^{78.0 \times 16.4}$ | 123.255109. | 220.08262.0 |
|  |  |  |  |  | ${ }_{\text {rar }}$ |  |  | rear | eff left | ${ }^{\text {art }}$ lest, |  |  |  | rar |  |  |  |  | nut |
| Learism - sitato or nearage | rasr | Left | lort | left |  |  |  | Stisexo | 59.2876 .75 <br> med 10 art |  | ${ }_{\text {rax }}$ |  |  |  | rar | nat loft | woilett | rar |  |
|  | ${ }^{55} 6$ | 9.0 | 56.5 | 20.0 | 112.0 | 112.0 | 106.0 | ${ }^{20.0}$ | nut- -135.3 | nme - 135.3 | 33.5 | 156.0 | 158.0 | 9.015.0 | 39.0/1.0 | 177.0/38.0 | แ7.0л38.0 | 0.5 | 55.073 .0 |
| Leengt uable (in.) |  | 52.0 | 36.5 | 596.4 | 179.2 | ${ }^{73} \cdot 2$ | ${ }^{816.0}$ |  | $\xrightarrow{\text { art- }} \mathbf{- 1 2 . 5}$ |  | 315.0 | 67,0. | ${ }^{\text {876.0 }}$ | 492.0 $0^{\text {d }}$ | ¢92.0 $0^{\text {d }}$ | 8 80.0 | 880.0 | ${ }_{\text {8, }}^{\text {8, }} 0^{\text {d }}$ | $1459^{\circ}$ |
| Watat fioor (in.) | ${ }_{81}$ | 27.6 | ${ }^{88.8}$ | 103.2 | 109.6 | 1096 | ${ }_{\text {10, }}^{10.0} 0$ | 109.2 | 121.0 | 122.0 | ע0.025.0 |  | 235.0 | 123.0 | 123.0 : | 129.0 | 129.0 |  |  |
| Hestat cleare (in.) | ${ }^{75}$ | 84.0 | ${ }^{76.8}$ | 93.6 | 74.0 | ${ }^{\text {ru. }}$, | 93.0 |  | ${ }^{80.4}$ | ${ }^{60.4}$ | 98.0120.0 | 139.0 | 139.0 | 199.0 | 109.0. | 84.0 | 84.0 | 299.0 | 126.0 |
| Raprp noilire (derrees) | ${ }^{16}$ | w/ | n/4 | w/ | ${ }^{24}$ | ${ }_{24}$ | w/a |  | w/ | \%/ |  |  | ${ }^{17}$ | 22.5 | 12.5 | \%/4 | н/4 | 11 | cind |
| Fayload /anatioar niles | 7,000/100 | ${ }_{6,000}, \infty$ | 7,500\%,, 00 | 13,00/1,90 | 27,000/,00 | 5,60/1,80 | 18,70/2,000 | 18, 1000,55 | 500/2,00 | 27,600/200 | 12,00/980 | 0,500 | ,00/3,500 | 25,000, , ${ }^{12,}$ | 37,00/2,500 | 61,20/2,200 | ${ }_{61,200 \%, 30}$ | 57,16271,000 | \% $0 / 3,0$ S |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

## CURRENT CARGO COMPARTMENT ENVELOPE

AND ACCESS LIMITATIONS


HELICOPTERS

| UH-1B | 5.0 | CROSS <br> SECTION REQUIREMENTS |  | $\begin{aligned} & \text { SIDE } \\ & \text { LOADING } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: |
| UH-1D |  | OPTIMUM ARMY/ AIR FORCE SIZE $\square$ |  | SIDE LOADING |
| CH-34C | $\frac{\square}{13.6^{\prime}}$ | minimum army/ AIR FORCE SIZE 8.3 $\square$ 85 |  | $\begin{aligned} & \text { SIDE } \\ & \text { LOADING } \end{aligned}$ |
| CH-47A |  |  |  | REAR LOADING |
| CH-54 POD |  | $\begin{array}{lr} \text { ENGINE- } & 60 \cdot \frac{\text { 皿 }}{\text { ENE }} \\ \text { STAND SIZE } \end{array}$ |  | REAR LOADING |

Figure 2-2. Cargo compartment envelope and access
limitations.
C. 5 interion

Detrils of the airraft interiar are shown on this page
As illustroted, the corgo campariment floor is 121.1 feet long, with a forward romp 10.1 feet long and an aft ramp 13.4 teet long. The cargo floor and each ramp are 19.0 feet wide, providing 2745 square feet of tatal floor area. Thiy includes the areo shodowed by the deplayed troop lodder and crew lodder. Subtrocting this area from the tolal leoves 2702 zquare feat of usable cargo area. The entire area is air canditianed and fully presurized.


Figure 2-3. C-5A (Galaxy) cargo compartment.


Figure 2-4. O-1E (Bird Dog).

WING
AREA 330 SO FT
MAC 98 IN.
ASPECT RATIO 5.35
SECIION
NACA 2412


Figure 2-5. OV-1A (Mohawk).


Figure 2-6. U-1A (Otter).


Figure 2-7. U-1A (Otter). Cabin dimensions.


PLAN VIEW - COCKPIT AND CABIN


RIGHT-HAND SIDE VIEW-CABIN


LEFT-HAND SIDE VIEW-CABIN

Figure 2-8. U-1A (Otter). Troop seating.

## C 1, FM 55-15



Figure 2-9. $U_{-6 A}$ (Beaver).


Figure 2-10. U-8D (Seminole).


Figure 2-11. UH-1B (Iroquois).


Figure 2-12. UH-1B, UH-1C (Iroquois). Cargo features.

(2) 1. Tlo-dawn fittingo.
(1) Stanchion Stowago
(2) Mirror Stargogo

NOTES:

1. Carga floor loading vo $\mathbf{C}$ load factar

| Lb Sq Ft | Sofoty Factor |
| :---: | :---: |
| 300 | 1.0 |
| 150 | 2.0 |
| 100 | 3.0 |

2. Tio-down fittingo, otrongth 1250 lb vorileal, 500 ib harizontal load por fipiling.


Figure 2-13. UH-1D, UH-1H (Iroquois). Cargo features.


Figure 2-14. CH-34C (Choctaw).

C 1, FM 55-15


Figure 2-15. CH-34C (Choctaw). Cargo compartment dimensions.


Figure 2-16. CH-47A (Chinook).


Figure 2-17. CH-47A, B, C, (Chinook). Cargo compartment.


Figure 2-18. CH-54 (Sky Crane).
POD
HUD
STA
STA
165
FORWARD
493

SECTION $1 \rightarrow$ SOECTION $2 \rightarrow$ SECTION $3 \rightarrow$ SECTION 44

| COMPARTMENT DESIGN DATA |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| SECTION DESIGNATION | In. FROM REFF DATUM |  |  | $\left\lvert\, \begin{gathered} \text { CAPAC- } \\ \text { (LTMS }) \end{gathered}\right.$ | $\begin{aligned} & \text { AREA } \\ & \text { SQ FT } \end{aligned}$ | VOLUME <br> du FT | SECPION FLOOR LOADING | MAXIMUM ALLOWABLE FLOOR LOADING |
|  | $\left\|\begin{array}{c} \text { CEN }- \\ \text { TROID } \end{array}\right\|$ | SECTION LIMITS |  |  |  |  |  |  |
| SECTION 1 | 214.5 | 165 | 264 | *5500 | 74.3 | 482.6 | 74 LB SQ FT | $334 \mathrm{LB} \mathrm{SQ.FT}$ |
| SECTION 2 | 314.0 | 264 | 364 | 17,000 | 75.0 | 487.5 | 227 LB SQ FT | 334 LB SQ.FT |
| SECTION 3 | 401.0 | 364 | 438 | *5500 | 55.5 | 360.8 | 91 LBSQ FT | $334 \mathrm{LB} \mathrm{SQ.FT}$ |
| SECTION 4 | 465.5 | 438 | 493 | *5500 | 41.3 | 268.1 | 133 LB SQ FT | 334 LB SQ.FT |

*NOTE: LOAD CARGO ON OR SYMMETRICALLY ABOUT THE CENTER LINE OF THE POD AT ALC TIMES.


Figure 2-19. (Top) pod cargo loading information; (bottom) detachable universal pod. $\mathrm{CH}-54$.

## $\star$ Section III.

## 2-11. Outline Standing Operating Procedure for Air Movements

a. General. Amplification of command policies on use of air transportation (intratheater and intertheater), including responsibilities, utilization, and procedures in the employment of organic aviation units; responsibilities for coordination with Air Force aerial ports.
(1) Submission of space requirements. Responsibilities for, timing, format, procedures, and policies affecting submission of advance and firm space requirements for air movement of supplies and personnel.
(2) Airspace assignments. Controlling agency; procedures for application, space assignment, and use of space assignments; formats.
(3) Air priorities system. Controlling agency; procedures and responsibilities for application, determination, dissemination, and use of priorities; implementation of command policies and directives.
(4) Aerial port calls. Responsibilities and procedures for the issue of port calls for supply and personnel movements, implementation and execution of such calls.
(5) Special movement control actions. Special actions required to integrate movement control of air transportation with other applicable modes of transportation.
(6) Loading and unloading of aircraft. Folicies, responsibilities, and procedures for loading and unloading troops, accompanied supplies, and equipment at air terminals.
(7) Diversions and reconsignments. Authority, procedures, and channels prescribed for effecting and executing diversions or reconsignments.
b. Supply Movements.
(1) Designation for air movement. Authority for, responsibilities, how accomplished and disseminated, actions to be taken.
(2) Special packing requirements. Special instructions for packing or preparing supplies for air movement. Responsioility for packing and inspecting before air movement.
(3) Special marking. Types, responsibilities for applying marking on containers and
for obliterating old markings.
(4) Documentation. Responsibilities and procedures for preparing and distributing established documents.
(5) Airdrops and extractions. Amplification of command policies and directives on packaging and delivery responsibilities, methods and procedures for obtaining and accomplishing airdrops, methods and responsibilities for marking landing or drop zones.
(6) Records and reports. Responsibilities and methods of maintenance of specific records and reference to reports to be submitted.

## c. Personnel Movements.

(1) Preparation for air movement. Command policies and directives on procedures and requirements for preparing units and individuals for air movement.
(2) Movement to air terminals. Procedures and responsibilities for the movement of units and individuals to air terminals for air movement.
(3) Documentation. Preparation, distribution, and uses of established flight forms and documentation.
(4) Records and reports. Responsibilities and methods for maintenance of specific records and reference to reports to be submitted.

## 2-12. Outline Standing Operating Procedure for Air Transport Service (Air Force and Army Aviation)

a. General. Policies involved in control, operation, and maintenance of facilities, equipment, and installations; command responsibility; technical supervision required and agencies involved; responsibility for operational control.
b. Mission. Service to be provided by organic aviation units when made available for administrative movements, Air Force tactical airlift units, and other aircraft in direct support; extent of operation.
c. Functions.
(1) Scheduled and nonscheduled operations.
(2) Maintenance of equipment: responsibilities, procedures, facilities, inspections.
d. Operational Planning. Personnel, equipment, and supply requirements; capabilities and capacities; communication procedures.
e. Operations. Operational procedures and control; utilization of personnel, equipment, and facilities; priorities; coordination; documentation; records and reports; service to be given personnel and cargo; liaison established between aviation and user units.
f. Maintenance. Responsibilities and procedures for maintenance, regulations, reports, and records.
g. Supply. Responsibilities, authorized levels, procedures, and accounting methods for the Air Force.
h. Intelligence. Responsibility for collection, collation, evaluation and dissemination of air transportation intelligence.
i. Security. Responsibilities, disaster and defense plans, and equipment and supply security.
j. Records and Reports. Responsibilities: technical, operational, personnel, and stock records and reports.
k. Training. Responsibilities: unit and technical training.

## 2-13. Weight and Balance Terms

a. Aircraft Balance Limits. The maximum forward and maximum aft permissible locations of the aircraft center of gravity expressed as station numbers or as percentages of the mean aerodynamic chord (MAC). If these limits are exceeded, the aircraft will have unsatisfactory flight characteristics.
b. Center of Gravity (CG). The point about which an object would balance if supported at that point or the point at which the weight of an object or group of objects can be considered concentrated.
c. Reference Datum Line ( $R D L$ ). An imaginary vertical line at or near the nose of the aircraft from which all horizontal distances are measured. Aircraft diagrams show this line as structural station zero.
d. Station Number. A number, generally
marked on the interior of an aircraft, indicating a plane extending across the fuselage of the aircraft parallel to the reference datum line and representing the distance from it in inches.
e. Arm. The horizontal distance in inches from the reference datum line to the center of gravity of an object.
$f$. Moment. The product of the weight of an item multiplied by its arm. Moment may be expressed in pound-inches; for example, 2 pounds (weight) $\times 10$ inches (arm) $=20$ pound-inches (moment).
g. Allowable Cabin Load-Allowable Cargo Load. The load, of either passengers or cargo, which an aircraft is considered capable of airlifting safely over a given route under prescribed conditions. Expressed in terms of weight.
h. Basic Weight. The empty weight of an aircraft in its basic configuration, including all appointments, integral equipment, instrumentation, and trapped fuel and oil, but excluding passengers, cargo, crew, and fuel and oil.
i. Operating Weight. Basic weight of the aircraft plus oil, crew, crew's baggage, and mission equipment.
j. Ready-for-Loading Weight. Total aircraft, crew, oil, and fuel weight; or the gross weight less cargo; or the basic weight plus crew, oil, and fuel.
k. Maximum Allowable Gross Weight. The maximum allowed total weight of the aircraft prior to takeoff; the "basic weight" of the aircraft plus the crew, personnel equipment, special devices, passengers/cargo, and usable fuel and oil. This is limited by structure, power available, or landing load.
l. Maximum (Al̄ternate) Gross Weight. A gross weight in excess of the design gross weight. The maximum alternate gross weight is normally used in combat operations, but does not afford any margin of safety.

## 2-14. Calculating Center of Gravity of a Loaded Aircraft

To determine the center of gravity (CG) lo-
cation of a loaded aircraft, it is first necessary to obtain the weight and CG (moment) of the aircraft ready for loading.
a. Procedures. The procedures for computing the center of gravity of a loaded aircraft are as follows:
(1) Calculate for moment. Weight $\times$ Arm $=$ Moment.
(2) List aircraft ready-for-loading weight times the ready-for-loading $\mathrm{CG}=$ moment.
(3) List weight times the arm of each cargo item $=$ moment.
(4) Add all the weights and enter the total.
(5) Add all the moments and enter the total.
(6) Divide the total moment by the total weight; round off any decimals.
This figure is the station number at which the aircraft is balanced. If the figure does not fall within the safe flight limits, the load or a part of it must be relocated and aircraft balance recomputed.
b. Example. Sample problem (C-141 aircraft) : The C-141 aircraft is loaded with three M35, $21 / 2$ ton trucks, each weighing 13,700 pounds, and six passengers ( 1,800 pounds). All trucks are positioned, facing the rear of the aircraft, with the CG of truck No. 1 at station No. 630; The CG of truck No. 2 at station No. 920 ; the CG of truck No. 3 at station No. 1200 ; and the CG of the six passengers at station No. 930. Weight of aircraft ready for loading is 271,000 pounds, with its CG at station No. 915.
Weight $\times$ Arm $=$ Moment.
Weight of aircraft ready for loading $\times$ CG of aircraft
ready for loading.

Station No. 915 is the CG of the loaded aircraft. The CG limits for safe flight for the C-141 are 906.7 to 948 . The aircraft balanced at station No. 915 is safe for flight.

## 2-15. Air Movement Designator

This combination of code letters and numbers is assigned by the issuing agency to identify and indicate precedence of traffic movement within each service's allocation (AR 59-8 and para 7-20). Each air movement designator consists of code symbols in sequence as shown in the following example and as explained below.


## Type of Traffic

a. SUU-Indicates the MAC airport of origin of the traffic; in this example, "Travis AFB."
b. $T A W$-Indicates the MAC airport of destination of the traffic; in this example, "Tachikawa."
c. 3-Indicates the priority assigned to the traffic movement; in this example, "Priority 3" (para 2-16).
d. $E L$-Indicates the type of traffic (i.e., whether passenger or cargo moved; in this example, "Passenger-Emergency leave").
e. GF-Indicates the sponsoring department in whose interest the traffic is being moved; in this example, "The Department of the Army."
$f$. 6-Indicates the month in which the traffic is to be moved; in this example, "June."

## 2-16. Cargo Priorities <br> MILSTAMP Transportation

 Priority1

> MILSTRIP Iseue Priority
> Desionator
> 1 through 3
> 4 through 8
> 9 through 15

## 2-17. Restraint

a. Restraint Safety Factor (RSF). A numerical factor developed by the designer of a particular aircraft. The restraint safety factor
multiplied by the weight of the cargo gives the total thrust or force that must be compensated for or restrained against in an aircraft.
b. Cargo Tiedown Fitting Pattern. The location and spacing of the cargo tiedown fittings in the floor, ceiling, or wails of an aircraft.
c. Rated Strength. The safe load capacity of a cargo tiedown device including an applied safety factor.
d. Effective Angle. Angle of tiedowns used to secure cargo to prevent movement in multiple directions.
e. Restraint Device. Straps, cable, or chains used to apply the required restraint to cargo and generally referred to as tiedown devices. (Rope may be used only when special devices are not available.)
f. General Cargo. Cargo which is susceptible to loading in general, nonspecialized storage areas, e.g., boxes, barrels, bales, crates, packages, bundles, and pallets.

## 2-18. Computing Required Restraint

a. Restraint Safety Factors. The restraint safety factor (RSF) is a numerical facior established by the designer of an aircraft. The RSF is sometimes expressed in G's acting on a given load. The RSF multiplied by the weight of the cargo gives the amount of thrust which must be offset with tiedowns. For exarnple, when a C-5 stops abruptly, tiadowns must withstand a forward thrusi equal to three times the weight of the cargo. Accordingly, a 1,000pound load requires 3,000 pounds restraint to withstand forwara tnrust. Kestraint safeiy factors are determined by certain characteristics of the aircraft-acceleration during takeoff, stability during flight, deceleration during landing, and the type of landing field for which it is designed. Aircraft with a greater forward thrust factor require a greater forward RSF. For instance, the C-130 has more of a forward thrust factor than the C-5 because it can stop in a very short distance on unimproved fields.
b. Rated Strength of Tiedown Devices. The rated strength (RS) and characteristics of the common type of tiedown devices must be known to determine the kind of device needed. The rated strength includes an applied safety factor. Figure $2-20$ illustrates these devices. Appropriate types of tiedown devices with the highest rated strength should be selected thereby providing the needed restraint with the least number of devices.
c. Types of Tiedown Devices (fig 2-20).
(1) A-1A-An 18-foot length of cotton webining with two metal hooks, one stationary and one movable, and a quick-release adapter. It has a 1,250 -pound rated strength and is used for lashing general cargo. Although still in use, this device is gradually being phased out.
(2) $C G U-1 / B-A$ device similar to the $\mathrm{MC}-1$. It is an improvement over the MC-1 and will eventually replace it. It has a rated strength of 5,000 pounds and consists of a web nylon strap approximately 20 feet long with a fixed snaphook on one end and a movable hook on the other. The movable hook end of this device, unlike the MC-1, has a ratchet system for tensioning the device. It weighs approximately 3.75 pounds.
(3) C-2-A length of chain with an Lshaped hook at one end and a detachable quickrelease jaw and tightening mechanism at the other end. It has a 10,000 -pound rated strength and is used for all vehicles.
(4) D-1-A steel chain with a hook at one end and a detachaiole jaw and turnbuckle fitting at the other. It has a 25,000 -pound rated strength and is used primarily on heavy vehicles.
(5) MB-1—Similar to the C-2 but with a hook which is engaged with the tiedown fitting in place of the jaws on the C-2. It is used with the same chain as the $\mathrm{C}-2$. It has a $10,000-$ pound rated strength.
(6) $M B-2$-Similar to the $\mathrm{D}-1$. It has a heavy hook that is engaged with the tiedown fitting and is used with the same hooked chain as the D-1 except that it has a quick-release device. It has a 25,000 -pound rated strength.
(7) $M C-1$-A nylon w $\in b$ strap with two metal hooks, one stationary and one movable.


CGU-I/B


MB-I


MB-2


MC-I


Figure 2-20. Types of tiedown devices.


Figure 2-21. Percentage value of tiedowns applied at $30^{\circ}$ and $45^{\circ}$ angles.

It is similar in appearance to the $A-1 A$ and has a 5,000 -pound rated strength.
(8) Manila rope-Usually an 18 -foot length of $1 / 2$-inch manila hemp rope. It has a safe working capacity of 660 pounds with a safety factor of 4 , although its rated strength is 2,000 pounds.

## 2-1.9. Tiedown Angles

(fig 2-21)
a. Tiedown chains attached to a load at a point above the floor form two angles that can be measured-a floor angle and a longitudinal plan angle. The floor angle (sometimes called the vertical angle) is the angle between
the chain and the floor. The longitudinal angle is the angle between the chain and a line which runs fore and aft in the cargo compartment through the attachment point.
$b$. Tiedown chains attached at floor and plan angles of 30 degrees provide the best compromise for adequate restraint of cargo in all directions. Frequently it will not be possible to use 30 -degree angles, and other arrangemerits will be necessary. In these cases, try to place the tiedowns as close to a 30 -degree angle as possible. Increasing the floor angle while keeping constant plan angles will provide a higher value of vertical restraint but will reduce the amount of longitudinal and lateral restraint.

## PERCENTAGE RESTRAINT CHART

NOTE: 1. Anglea acroan the top are those formad between the tie-down device and the cebin foor.
2. Anglea down the eide are those formed between the tie-down devica and the longitudinal axio of the aircraft.

- Vertical raatraint ia related only to the angle between the tie-down device and the cabin floor. The lateral angle hae no bearing on it.
* The toned area indicatee the "beot compromiee' poition

|  |  | $5^{\circ}$ | $10^{\circ}$ | $15^{\circ}$ | $20^{\circ}$ | $23^{\circ}$ | $30^{\circ}$ | $35^{*}$ | $\omega^{\circ}$ | $45^{\circ}$ | $50^{\circ}$ | 53* | $60^{\circ}$ | $65^{*}$ | $70^{\circ}$ | 75* | $80^{\circ}$ | $85^{\circ}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | VERTICAL* | 8.7 | 17.4 | 25.9 | 34.2 | 42.3 | 50.0 | 57.4 | 64.3 | 70.7 | 76.6 | 81.9 | 86.6 | 90.6 | 93.9 | 96.6 | 98.5 | 99.6 |
| $5{ }^{\circ}$ | LOM6. | 99.2 | 98.1 | 96.2 | 93.6 | 90.2 | 86.3 | 81.6 | 76.3 | 70.4 | 64.0 | 57.2 | 49.8 | 42.1 | 34.1 | 25.8 | 17.3 | 8.7 |
|  | Lat | 8.7 | 8.6 | 8.4 | 8.2 | 7.9 | 7.5 | 7.1 | 6.7 | 6.2 | 5.6 | 4.9 | 4.4 | 3.7 | 2.9 | 2.3 | 1.5 | 0.8 |
| $10^{\circ}$ | LOM 6. | 98.1 | 97.0 | 95.2 | 92.6 | 89.2 | 85.3 | 80.7 | 75.5 | 69.6 | 63.3 | 56.5 | 49.3 | 41.7 | 33.7 | 25.5 | 17.1 | 8.6 |
|  | Lat | 17.3 | 17.1 | 16.8 | 16.6 | 15.8 | 15.1 | 14.3 | 13.3 | 12.3 | 11.2 | 9.9 | 8.7 | 7.4 | 5.9 | 4.5 | 3.0 | 15 |
| 15* | LOME. | 96.2 | 95.2 | 93.3 | 90.8 | 87.5 | 83.7 | 79.1 | 73.9 | 68.3 | 62.1 | 55.4 | 48.3 | 40.9 | 33.0 | 25.0 | 16.8 | 8.4 |
|  | Lat | 25.8 | 25.5 | 25.0 | 24.3 | 23.5 | 22.4 | 21.2 | 19.8 | 18.3 | 16.7 | 14.9 | 12.9 | 10.9 | 8.9 | 6.7 | 4.5 | 2.3 |
| $20^{\circ}$ | leme. | 93.6 | 92.6 | 90.8 | 88.4 | 85.2 | 81.4 | 76.9 | 72.0 | 66.5 | 60.4 | 53.9 | 47.0 | 39.8 | 32.1 | 24.3 | 16.6 | 8.2 |
|  | Lat | 34.1 | 33.7 | 33.0 | 32.1 | 30.9 | 29.6 | 28.0 | 26.2 | 24.2 | 21.9 | 19.6 | 17.1 | 14.5 | 11.7 | 8.9 | 5.9 | 2.9 |
| 25 * | semo. | 90.2 | 89.2 | 87.5 | 85.2 | 82.1 | 78.5 | 74.2 | 69.4 | 64.1 | 58.3 | 52.0 | 45.3 | 38.3 | 30.9 | 23.5 | 15.8 | 7.9 |
|  | 6at | 42.1 | 41.7 | 40.9 | 39.8 | 38.3 | 36.6 | 34.6 | 32.4 | $29.9{ }^{\circ}$ | 27.2 | 24.3 | 21.2 | 17.9 | 14.5 | 10.9 | 7.4 | 3.7 |
| 30** | Lomo. | 86.3 | 85.3 | 83.7 | 81.4 | 78.5 | - 44.9 | 70.9 | 66.3 | 61.2 | 55.7 | 49.7 | 43.3 | 36.6 | 29.6 | 22.4 | 15.1 | 7.5 |
|  | Lat | 49.8 | 49.3 | 48.3 | 47.0 | 45.3 | 43.3 | 40.9 | 38.3 | 35.4 | 32.2 | 28.7 | 25.0 | 21.2 | 17.1 | 12.9 | 8.7 | 4.4 |
| $35^{*}$ | Lomo. | 81.6 | 80.7 | 79.1 | 76.9 | 74.2 | 70.9 | 67.1 | 62.7 | 57.9 | 52.7 | 47.0 | 40.9 | 34.6 | 28.0 | 21.2 | 14.3 | 7.1 |
|  | lat | 57.2 | 56.5 | 55.4 | 53.9 | 52.0 | 49.7 | 47.0 | 43.9 | 40.6 | 36.9 | 32.9 | 28.7 | 24.3 | 19.6 | 14.9 | 9.9 | 4.9 |
| $40^{\circ}$ | Lomo. | 76.3 | 75.5 | 73.9 | 72.0 | 69.4 | 66.3 | 62.7 | 58.7 | 54.2 | 49.3 | 43.9 | 38.3 | 32.4 | 26.2 | 19.8 | 13.3 | 6.7 |
|  | lat | 64.0 | 63.3 | 62.1 | 60.4 | 58.3 | 55.7 | 52.7 | 49.3 | 45.5 | 41.3 | 36.9 | 32.2 | 27.2 | 21.9 | 16.7 | 11.2 | 5.6 |
| $45^{\circ}$. | LOMG. | 70.4 | 69.6 | 68.3 | 66.5 | 64.1 | 61.2 | 57.9 | 54.2 | 49.9 | 45.5 | 40.6 | 35.4 | 29.9 | 24.2 | 18.3 | 12.3 | 6.2 |
|  | Lat | 70.4 | 69.6 | 68.3 | 66.5 | 64.1 | 61.2 | 57.9 | 54.2 | 49.9 | 45.5 | 40.6 | 35.4 | 29.9 | 24.2 | 18.3 | 12.3 | 6.2 |
| $50^{\circ}$ | came. | 64.0 | 63.3 | 62.1 | 60.4 | 58.3 | 55.7 | 52.7 | 49.3 | 45.5 | 41.3 | 36.9 | 32.2 | 27.2 | 21.9 | 16.7 | 11.2 | 5.6 |
|  | cat | 76.3 | 75.5 | 73.9 | 72.0 | 69.4 | 65.3 | 62.7 | 58.7 | 54.2 | 49.3 | 43.9 | 38.3 | 32.4 | 26.2 | 19.8 | 13.3 | 6.7 |
| $53^{*}$ | Lons. | 57.2 | 56.5 | 55.4 | 53.9 | 52.0 | 49.7 | 47.0 | 43.9 | 40.6 | 36.9 | 32.9 | 28.7 | 24.3 | 19.6 | 14.9 | 9.9 | 4.9 |
|  | Lat | 81.6 | 80.7 | 79.1 | 76.9 | 74.2 | 70.9 | 67.1 | 62.7 | 57.9 | 52.7 | 47.0 | 40.9 | 34.6 | 28.0 | 21.2 | 14.3 | 7.1 |
| $60^{\circ}$ | lonc. | 49.8 | 49.3 | 48.3 | 47.0 | 45.3 | 43.3 | 40.9 | 38.3 | 35.4 | 32.2 | 26.7 | 25.0 | 21.2 | 17.1 | 12.9 | 8.7 | 4.4 |
|  | lat | 86.3 | 85.3 | 83.7 | 81.4 | 78.5 | 74.9 | 70.9 | 66.3 | 61.2 | 55.7 | 49.7 | 43.3 | 36.6 | 29.6 | 22.4 | 15.1 | 7.5 |
| $65^{\circ}$ | tomo. | 42.1 | 41.7 | 40.9 | 39.8 | 38.3 | 36.6 | 34.6 | 32.4 | 29.9 | 27.2 | 24.3 | 21.2 | 17.9 | 14.5 | 10.9 | 7.4 | 3.7 |
|  | Lat | 90.2 | 89.2 | 87.5 | 85.2 | 82.1 | 78.5 | 74.2 | 69.4 | 64.1 | 58.3 | 52.0 | 45.3 | 38.3 | 30.9 | 23.5 | 15.8 | 7.9 |
| $70^{\circ}$ | Lonc. | 34.1 | 33.7 | 33.0 | 32.1 | 30.9 | 29.6 | 28.0 | 26.2 | 24.2 | 21.9 | 19.6 | 17.1 | 14.5 | 11.7 | 8.9 | 5.9 | 2.4 |
|  | lat | 93.6 | 92.6 | 90.8 | 88.4 | 85.2 | 81.4 | 76.9 | 72.0 | 66.5 | 60.4 | 53.9 | 47.0 | 39.8 | 32.1 | 24.3 | 16.6 | 8.2 |
| $75^{\circ}$ | Lono. | 25.8 | 25.5 | 25.0 | 24.3 | 23.5 | 22.4 | 21.2 | 19.8 | 18.3 | 16.7 | 14.9 | 12.9 | 10.9 | 8.9 | 6.7 | 4.5 | 2.3 |
|  | Lat | 96.2 | 95.2 | 93.3 | 90.8 | 87.5 | 83.7 | 79.1 | 73.9 | 68.3 | 62.1 | 55.4 | 48.3 | 40.9 | 33.0 | 25.0 | 168 | 8.4 |
| $80^{\circ}$ | coes. | 17.3 | 17.1 | 16.8 | 16.6 | 15.8 | 15.1 | 14.3 | 13.3 | 12.3 | 11.2 | 9.9 | 8.7 | 7.4 | 5.9 | 4.5 | 3.0 | 1.5 |
|  | Lat | 98.1 | 97.0 | 95.2 | 92.6 | 89.2 | 85.3 | 80.7 | 75.5 | 69.6 | 63.3 | 56.5 | 49.3 | 41.7 | 33.7 | 25.5 | 17.1 | 8.6 |
| 25* | Lome. | 8.7 | 8.6 | 8.4 | 8.2 | 7.9 | 7.5 | 7.1 | 6.7 | 6.2 | 5.6 | 4.9 | 4.4 | 3.7 | 2.9 | 2.3 | 1.5 | 0.8 |
|  | Lat | 99.2 | 98.1 | 96.2 | 93.6 | 90.2 | 86.3 | 81.6 | 76.3 | 70.4 | 64.0 | 57.2 | 49.8 | 42.1 | 34.1 | 25.8 | 17.3 | 8.7 |

Figure 2-22. Percentage restraint chart.

## 2-20. Percentage Restraint Chart

The percent value of a restraint device for angles from 5 to 85 degrees is illustrated at figure 2-22.

## 2-21. Strength of Tiedown Fittings

$a$. A chain is only as strong as its weakest link. Tiedown devices and tiedown fittings of the same rated strength should be used together. For example, a 10,000 -pound tiedown device attached to a 5,000 -pound floor fitting has a holding strength of only 5,000 pounds.
$b$. For both forward and rearward restraint, devices should be attached in a regular pattern by using corresponding points of attachment on opposite sides of the equipment and corresponding tiedown fittings on each side of the cargo floor centerline.

## 2-22. Computing Number of Tiedowns Required

$a$. Two elements used for computing the exact number of tiedowns required in a given situation are- (1) force to be secured, and (2) effective holding strength of one device. The first is the product of the cargo weight and restraint safety factors. The second is the product of the rated strength of the tiedown device and the percent effectiveness of the angle of tie. The first element divided by the second makes up the formula for computing the number of tiedowns required in any situation.

## $\frac{\text { Force to be secured }}{\text { Effective holding }}=$ Number of tiedowns required. strength

b. Specific working formulas for each angle of tie are as follows:
(1) Straight $45^{\circ}$ angle of tie (compute for forward and lateral).

[^1](3) Straight $30^{\circ}$ angle of tie (compute for forward and lateral).

Cargo weight
$\frac{\times \text { restraint safety factor }}{\text { Tiedown rated strength } \times 86 \%}=$ Number of tiedowns
Cargo weight
$\frac{\times \text { restraint safety factor }}{\text { Tiedown rated strength } \times 50 \%}=$ Number of tiedowns
(4) $30^{\circ} \times 30^{\circ}$ angle of tie (compute for forward and aft).

Cargo weight
$\frac{\times \text { restraint safety factor }}{\text { Tiedown rated strength } \times 75 \%}=$ Number of tiedowns
Cargo weight
$\frac{\times \text { restraint safety factor }}{\text { Tiedown rated strength } \times 43 \%}=$ Number of tiedowns
EXAMPLE: C-130 aircraft
Restraint " $G$ " or safety factor (RSF)
Forward *8,
Aft 1.5
Side 1.5
Vertical 2.

[^2]
## 2-23. Typical Loads

See TM 55-450-10-series or TM 1-(transported $a c f t$ )-S-series for typical loads.

## 2-24. Standard Parachutes and Carrying Capacities

| Parachute | Diameter (ft) | Maximum load capability (lb) |
| :---: | :---: | :---: |
| G-12D | 64 | 2,200 |
| G-13 | 24.25 | 500 |
| G-11A | 100 | 3,500 |
| T-7A | 28 | 300 |

## 2-25. Aerial Delivery Containers and Typical Loads

| Container | $\begin{gathered} \text { Average gafe } \\ \text { load (lb) } \end{gathered}$ | Typical load |
| :---: | :---: | :---: |
| A-7A | 500 | Packaged nonfragile supplies |
| A-21 | 500 | Fragile and nonfragile supplies |
| A-22 | 2,200 | Fragile and nonfragile supplies |
| A-22 (G-12D) | 750 | Fragile and nonfragile supplies |

## 2-26. Loading or Unloading Time for Army Aircraft

a. Rotary-Wing Aircraft.
(1) Troops- 3 minutes.
(2) Casualties- 10 minutes.
(3) Cargo, in fuselage- 5 to 25 minutes, depending on the type cargo and aircraft.
(4) Cargo, external load- 30 seconds.
(5) Refueling-
(a) Observation (OH-6, OH-13, $\mathrm{OH}-$ 23, and $\mathrm{OH}-58$ ) -7 minutes.
(b) Utility (UH-19 and UH-1)-10 minutes.
(c) Light transport (CH-34)-15 minutes.
(d) Medium transport (CH-47 and CH54) - 20 minutes.
b. Fixed-wing Aircraft.
(1) Troops-approximately 2 to 3 minutes, depending on aircraft.
(2) Casualties- 10 minutes.
(3) Cargo, in fuselage-
(a) Load- 10 to 30 minutes, depending on cargo.
(b) Unload-5 to 15 minutes.
(4) Cargo, external load-
(a) Load- 10 minutes.
(b) Air-landed- 10 minutes.
(c) Parachute- 30 seconds.
(d) Free fall.
(5) Refueling-
(a) Observation, light (0-1)-5 minutes.
(b) Utility (U-6) - 8 minutes.
(c) Utility (U-1A)-15 minutes.
(d) Utility (U-8) - 10 minutes.

## 2-27. Aircraft Landing Sites

See FM 57-35, FM 1-100, and TM 5-330.

## 2-28. Estimating Army Aircraft Movement Capability <br> a. General. To assess capability to move per-

 sonnel and supplies by Army aircraft, the analyst must consider the various factors involved. Some or all of the factors will apply to a particular problem. Factors involved and methods of making capability estimates are given in $b$ and $c$ below.b. Factors Involved. Depending upon the nature of a particular mission, the analyst must consider the following:
(1) Type and number of aircraft involved.
(2) Loading.
(a) Weight of cargo and lift capability (payload) of aircraft.
(b) Configuration of cargo in relation to size of cargo compartment and cargo compartment doors.
(c) Sling loads for helicopters.
(d) Wing loads for fixed-wing aircraft.
(3) Hours of daily operation (flying hours).
(a) Helicopters-4.
(b) Fixed-wing aircraft-6.
(4) Availability. Availability is affected by the adequacy and efficiency of maintenance and supply and by the relative location of operating and service units. The average availability of aircraft on hand for sustained and short-term operations is shown below.

| Fixed-wing | aircraft | Sustained <br> (percent) | Short-term <br> (percent) |
| :--- | :--- | :--- | :---: | :---: |
| Helicopters $-\ldots-\ldots$ | 75 | 90 |  |
| $-\ldots$ | 67 | 90 |  |

(5) Aircraft requirement. The number of aircraft sorties required to accomplish a mission is determined by two factors-the basic requirement and the type of operation.
(a) Basic requirement. The number of aircraft needed to meet the basic requirement is obtained by dividing the total tonnage to be moved by the payload of one aircraft of the type to be used in the operation.
(b) Type of operation. The basic air-
craft requirement figure has to be adjusted according to the variable factors involved. The most common variable factors are-

1. Distance. Distance causes the fuel and payload relationship to vary inversely. When the operation exceeds 50 miles ( 80 kilometers), the basic aircraft requirement should be increased approximately 7 percent for each 20-mile (32-kilometer) increment.
2. Sustained operation. In a sustained operation, the basic number of aircraft required should be increased by 50 percent.
3. Combat loading. A 10-percent increase of the basic requirement is necessary for combat loading.
4. Miscellaneous variables. As altitude and/or temperature increase, the aircraft requirements will also increase because of a decrease in weight-lifting capability. Humidity and other weather conditions also affect the aircraft requirement. The analyst must determine the adjustments to be made because of these variables.

## 2-29. Airlift

This paragraph contains a nomograph (fig 223) which provides staff planners a rapid and accurate method for determining airlift capability, requirements, and deployment times under sustained operations.
a. General. Although aircraft planning factors and related data are available in various Army and Air Force manuals, these factors are neither correlated nor assembled in such manner as to permit their ready application to air transport problems that daily confront staff planners. The nomograph is designed to overcome this deficiency and to eliminate many tedious computations required to determine airlift capability and deployment time. To make full use of the nomograph, particular note
should be made of the "Explanatory Notes" therein.
b. Functions and Factors Employed for Nomograph.
(1) Aircraft payload. The payload (ACL -allowable cabin load) of a transport aircraft, in short tons, is obtained from the pay-load-range curve for the aircraft. Since payload reduces as the nonstop range increases, the longest nonstop distance (critical leg) of the route determines the maximum cargo payload for an entire route because effective airlift operations assume the movement of a fixed load over all legs of a route. Since unit movement requirements include primarily outsize/ vehicle (bulky or low density) cargo, average ACL's are provided for both bulk (palletized or high density) and outsize cargo.
(2) Aircraft speed. Speed in knots (nautical miles per hour).
(3) Ton-mile requirement. The short tons of passengers, equipment, and supplies to be moved times the distance to be moved.
(4) Passenger conversion factor. 7 troops approximate 1 short ton based on a combined passenger and baggage weight of 286 pounds per individual. Use precomputed personnel short ton conversion chart (fig 2-24).
(5) Distances. Use table of approximate airline distances (tables 2-5 and 2-6).
c. Conversion Factors for Other Aircraft. The nomograph (fig 2-23) is based on C-124/ C-130 aircraft data, but can be used for other transport aircraft as required. By application of the following conversion factors, a given inventory of various types of military transport aircraft can be converted to either C-124 or C-130 "equivalents" and applied to the number of aircraft scale on the nomograph.
(1) Outsize/vehicle cargo conversion factors.

|  | Type of aircraft | Conversion <br> $C-124$ | $\begin{aligned} & \text { uivalents } \\ & C-190 \end{aligned}$ |
| :---: | :---: | :---: | :---: |
| C-124 |  | 1.00 | --- |
| C-130 |  | --- | 1.00 |
| C-141 |  | 2.93 | 2.48 |
| C-97 |  | 0.72 | 0.61 |
| C-5A |  | 6.22 | 4.37 |

(2) Bulk or palletized cargo conversion factors.

|  | Type of aircraft | Converaion C-124 | $\begin{aligned} & \text { quivalents } \\ & \text { C-1s0 } \end{aligned}$ |
| :---: | :---: | :---: | :---: |
| C-124 |  | 1.00 |  |
| C-130 |  | --- | 1.00 |
| C-141 |  | 2.62 | 1.84 |
| C-97 |  | 1.09 | 0.77 |
| C-135 |  | 3.13 | 2.20 |
| C-121 |  | 1.02 | 0.72 |
| C-5A | --------- | 6.50 | 4.57 |

(3) Application of conversion factors. The number of $\mathrm{C}-124$ or $\mathrm{C}-130$ aircraft equivalents is derived by multiplying the number of given types of aircraft by applicable C-124 or C-130 factors shown above (outsize/vehicle or bulk cargo). For example, conversion of an inventory to C-124 equivalents (outsize/vehicle requirement) is as follows:

| Type of aircraft | Number $\times$ | Conversion factor | $\underset{\text { equivalent }}{C-124}$ |
| :---: | :---: | :---: | :---: |
| C-124 ------- | 20 | 1.00 |  |
| C-141 | 10 | 2.93 | 29 |
| C-5A | 4 | 6.22 | 25 |
| Totals | 34 |  | 74 |

# AIRLIFT <br> CAPABILITY - REQUIREMENTS - DEPLOYMENT TIMES <br> C-I24/C-I30 AIRCRAFT 

NOTE: Para 2-29c gives conversion factors for use with other transport aircraft.

TON MILE REQUIREMENT/
CAPABILITY (OUTBOUND)

NUMBER OF
AIRCRAFT


Figure 2-23. Airlift nomograph.

## USES OF GRAPH

To determine:
DEPLOYMENT TIME (DAYS): If the requirement and number of aircraft are known.

TON MILE CAPABILITIY (OUTBOUND): If the number of aircraft and deployment time are known.

NUMBER OF AIRCRAFI REQUIRE: If the requirement and deployment time are known.

## EXAMPLES AND APPLICATION

DEPLOYMENT TIME (DAYS): Determine the time required to deploy a unit with 3330 personnel and 625 short tons ( $S / T$ ) of equipment/supplies from Okinawa to Saigon (distance of 1816 nautical miles) with 50 $\mathrm{C}-124$ or $50 \mathrm{C}-130$ aircraft.
Step 1 - Compute ton mile requirement ( $\mathrm{S} / \mathrm{T}$ $x$ Distance). Convert personnel to S/T (fig. $2-24$ ) 3300 pers $=476 \mathrm{~S} / \mathrm{T}$, plus $625 \mathrm{~S} / \mathrm{T}$ equip/supplies $=1101 \mathrm{~S} / \mathrm{T}$ requirement. 1101 total $\mathrm{S} / \mathrm{T}$ requirement $\times 1816 \mathrm{miles}=$ $1,999,400$ ton mile requirement rounded off to $2,000,000$. (use chart at left). Place a mark at 2000 on the ton mile requirement scale.

Step 2 - Place a mark at 50 on the Number of Aircraft scale.

Step 3 - Draw a straight line connecting the marks on both scales and the intersecting point on the Deployment Time (Days) scale of approximately $4^{\frac{1}{2}}$ for $\mathrm{C}-124$ and $33 / 4$ for $C-130$ is the number of days required to deploy this unit with $\mathrm{C}-124$ or C-130 aircraft.

TON MILE CAPABILITY (OUTBOUND): Determine the total ton mile capability of $25 \mathrm{C}-124$ aircraft for a nine (9) day period.
Step 1 - Place a mark at 25 on the Number of Aircraft scale.

Step 2 - Place a mark at 9 on the C-124 Deployment Time (Days) scale.

Step 3 - Draw a straight line from 25 on the Number of Aircraft scale through 9 on the C-124 Deployment Time scale and extend the line to the Ton Mile Capability scale. The reading of approximately $2,000,000$ will be the total outbound ton mile capability of $25 \mathrm{C}-124$ aircraft for a none (9) day period.

NUMBER OF AIRCRAFT: Determine the number of $\mathrm{C}-130$ aircraft required to deploy in four (4) days a ton mile requir ement of $2,000,000$.
Step I - Place a mark at 2000 on the Ton Mile Requirement scale.

Step 2 - Place a mark at 4 on the C-130 Deployment Time (Days) scale.

Step 3 - Draw a straight line from 2000 on the Ton Mile Requirement scale through 4 on the C-130 Deployment Time scale and extend the line to the Number of Aircraft scale. The reading of approximately 46 will be the number of $\mathrm{C}-130$ aircraft required to deploy in 4 days a $2,000,000$ ton mile requirement.

## EXPLANATORY NOTES

1/ SCALE VALJES: Although this graph reflects specific scale values, it is applicable to higher or lower scale values by merely applying the percentage change to the answer derived from any of the given uses. Examples:
a. The time required to deploy a unit with double the requirement shown in the first example under application would be approximately 9 days for $\mathrm{C}-124$ and $7 \frac{1}{2}$ days for C-130 aircraft. This is obtained by applying the $100 \%$ increase in ton mile requirement ( $4,000,000+$ $2,000,000$ ) to the answer of $4^{\frac{1}{2}}$ and $33 / 4$ days for C-124 and C-130 aircraft, respectively.
b. A utilization rate of 8 hours/day ( 250 hours/month) was used. If a higher or lower rate is planned, the percentage change is applicable as indicated in a. above.

Table 2-5. Approximate Airline Distances-Pacific Area Nautical Miles

| R <br> $\mathbf{O}$ <br> $\mathbf{U}$ <br> $\mathbf{T}$ <br> $\mathbf{E}$ <br> R <br> $\mathbf{E}$ <br> $\mathbf{F}$ <br> $\mathbf{N}$ <br> $\mathbf{O}$ | Area/Airfield |  $\underset{\sim}{2}$ | $\begin{aligned} & \text { 믄 } \\ & \text { O} \\ & \text { O} \\ & \text { 10 } \end{aligned}$ | -Rangoon <br> 昆 |  |  |  <br> 틀 | 易 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| (1) | US -TRAVIS | 0 | 5,78 | 8461(14) | 7469(14) | 6536 ( 9) | 5461 (18) | 2142 |
| (2) | -McCHORD |  | 0 | 8647(14) | 7655(14) | 6722( 9) | 5647 (18) | 2328 |
| ( 3) | BURMA -RANGOON |  |  | 0 | 2228(15) | 2887( 4) | 3000 (14) | 6319(18) |
| (4) | CHINA -HONG KONG |  |  |  | 0 | 659 | 2008(14) | 5327(18) |
| ( 5) | -SHANGHAI |  |  |  |  | 0 | 1690(13) | 4394 (12) |
| ( 6) | GUAM -ANDERSON |  |  |  |  |  | 0 | 3319(18) |
| ( 7) | HAWAII -HICKAM |  |  |  |  |  |  | 0 |
| ( 8) | JOHNSTON ISLAND |  |  |  |  |  |  |  |
| (9) | JAPAN -TACHIKAWA |  |  |  |  |  |  |  |
| (10) | KWAJALEIN ISLAND |  |  |  |  |  |  |  |
| (11) | KOREA -KIMPO |  |  |  |  |  |  |  |
| (12) | MIDWAY ISLAND |  |  |  |  |  |  |  |
| (13) | OKINAWA -KADENA |  |  |  |  |  |  |  |
| (14) | PHILIPPINE I. -CLARK |  |  |  |  |  |  |  |
| (15) | S. VIETNAM - -SAIGON |  |  |  |  |  |  |  |
| (16) | TAIWAN -TAIPEI |  |  |  |  |  |  |  |
| (17) | THAILAND -BANGKOK |  |  |  |  |  |  |  |
| (18) | WAKE ISLAND |  |  |  |  |  |  |  |

*Number in paren ( ) after distances indicates airline routing.

|  | －Tachikawa <br>  |  | $\begin{aligned} & \circ \\ & 0 \\ & \hline \end{aligned}$ $\begin{aligned} & \text { Wू } \\ & \text { Wix } \end{aligned}$ |  | $\begin{aligned} & \text { a } \\ & \text { 哥 } \\ & \text { E゙ } \\ & \mid \end{aligned}$ | 穼 |  |  <br>  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2852（7） | 5651 （12） | 4273（8） | 6296（9） | 3289（7） | 6350（18） | 6891 （18） | 7814 （14） | 6716 （13） | 8144 （14） | 4151（7） |
| 8038（7） | 673，7（12） | 4459（8） | 6482（ 9） | 3475（ 7） | 6536 （18） | 7077（18） | 8000 （14） | 6902 （13） | 8330 （14） | 4337（ 7） |
| 5803 （10） | 8310 （14） | 4382（ 6） | 3138 （13） | 5341 （18） | 2463（14） | 1570 （17） | 725 （17） | 2200 （14） | 817 | 4310（6） |
| 4811 （10） | 1718 （16） | 3390（ 6） | 1615（13） | 4349（18） | 840 （16） | 678 | 1503 | 474 | 1911 （15） | 3318（ 6） |
| 4127（18） | 986 | 3386 （18） | 466 | 324，7（ 9） | 440 | 1001（13） | 2162（4） | 371 | 2570 （15） | 2750（9） |
| 2687（18） | 1386 | 1382 | 2131（9） | 2841 （18） | 1250 | 1430 | 2353 （14） | 1616（13） | 2683（14） | 1310 |
| 710 | 3409（12） | 2131（ 8） | 4154（9） | 1147 | 4280（ 9） | 4749（ 6） | 5672（14） | 4646 （13） | 6002（14） | 2009 |
| 0 | 3142 （18） | 1421 | 3887（18） | 816 | 3576（18） | 4233（ 6） | 5156 （14） | 4308 （13） | 6486（14） | 1877 |
|  | 0 | 2401 （18） | 745 | 2262 | 871 | 1740 | 2663 （14） | 1244 | 2993（14） | 1765 |
|  |  | 0 | 8146（9） | 1667（18） | 2632（ 6） | 2812（ 6） | 3735 （14） | 2998（13） | 4065 （14） | 636 |
|  |  |  | 0 | 3007 （ 9） | 675 | 1568（13） | 2491 （14） | 1041（13） | 2821 （14） | 2510（9） |
|  |  |  |  | 0 | 3133（9） | 3771 （ 6） | 4694 （14） | 3506（ 9） | 6024 （14） | 1031 |
|  |  |  |  |  | 0 | 898 | 1816（14） | 366 | 2146 （14） | 2199 |
|  |  |  |  |  |  | 0 | 923 | 630 | 1263 | 2740（ 6） |
|  |  |  |  |  |  |  | 0 | 1653 （14） | 408 | 3663（ 6） |
|  |  |  |  |  |  |  |  | 0 | 1883 （14） | 3370（ 6） |
|  |  |  |  |  |  |  |  |  | 0 | 8993（ 6） |
|  |  |  |  |  | － |  |  |  |  | 0 |

Table 2－6．Approximate Airline Distances－A tlantic Area Nautical Miles

| AREA／AIRFIELD |  $\stackrel{\bullet}{3}$ | $\begin{aligned} & \text { 第 } \\ & 0 \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { 思 } \\ & \text { O} \\ & \text { O } \end{aligned}$ | Straiv sonang vnulngouv |  | O 4 4 4 4 4 4 <br> 总 | mildenhall <br> 号 4 ㄴ․ 䀂 |  <br>  |  |  |  |  <br> Z |  |  | $\begin{aligned} & \text { O} \\ & \text { O } \\ & 0 \end{aligned}$ | $\begin{aligned} & \text { 茍 } \\ & \text { 品 } \end{aligned}$ |  | 态 $\begin{aligned} & Z \\ & \frac{Z}{4} \\ & \underset{\sigma}{2} \end{aligned}$ |  | פanasannyhor vorasv hlnos |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| U．S．Charleston | 0 | 470 | 420 | 4500 | 4012 | 4417 | 3734 | 3955 | 2813 | 4238 | 2965 | 6726 | 1535 | 1633 | 4050 | 3099 | 6481 | 3607 | 5507 | 7000 |
| Dover |  | 0 | 84 | 4970 | 4482 | 4887 | 3228 | 3505 | 2394 | 4072 | 2432 | 6391 | 1125 | 1197 | 3629 | 3570 | 6600 | 3240 | 5172 | 7200 |
| McGuire |  |  | 0 | 5020 | 4560 | 4967 | 3184 | 3520 | 2377 | 4100 | 2350 | 6370 | 1029 | 1113 | 3549 | 3650 | 6620 | 3203 | 5151 | 7300 |

## PRECOMPUTED PASSENGER:SHORT TON CONVERSION CHART

| Number of Passengers | Number of <br> Short Tons | Number of Passengers | Number of <br> Short Tons | Number of Passengers | Number of <br> Short Tons |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 7 | 1 | 252 | 36 | 497 | 71 |
| 14 | 2 | 259 | 37 | 504 | 72 |
| 21 | 3 | 266 | 38 | 511 | 73 |
| 28 | 4 | 273 | 39 | 518 | 74 |
| 35 | 5 | 280 | 40 | 525 | 75 |
| 42 | 6 | 287 | 41 | 532 | 76 |
| 49 | 7 | 294 | 42 | 539 | 77 |
| 56 | 8 | 301 | 43 | 546 | 78 |
| 63 | 9 | 308 | 44 | 553 | 79 |
| 70 | 10 | 315 | 45 | 560 | 80 |
| 77 | 11 | 322 | 46 | 567 | 81 |
| 84 | 12 | 329 | 47 | 574 | 82 |
| 91 | 13 | 336 | 48 | 581 | 83 |
| 98 | 14 | 343 | 49 | 588 | 84 |
| 105 | 15 | 350 | 50 | 595 | 85 |
| 112 | 16 | 357 | 51 | 602 | 86 |
| 119 | 17 | 364 | 52 | 609 | 87 |
| 126 | 18 | 371 | 53 | 616 | 88 |
| 133 | 19 | 378 | 54 | 623 | 89 |
| 140 | 20 | 385 | 55 | 630 | 90 |
| 147 | 21 | 392 | 56 | 637 | 91 |
| 154 | 22 | 349 | 57 | 644 | 92 |
| 161 | 23 | 406 | 58 | 651 | 93 |
| 168 | 24 | 613 | 59 | 658 | 94 |
| 175 | 25 | 420 | 60 | 665 | 95 |
| 182 | 26 | 427 | 61 | 672 | 96 |
| 189 | 27 | 434 | 62 | 679 | 97 |
| 196 | 28 | 441 | 63 | 686 | 98 |
| 203 | 29 | 448 | 64 | 693 | 99 |
| 210 | 30 | 455 | 65 | 700 | 100 |
| 217 | 31 | 462 | 66 | 798 | 114 |
| 224 | 32 | 469 | 67 | 903 | 129 |
| 231 | 33 | 476 | 68 | 1001 | 143 |
| 238 | 34 | 483 | 69 | 2002 | 286 |
| 245 | 35 | 490 | 70 | 3003 | 429 |

NOTES: 1. Passengers and short tons are shown in multiples of 7 and 1. For ease in computation, fractions of these multiples should be rounded off to the next highest multiple of 7 passengers or 1 short ton.
2. Use combinations of the above conversions for number of passengers not shown.

Figure 2-24. Precomputed personnel short ton
conversion chart.

MOTOR

## Section I. ORGANIZATION

## 3-1. Organization

Unit
Headquarters and headquarters company transportation motor transport brigade.

Headquarters and headquarters detachment, transportation motor transport group.

Headquarters and headquarters detachment transportation motor transport battalion.

To command, plan, supervise, coordinate, and control the activities of transportation highway transport groups and other assigned or attached units required in the movement of cargo or personnel by highway transport, particularly in a continuous intersectional or other line haul operation.

55-12 To provide command, staff planning, and control of operations of transportation truck and/or tracked vehicle battalions.

55-16 To provide command and supervision of units engaged in all types of motor transport, such as direct support of tactical units, depot and terminal operations, and line hauls.

## Assignment

To a theater army command. Normally attached to the transportation command TOE 55-2.

To a transportation command or brigade. Normally attached to a motor transport brigade ór may operate separately.
To a field army support command or theater army support command. Normally attached to a transportation motor transport group, TOE 55-12, when employed in the communications zone; to a transportation brigade, TOE 55-62; or a transportation composite group, TOE 5552 ; or a support brigade TOE 54-22, when employed in the combat zone.

## Capability

Commanding and supervising the activities of three to seven transportation motor transport groups and supporting units.

Commanding, planning, and supervising the activities of three to seven transportation motor transport battalions.

Provide command and supervision for three to seven of the following transportation companies or any appropriate combination thereof and attached supporting services as required.
a. Transportation Light Truck Company, TOE 55-17.
b. Transportation Medium Truck Company, TOE 55-18.
c. Transportation Car Company, TOE 55-19.
d. Transportation Cargo Carrier Company (Tracked), TOE 55-27.
e. Transportation Heavy Truck Company, TOE 55-28.
f. Transportation Light-Medium Truck Company, TOE 55-67.
Operate a truck terminal and/or trailer relay system when required. (These operations require assignment of teams from TOE 55-540 and 29-500.)
At full strength, with 45 trucks available making four round trips per day in local hauls or two round trips per day (one per 10-hour shift) in line hauls, a light truck company can transport the following:
a. When equipped with $21 / 2$-ton trucks:
(1) For local hauls- 720 short tons of cargo ( 4 tons per truck) based on 75 -percent availability of vehicles and four trips daily on highway or 3,600 passengers ( 20 passengers per truck) on or off highway.
(2) For line hauls- 360 short tons of cargo ( 4 tons per truck) based on 75 -percent availability of vehicles and two trips daily on highway or 1,440 passengers ( 16 passengers per truck) on or off highway.
(3) In one lift off highway -112.5 short tons of cargo ( $21 / 2$ tons per truck).
b. When equipped with 5-ton trucks:
(1) Local hauls- 1,080 short tons of cargo ( 6 tons per truck) based on 75 percent availability of vehicles and four trips daily on or off highway or 3,600 passengers ( 20 passengers per truck) on or off highway. company.

To provide transportation for the movement of general cargo and personnel by motor transport.

To a field army, corps, or logistical command. Normally attached to a headquarters and headquarters detachment, transportation motor, transport battalion, TOE 55-16.
(2) Line hauls- 540 short tons of cargo ( 6 tons per truck) based on 75 -percent availability of vehicles and two trips daily on highway or 1,620 passengers ( 18 passengers per truck) on or off highway.
(3) In one lift off highway- 180 short tons of cargo ( 4 tons per truck).
a. At full strength, with 45 semitrailer combinations available making four round trips per day in local hauls or two round trips per day (one per 10-hour shift) in line hauls, a medium truck company can transport the following:
(1) When equipped with 12 -ton cargo semitrailers:
(a) Local hauls-2,160 short tons of cargo ( 12 tons per semitrailer) or in an emergency only, 9,000 passengers (50 passengers per semitrailer).
(b) Line hauls- 1,080 short tons of cargo ( 12 per semitrailer) or in an emergency only, 4,500 passengers ( 50 passengers per semitrailer).
(2) When equipped with $5,000-$ gallon petroleum semitrailers:
(a) Local hauls- 900,000 gallons.
(b) Line hauls- 450,000 gallons.
(3) When equipped with $71 / 2$-ton refrigerator semitrailer carrying 6 tons per vehicle:
(a) Local hauls- 1,080 short tons.
(b) Line hauls- 540 short tons.
b. With a minor modification, i.e., military desert design tires, this unit can provide logistical and combat support in desert areas of the world.

## Unit

Transportation car company.

To transport personnel and light cargo by motor vehicle.

Transportation cargo carrier company (tracked).

55-27 To provide transportation for supply distribution in regions where wheeled vehicles cannot operate effectively.
a. To a field army or logistical command. Normally attached to headquarters and headquarters detachment, transportation motor transport battalion, TOE 55-16; may also be assigned to independent corps force or to a corps.
b. To an airborne corps.

To a division employed in regions where wheeled vehicles cannot operate effectively. To a corps, field army, or logistical command, as required.
a. Each platoon when equipped with sedans can transport 75 personnel in one lift.
b. Each platoon when equipped with $1 / 4$-ton trucks and trailers can transport 45 personnel and $21 / 2$ tons of baggage or small-sized supplies of $61 / 4$ tons of small-sized supplies and cargo, mail, or light commodities in one lift.
c. Each platoon when equipped with $3 / 4$-ton trucks can transport $111 / 4$ tons of cargo or 120 people in one lift.
d. Each composite platoon composed of ten $1 / 4$-ton trucks and trailers and ten $3 / 4$-ton trucks (designated the airborne platoons in the airborne organization) is capable of transporting 82 personnel and $71 / 2$ tons of baggage or small-sized supplies or 10 tons of small-sized supplies and cargo, mail, or light commodities in one lift.
e. All capabilities are computed on a 75-percent availability of vehicles and all vehicles carrying rated capacity.
f. When organized for assignment to an airborne corps, the parachute platoon has the capability of being landed by parachute or aircraft. All personnel in this platoon are airborne qualified.

At full strength (level 1) this unit is capable of the following:
a. With all vehicles available, transporting in one lift 288 short tons of cargo.
b. In sustained operations, based on 75 -percent vehicle availability, transporting 216 short tons of cargo or

Transportation heavy truck company.

To provide truck transportation for the movement of tanks and other heavy or bulky vehicles and to transport heavy, bulky, and outsized cargo.

Transportation light-medium truck company.

Transportation motor transport company, supply and transport battalion, infantry division (mechanized).

55-84 a. To provide transportation for unit distribution of all classes of supply except class $V$.
b. To transport division reserve supplies for which the unit is re-

To a field army, corps, or a logistical command.

To a field army support command, corps support brigade, or a logistical command. Normally attached to a supply and service battalion, transportation general support battalion, or transport battalion (DS).
when equipped with tank units, transporting 43,200 gallons of fuel 50 miles forward daily.

At full strength, operating two $10-$ hour shifts per day, with 18 tractor trucks and semitrailers available, this unit can:
a. For local hauls-transport 2,880 short tons of cargo, or tanks, or similar vehicles, avraging 40 tons per truck, four round trips daily.
b. For line hauls-transport 1,440 short tons of cargo or tanks or similar vehicles, averaging 40 tons per truck, two round trips daily.

|  | Cargo | $\begin{gathered} \text { Person- } \\ \text { nel } \end{gathered}$ |
| :---: | :---: | :---: |
| a. At full strength, |  |  |
| all vehicles available, one-time lift | 360 | 1,700 |
| b. At full strength, |  |  |
| 75 percent of vehicles |  |  |
| available, one-time lift | 276 | 1,300 |
| c. Local haul, 15 |  |  |
| miles forward, two- |  |  |
| to 80 percent of ve |  |  |
| hicles available, four |  |  |
| trips cargo and six |  |  |
| trips personnel ----- | 1,104 | 7,800 |
| d. Line haul, 75 miles |  |  |
| forward, two-shift op- |  |  |
| erations, 75 to 80 per- |  |  |
| cent of vehicles avail- | 552 |  |
| able, two trips daily --- | 552 | 2,600 |

At level 1, this unit has, based on 75percent vehicle availability, a capability of transporting:
sponsible.
c. To furnish vehicles required for displacing division headquarters and division administration company and to supplement transport means available to other elements of the division.

Transportation motor transport company, supply and transport battalion, armored division.

Transportation motor transport company supply and transport battalion infantry division.

Transportation motor transport company, supply and transport battalion, airborne division.
a. To provide transportation for unit distribution of all classes of supply except class V.
b. To transport the division reserve supplies for which the unit is responsible.
c. To furnish vehicles required for displacing division headquarters and the division administration company and to supplement means available to other elements of the division.

55-88 a. To provide transportation for unit distribution of all classes of supply except class V .
b. To transport the division reserve supplies for which the unit is responsible.
c. To furnish vehicles required for displacing division headquarters and the division administration company and to supplement means available to other elements .of the division.

55-97 To provide transportation for unit distribution of all classes of supply except class $V$.
$\begin{array}{lrr} & \begin{array}{c}\text { Capability } \\ \text { Single } \\ \text { lift }\end{array} & \text { Shuttle } \\ \text { Cargo, short tons -- } & 270 & 342 \\ \text { POL, gallons ----- } & 95,700 & 104,550\end{array}$

Organic to supply and transport battalion, armored division, TOE 29-115.

Organic to supply and transport battalion, armored division, TOE 29-5.

Organic to supply and transport battalion, airborne division, TOE 29-45.

At level 1, this unit, based on 75percent vehicle availability, has a capability of transporting:

|  | Single <br> lift | Shuttle |
| :--- | ---: | ---: |
| Cargo, short tons -- | 270 | 360 |
| POL, gallons ------ | 119,550 | 119,550 |

At level 1, this unit, based on 75percent vehicle availability, has a capacity of transporting:

|  | Single <br> lift | Shuttle |
| :--- | ---: | ---: |
| Cargo, short tons -- | 270 | 120 |
| POL, gallons $-\ldots-)^{-}$ | 74,250 | 74,250 |

a. At full strength, based on 75percent availability, transports in one lift:
(1) 108 short tons of general cargo.
(2) 3,600 gallons of POL.
b. At full strength, this unit is cap-

Team GA, car squad

## Team GB, bus squad

Team GC, heavy truck squad

55-540 To transport passengers, messengers, and a limited amount of cargo by sedans, $1 / 4$-ton utility truck, or $3 / 4$-ton cargo truck.

To a theater army or field support command. Normally attached to a headquarters and headquarters detachment, transportation motor transport battalion, TOE 5516 , or may operate separately under the supervision of the appropriate staff movements officer.

To a theater army or field army support command. Normally attached to a headquarters and headquarters detachment, transportation motor transport battalion TOE 55-16, or may operate separately under the supervision of the appropriate staff movements officer.

To a theater army or field army support command. Normally, attached to a motor transport company or may operate separately under supervision of the appropriate staff movements officer.

To a theater army or field army support command. Normally, attached to a motor transport company or may operate separately under supervision of the appropriate staff movements officer.
able of providing transportation for two 10 -hour shifts during a round-theclock operation.
(1) When equipped with sedans, transporting 40 passengers per lift, eight sedans available.
(2) When equipped with $1 / 4$-ton utility trucks, transporting 24 passengers and 2 -tons of cargo ( $1 / 4-$ ton per . trailer) per lift based upon eight available $1 / 4$-ton utility trucks.
(3) When equipped with $3 / 4$-ton cargo trucks, transporting six passengers or 12 tons of cargo ( $3 / 4$-ton per truck and trailer) per lift based upon eight available $3 / 4$-ton trucks.

Transporting 185 passengers (five available buses carrying 37 passengers each) or 90 litter patients (five available buses carrying 18 litter patients each) per lift in local haul.

Transporting 300 short tons per lift in local or line haul based upon 50 tons per each of six available truck tractor-semi-trailer combinations.
(1) When equipped with a $21 / 2-$ ton cargo truck, transporting 32 tons of cargo or 160 passengers per lift based upon eight available trucks and eight available $11 / 2$-ton cargo trailers.
(2) When equipped with 5 -ton cargo trucks, transporting 52 tons of

## Team GE, medium truck squad

55-540 To transport general cargo bulk petroleum products, or refrigerated cargo by medium truck tractor-semitrailer combinations.

Team GF, trailer transfer point operations team

55-540 To operate a trailer transfer point marshaling yard or truck terminal in conjunction with line haul operations.

Team GG, highway regulating point team

55-540 To operate a highway regulating point to coordinate the movement of authorized traffic and to effect changes in truck or convoy routings.

To a theater army or field army support command. Normally, attached to a motor transport company or may operate separately under supervision of the appropriate staff movements officer.

To a transportation motor transport group responsible for line of communications (LOC) motor transport operations.

To a theater army or field army support command. Normally attached to a headquarters and headquarters detachment, transportation movement control agency or company.
cargo or 176 passengers per lift based upon eight available trucks and eight available $11 / 2$-ton cargo trailers.
(1) When equipped with 12 -ton stake and platform semitrailers, the squad can transport 96 tons of cargo per lift based upon eight available semitrailer-tractor combinations, each carrying 12 tons.
(2) When equipped with 5,000 gallon petroleum semitrailers, the squad can transport 40,000 gallons of bulk petroleum products per lift based upon eight available semitrailertractor combinations, each carrying 5,000 gallons.
(3) When equipped with $71 / 2$-ton refrigerator semitrailers, the squad can transport 60 -tons of refrigerated cargo in one lift, based upon eight available semitrailer-tractor combinations, each carrying 7.5 tons of cargo.

Operates in conjunction with a line haul operation, a trailer transfer point with a maximum capacity of 250 12-ton trailer units in and out per day. The operation includes receiving, segregating, and assembling loaded or empty semitrailers for convoys; maintaining POL dispersing facilities to refuel hauling equipment; and servicing, inspecting, and if required, making emergency repairs to incoming vehicles.
Performs the following on a 24 -hour per day basis:
(1) Reports on convoy and other elements arriving at and clearing the point so that progress may be re-
ported and recorded; adjusts their rate of advance as required.
(2) Receives, correlates, and disseminates information of forecasted or passing traffic; makes reports on current highway conditions and changes as they occur.
(3) Transmits orders from higher headquarters to passing units or organizations and makes diversions and effects changes in priorities of traffic as directed by the appropriate traffic headquarters or comparable unit.
(4) Receives and passes to appropriate agency requests for road clearance; checks clearance of passing units.

## Section II. VEHICLE CHARACTERISTICS

## 3-2. Performance Data

| Nomenclature | ${ }_{\text {cross- }}{ }^{\text {Payload ( }}$ (b) |  | $\begin{gathered} \text { Maximum grade } \\ \text { (percent } \\ \text { w/towed } \begin{array}{c} \text { wo } \\ \text { load } \\ \text { load } \end{array} \end{gathered}$ |  | $\begin{aligned} & \text { Maximum } \\ & \text { allowable } \\ & \text { speed (mph) } \end{aligned}$ | $\begin{gathered} \text { Cruising } \\ \text { (minges } \\ \text { (miles } \end{gathered}$ | Towed load allowance (lb) cross- | highway | Fording depth (in.)w/ospequipW/spequip |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { cross- } \\ \text { country } \end{gathered}$ | highway |  |  |  |  |  |  |  |  |
| Truck, utility, $1 / 4$-ton, $4 \times 4$, M38A1 | 800 | 1,200 | 69 | -- | 55 | 280 | 1,500 | 2,000 | 36 | 70 |
| Truck, utility, $1 / 4$-ton, $4 \times 4$, M151 | 800 | 1,200 | 60 | -- | 66 | 300 | 1,500 | 2,000 | 21 | 60 |
| Truck, utility, $1 / 4$-ton, $4 \times 4, \mathrm{M} 151 \mathrm{~A} 1$ | 800 | 1,200 | 75 | -- | 65 | 300 | 1,500 | 2,000 | 21 | 60 |
| Truck, cargo, \%-ton, $4 \times 4$, M37 | 1,500 | 2,000 | 67 | 68 | 55 | 225 | 4,000 | 6,000 | 42 | 84 |
| Truck, cargo, 2112-ton, $6 \times 6$, M34 | 5,000 | 10,000 | 48 | 64 | 62 | 300 | 6,000 | 10,000 | 31 | 72 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M35 | 5,000 | 10,000 | 46 | 63 | 58 | 300 | 6,000 | 10,000 | 30 | 72 |


| Nomenclature | $\begin{aligned} & \text { Payload } \\ & \text { cross-- } \\ & \text { country } \end{aligned}$ | d (lb) | Maximum grade (percent) |  | $\begin{aligned} & \text { Maximum } \\ & \text { allowable } \\ & \text { speed (mph) } \end{aligned}$ | $\begin{gathered} \text { Cruising } \\ \text { range } \\ \text { (miles) } \end{gathered}$ | Towed load allowance (lb) cross- country | highway | Fording depth (in.) |  | 0 0 $\#$ 3 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Truck, cargo, 21/2-ton, $6 \times 6$, M35A1 | 5,000 | 10,000 | 45 | 60 | 56 | 320 | 6,000 | 10,000 | 30 | 72 | $\frac{1}{v}$ |
| Truck, cargo, $2 \frac{1}{2}$-ton, $6 \times 6$, M35A2 | 5,000 | 10,000 | 45 | 60 | 56 | 275 | 6,000 | 10,000 | 30 | 72 |  |
| Truck, cargo, drop side, $21 / 2$-ton, $6 \times 6$, M35A2C | 5,000 | 10,000 | 45 | 60 | 56 | 275 | 6,000 | 10,000 | 30 | 72 |  |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M36A1 | 5,000 | 10,000 | 45 | 60 | 56 | 320 | 6,000 | 10,000 | 30 | 72 |  |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M36A2 | 5,000 | 10,000 | 45 | 60 | 56 | 320 | 6,000 | 10,000 | 30 | 72 |  |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M36C | 5,000 | 10,000 | 45 | 63 | 58 | 300 | 6,000 | 10,000 | 30 | 72 |  |
| Truck, tank, fuel, servicing, 1,200-gal., $21 / 2-$ ton, M49A1C | 600-gal. | 1,200-gal. | 45 | 60 | 56 | 320 | 6,000 | 10,000 | 40 | 72 |  |
| Truck, gasoline, tank, $21 \dot{1} / 2-$ ton, M49 | 5,000 | 7,500 | 47 | 62 | 58 | 300 | 6,000 | 10,000 | 40 | 72 |  |
| Truck, tank, water, $21 / 2$ ton, $6 \times 6$, M50 | 5,000 | 8,300 | 47 | 63 | 58 | 300 | 6,000 | 10,000 | 30 | 78 |  |
| Truck, tank, water, 1000 gal., $21 / 2$-ton, $6 \times 6$, M50A1 | 400-gal. | 1,000-gal. | 45 | 60 | 56 | 320 | 6,000 | 10,000 | 40 | 72 |  |
| Truck, dump, $21 / 2$-ton, $6 \times 6, \text { M59 }$ | 5,000 | 10,000 | 47 | 62 | 62 | 300 | 3,750 | 9,000 | 40 | 72 |  |
| Truck, dump, 5-ton, $6 \times 6$, M51A2 | 10,000 | 20,000 | -- | 62 | 54 | 447 | 15,000 | 30,000 | 30 | 78 |  |
| Truck, tractor, 5 -ton, $6 \times 6$, M52 | 15,000 - | 25,000 | 28 | 68 | 53 | 300 | 37,500 | 55,000 | 30 | 78 |  |
| $\begin{aligned} & \text { Truck, cargo, } 5 \text {-ton, } 6 \times 6 \text {, } \\ & \text { M54 } \end{aligned}$ | 10,000 | 20,000 | 51 | 74 | 53 | 214 | 15,000 | 30,000 | 70 | 78 |  |
| Truck, cargo, 5 -ton, $6 \times 6$, M54A2 | 10,000 | 20,000 | 47 | 60 | 54 | 350 | 15,000 | 30,000 | 30 | 78 |  |
| Truck, cargo, 5 -ton, $6 \times 6$, drop side, M54A2C | 10,000 | 20,000 | 47 | 60 | 54 | 350 | 15,000 | 30,000 | 30 | 78 |  |


| Truck, cargo, 5-ton, $6 \times 6$, <br> M55A2 | 10,000 | 20,000 | 47 | 60 | 54 | 350 | 15,000 | 30,000 | 30 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Truck, medium wrecker, <br> 5-ton, M62 | 7,000 | 12,000 | 36 | 58 | 53 | 214 | 20,000 | 30,000 | 30 |
| Truck, van, expansible, 5- <br> ton, $6 \times 6$, M291A2C | 5,000 | 15,000 | -- | 60 | 58 | --- | 15,000 | 30,000 |  |

## 3-3. Axle Weights

| Nomenclature | Front axie | Rear axles w/winch | Curb weight Total | (1b) <br> Front axle wo/winch | Rear axles wo/winch | Total | Front axle w/winch | Gross wei <br> Rear axles <br> w/winch | , payload <br> Total | dersonnel Front axle wo/winch | (1b) <br> Rear axles wo/winch | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Truck, cargo, $2 \frac{112}{2}$-ton, $6 \times 6$, M34 | 5,900 | 6,286 | 12,186 | 5,405 | 6,370 | 11,775 | 6,325 | 11,211 | 17,536 | 5,830 | 11,295 | 17,125 |
| Truck, cargo, $21 \frac{1}{2}$-ton, $6 \times 6$, M35 | 5,810 | 7,070 | 12,880 | 5,315 | 7,150 | 12,465 | 6,256 | 11,974 | 18,230 | 5,761 | 12,054 | 17,815 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M35A1 | 6,580 | 7,320 | 13,900 | 5,980 | 7,420 | 13,400 | 7,472 | 16,828 | 24,300 | 6,976 | 16,824 | 23,800 |
| Truck, cargo, $2 \frac{1}{2}$-ton, $6 \times 6, \mathrm{M} 35 \mathrm{~A} 2$ | 6,580 | 7,320 | 13,900 | 5,980 | 7,420 | 13,400 | 7,472 | 16,828 | 24,300 | 6,976 | 16,824 | 23,800 |
| Truck, cargo, drop side, $21 / 2$-ton, M35A2C | 6,630 | 7,530 | 14,160 | 6,030 | 7,630 | 13,660 | 7,626 | 16,934 | 24,560 | 7,026 | 17,034 | 24,060 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M36A1 | 6,580 | 8,260 | 15,110 | 6,250 | 8,360 | 14,610 | 7,700 | 17,810 | 25,510 | 7,100 | 17,910 | 25,010 |
| Truck, cargo, $2 \frac{1}{2}$-ton, $6 \times 6$, M36A2 | 6,850 | 8,260 | 15,110 | 6,250 | 8,360 | 14,610 | 7,700 | 17,810 | 25,510 | 7,100 | 17,910 | 25,010 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M36C | 6,140 | 9,100 | 15,240 | 5,640 | 9,190 | 14,830 | 6,751 | 13,839 | 20,590 | 6,149 | 14,031 | 20,180 |
| ```Truck, tank, fuel servicing 1,200-gal., 21/2-ton, 6\times6, M49A1C``` | 6,495 | 8,630 | 15,125 | 5,895 | 8,730 | 14,625 | 7,205 | 17,320 | 24,525 | 6,605 | 17,420 | 24,025 |
| Truck, gasoline tank, $21 / 2$-ton, $6 \times 6$, M49 | 5,745 | 8,150 | 13,895 | 5,250 | 8,240 | 13,490 | 6,079 | 13,166 | 19,245 | 5,545 | 13,295 | 18,840 |
| ```Truck, tank, fuel servicing, 1,200-gal., 21/2-ton, 6\times6, M49A2C``` | 6,495 | 8,630 | 15,125 | 5,895 | 8,730 | 14,625 | 7,205 | 17,320 | 24,525 | 6,605 | 17,420 | 24,025 |


| Nomenclature | Front axle w/winch | Rear axles w/winch | Curb weight Total | (1b) <br> Front axle wo/winch | Rear axles wo/winch | Total | Front axle w/winch | Gross weigh Rear axles w/winch | t, payload Total | d personnel Front axle wo/winch | (1b) Rear axles wo/winch | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Truck, tank, water, $21 / 2$-ton, $6 \times 6$, M50 | ---- | - | ----- | 5,405 ${ }^{\text { }}$ | 9,779 | 15,184 | ---- | ----- | ----- | 5,715 | 14,819 | 20,534 |
| $\begin{aligned} & \text { Truck, tank, water, } \\ & 1,000 \text {-gal., } 21 / 2 \text {-ton, } \\ & 6 \times 6, \text { M } 50 \mathrm{~A} 1 \end{aligned}$ | 6,550 | 8,070 | 14,620 | 5,950 | 8,170 | 14,120 | 7,370 | 15,650 | 23,020 | 6,770 | 15,750 | 22,520 |
| Truck, tank, water, 1,000-gal., $21 / 2$-ton, $6 \times 6$, M50A2 | 6,550 | 8,070 | 14,620 | 5,950 | 8,170 | 14,120 | 7,370 | 15,650 | 23,020 | 6,770 | 15,750 | 22,520 |
| Truck, dump, $21 / 2$-ton, $6 \times 6, \text { M59 }$ | 5,950 | 8,510 | 14,460 | 5,420 | 8,630 | 14,050 | 6,220 | 13,590 | 19,810 | 5,680 | 13,710 | 19,400 |
| Truck, light, wrecker, $21 / 2$-ton, $6 \times 6$, M60 | ---- | - | ----- | 6,880 | 17,080 | 23,960 | ---- | ----- | ----- | 7,246 | 20,567 | 27,810 |
| Truck, van, shop, 21/2-ton, M109 | ---- | ---- | ----- | 5,485 | 9,746 | 15,231 | ---- | ----- | ----- | 5,855 | 14,726 | 20,581 |
| Truck, van, shop, $21 / 2-$ ton, $6 \times 6$, M109A2 | 6,550 | 8,980 | 15,530 | 5,950 | 9,080 | 15,030 | 7,110 | 16,320 | 23,430 | 6,510 | 16,420 | 22,930 |
| Truck, van, shop, $21 / 2$ ton, $6 \times 6, \mathrm{M} 109 \mathrm{~A} 3$ | 6,550 | 8,980 | 15,530 | 5,950 | 9,080 | 15,030 | 7,110 | 16,320 | 23,430 | 6,510 | 16,420 | 22,930 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M135 | 5,580 | 6,920 | 12,500 | 5,150 | 6,850 | 12,000 | 6,010 | 11,840 | 17,850 | 5,580 | 11,770 | 17,350 |
| Truck, repair shop van, $211 / 2$-ton, $6 \times 6$, M185A3 | ---- | -- | ---- | 5,980 | 10,820 | 16,800 | -- | -- | ----- | 6,290 | 15,910 | 22,900 |
| Truck, cargo, $2^{11 / 2}$-ton, $6 \times 6$, M211 | 5,740 | 7,840 | 13,580 | 5,300 | 7,870 | 13,170 | 6,070 | 12,870 | 18,930 | 5,630 | 12,890 | 18,520 |
| Truck, dump, 21/2-ton, $6 \times 5$ | 5,790 | 9,080 | 14,870 | 5,320 | 9,140 | 14,460 | 6,030 | 12,940 | 18,970 | 5,566 | 13,000 | 18,560 |
| Truck, gasoline tank, 21/2-ton, M217 | -- | ---- | ----- | 5,330 | 9,010 | 14,340 | -- | ----- | ----- | 5,970 | 13,720 | 19,690 |
| Truck, gasoline tank, 211/2-ton, M217C | ---- | ---- | -- | 5,330 | 9,010 | 14,340 | ---- | ----- | ----- | 5,970 | 13,720 | 19,690 |
| Truck, van shop, $2 \frac{1}{2}$ ton, M220 | ---- | ---- | --- | 5,305 | 9,780 | 15,085 | --- | ----- | ----- | 5,695 | 14,740 | 20,435 |
| Truck, water tank, $211 / 2$-ton, $6 \times 6$, M222 | ---- | ---- | ----- | 5,595 | 10,898 | 15,693 | ---- | ---- | ----- | 6,121 | 13,422 | 19,543 |


| Truck, van, expansible, $21 / 2$-ton, M292 | ---- | ---- | ----- | 7,495 | 13,114 | 20,609 | ---- | ----- | ----- | 8,085 | 17,874 | 25,959 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & \text { Truck, van, expan- } \\ & \text { sible, } 2 \frac{12}{2} \text {-ton, } 6 \times 6, \\ & \text { M292A2 } \end{aligned}$ | ---- | ---- | ----- | 8,045 | 13,164 | 21,209 | ---- | ----- | ----- | 8,635 | 17,974 | 26,609 |
| Truck, van, expansible, $21 / 2$-ton, $6 \times 6$, M292A5 | ---- | ---- | ----- | 7,520 | 15,409 | 22,929 | ---- | ----- | ----- | 8,110 | 20,219 | 28,329 |
| Truck, cargo, 2-1/2ton, $6 \times 6$, M602 | 5,915 | 7,050 | 12,965 | 5,315 | 7,150 | 12,465 | 6,909 | 16,456 | 23,365 | 6,309 | 16,556 | 22,865 |
| Truck, van, shop, $21 / 2$-ton, $6 \times 6$, M609A1 | 6,085 | 9,646 | 15,731 | 5,455 | 9,746 | 15,201 | 6,645 | 16,886 | 23,531 | 6,015 | 16,986 | 23,101 |
| Truck, tank water, 1,000 -gal., $21 / 2$-ton, $6 \times 6$, M610 | ---- | ---- | ----- | 5,400 | 8,120 | 13,520 | ---- | ----- | ----- | 6,220 | 15,700 | 21,920 |
| Truck, tank gasoline, 1,200-gal., $21 / 2$-ton, $6 \times 6$, M611 | ---- | ---- | ----- | 5,345 | 8,680 | 14,025 | ---- | ----- | ----- | 6,055 | 17,370 | 23,425 |
| $\begin{aligned} & \text { Truck, tank, fuel } \\ & \text { servicing, } 1,200-\mathrm{gal} \text {, } \\ & 21 / 2 \text {-ton, } 6 \times 6, \mathrm{M} 611 \mathrm{C} \end{aligned}$ | ---- | ---- | --- | 5,345 | 8,680 | 14,025 | ---- | ----- | ----- | 6,055 | 17,370 | 23,425 |
| Truck, van, shop, $2 \frac{1}{2}$ ton, $6 \times 6$, M613 | 6,030 | 10,670 | 16,700 | 5,430 | 10,770 | 16,200 | 6,340 | 15,760 | 22,100 | 5,740 | 15,860 | 26,600 |
| Truck, dump, 2½-ton, $6 \times 6$, M614 | 6,305 | 9,360 | 15,665 | 5,705 | 9,460 | 15,165 | 7,211 | 18,854 | 25,565 | 6,611 | 18,954 | 25,565 |
| Truck, cargo, $2 \frac{1}{2} / 2$-ton, $6 \times 6$, M621 | 6,692 | 6,752 | 13,444 | 6,092 | 6,852 | 12,944 | 7,688 | 16,156 | 23,844 | 7,088 | 16,256 | 23,344 |
| Truck, tank, fuel, servicing, 1,200-gal., $2 \not 1 / 2$-ton, $6 \times 6$, M622 | ---- | ---- | ----- | 6,007 | 8,162 | 14,169 | ---- | ----- | ----- | 6,717 | 16,852 | 23,596 |
| Truck, van, shop, $21 / 2$-ton, $6 \times 6$, M623 | ---- | ---- | ----- | 6,062 | 8,512 | 14,574 | ---- | ----- | ----- | 6,622 | 15,852 | 22,474 |
| Truck, dump, 211/2-ton, $6 \times 6$, M624 | ---- | ---- | ----- | 6,239 | 9,476 | 15,715 | ---- | ----- | ----- | 7,145 | 18,970 | ----- |
| Truck, cargo, 5-ton, $6 \times 6$, M41 | 9,185 | 10,650 | 19,835 | 8,330 | 10,790 | 19,120 | 9,665 | 20,520 | 30,185 | 2,810 | 20,660 | 29,470 |



| Semitrailer, van, 6ton, 2W, M119 | ---- | ---- | ----- | ---- | 4,925 | 7,180 | ---- | ----- | ----- | ---- | 14,160 | 23,380 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Semitrailer, van, shop, 6 -ton, 2 W , M146 | ---- | ---- | ----- | ---- | 4,880 | 6,950 | ---- | ----- | ----- | ---- | 11,880 | 18,950 |
| Semitrailer, van, shop, folding sides 6-ton, 4W, M447 | ---- | ---- | ----- | ---- | 10,900 | 15,175 | ---- | ----- | ----- | ---- | 16,415 | 23,120 |
| Semitrailer, van, shop, closed sides, rear doors, 6 -ton, 2W, M508 | ---- | ---- |  | ---- | 4,925 | 7,180 | ---- | ----- | ----- | ---- | 14,160 | 23,380 |
| Semitrailer, van, shop, double side doors, 6 -ton, $2 W$, M508C | ---- | ---- | ----- | ---- | 4,925 | 7,180 | ---- | ----- | ----- | ---- | 14,160 | 23,380 |
| Semitrailer, tank, fuel 4W, 5,000-gal., M131A4 | -- | ---- | ----- | ---- | 9,470 | 12,900 | ---- | ----- | ----- | ---- | 29,520 | 48,150 |
| Semitrailer, refrigerator, $71 / 2$-ton, 2 W , M349A1 | ---- | ---- | ----- | ---- | 4,940 | 8,600 | ---- | ----- | ----- | ---- | 13,960 | 23,600 |
| Semitrailer, cargo, 12-ton, 4W, M127 | ---- | ---- | ----- | ---- | 9,950 | 14,240 | ---- | ----- | ----- | ---- | 30,200 | 50,240 |
| Semitraileŕ, vañ, cargo, 12 -ton, 4 W , M128A1C | ---- | ---- | ----- | ---- | 10,800 | 15,600 | ---- | ----- | ----- | ---- | 31,300 | 51,600 |
| Semitrailer, van, supply, 12 -ton, 4 W M129A1C | ---- | ---- | ----- | ---- | 10,800 | 15,600 | ---- | ----- | ----- | ---- | 31,300 | 51,600 |
| Semitrailer, low bed, wrecker, 12 -ton, $25-\mathrm{ft}$ load deck, M269A1 | --- | ---- |  | --- | 10,520 | 14,200 | --- | ---- |  | ---- | 36,000 | 54,200 |
| Semitrailer, refrigerator, 15 -ton, 4 W , M347 | -- | - | -- | ---- | 10,650 | 16,350 | ---- | ----- | ----- | ---- | 30,000 | 46,000 |
| Semitrailer, low bed, 25-ton, 4W, M172 | ---- | ---- | ----- | ---- | 10,850 | 15,500 | ---- | ---- | ----- | ---- | 40,850 | 65,500 |


| Nomenclature | Front exle w/winch | Rear axles w/winch | Curb weight Total | (1b) <br> Front exle <br> wo/winch | Rear axles wo/winch | Total | Front axle w/winch | Gross weight, Rear axles w/winch | payload <br> Total | d personnel Front axle wo/winch | (1b) <br> Rear axles wo/winch | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Semitrailer, tank transporter, 50-ton, 8W, M15A2 | ---- | ---- | ----- | ---- | 28,520 | 41,790 | ---- | ----- | ----- | ---- | 81,890 | 141,790 |
| Semitrailer, gasoline tank, 5,000-gal., 4W, M131 | ---- | ---- | ----- | ---- | 11,530 | 14,850 | ---- | -- | ----- | ---- | 27,910 | 45,390 |
| Semitrailer, gasoline tank, 5,000-gal., 4W, M131A2 | ---- | ---- | - | ---- | 8,900 | 12,400 | ---- | ----- | ----- | ---- | 26,200 | 42,900 |
| Semitrailer, tank, fuel servicing, 5,000-gal., 4W, M131A4 | - | ---- | ----- | - | 9,470 | 12,900 | ---- | ----- | ----- | ---- | 29,520 | 48,150 |
| Semitrailer, tank, fuel servicing, 5,000 -gal., 4W, M131A4C | ---- | ---- | ---- | ---- | 10,150 | 13,850 | -- | ----- | ----- | ---- | 30,200 | 49,100 |
| Semitrailer, tank, fuel servicing, 5,000-gal., 4W, M131A5D | ---- | ---- | ----- | ---- | 10,450 | 14,200 | ---- | ----- | --- | --- | 30,500 | 48,200 |

## 3-4. Center of Gravity Location

|  | with winch Curb weight without winc |  |  |  | With payload evenly distributed with winch without winch |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | above ground (in.) | rear of centerline of front axle (in.) | above ground (in.) | rear of centerline of front axle (in.) | above ground (in.) | rear of centerline of front axle (in.) | above ground (in.) | rear of centerline of front axle (in.) |
| Truck, cargo, 3/4-ton, $4 \times 4$, M37 | 28 | 51 | 28 | 53 | 34 | 63 | 34 | 65 |
| Truck, ambulance, 3/4ton, $4 \times 4, \mathrm{M} 43 \mathrm{E} 2$ | -- | -- | 32 | 60 | -- | -- | 35 | 68 |
| $\begin{aligned} & \text { Truck, cargo, } 11 / 4 \text {-ton, } \\ & 4 \times 4, \text { M715 } \end{aligned}$ | 31 | 56.6 | 31 | 60.7 | 32 | 804 | 32 | 84.4 |
| Truck, ambulance, 11/4-ton, $4 \times 4$, M725 | -- | -- | 39 | 71 | -- | -- | 42 | 84 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M35A2 | 38 | 81 | 38 | 85.5 | 46 | 110 | 46.5 | 113 |
| Truck, cargo, drop side, 21 ²-ton, $6 \times 6$, M35A2C | 38 | 81 | 38 | 85.5 | 46 | 110 | 46.5 | 113 |
| Truck, cargo, 21/2-ton, $6 \times 6$, M36A1 | 39.5 | 84 | 40 | 88 | 46.5 | 104 | 47 | 111 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M36C | 34.7 | 95 | 34.3 | 98.5 | 43 | 110 | 42.6 | 113.5 |
| Truck, tank, fuel, servicing, 1,200-gal., 21/2-ton, M49A1C | -- | -- | 41 | 92 | -- | -- | 50 | 113 |
| Truck, gasoline tank, $21 / 2$-ton, $6 \times 6$, M49 | 41.1 | 90.2 | 41 | 94 | 49.8 | 105.8 | 50 | 109 |
| Truck, water, tank, $21 / 2$-ton, $6 \times 6$, M50A2 | 41 | 85 | 41 | 89 | 50 | 105 | 50 | 109 |
| Truck, light, wrecker, $21 / 2$-ton, $6 \times 6$, M60 | 42 | 110 | -- | -- | 49 | 114 | -- | -- |
| Truck, van, shop, $21 / 2$ ton, $6 \times 6, \mathrm{M} 109 \mathrm{~A} 3$ | 46 | 89 | 46.5 | 93 | 59 | 108 | 59.5 | 111 |
| Truck, cargo, 21/2-ton, $6 \times 6$, M135 | 38 | 85 | 38 | 88 | 48 | 102 | 48 | 105 |
| Truck, repair shop van, $21 / 2$-ton, $6 \times 6$, M185A3 | -- | -- | 48 | 99 | -- | -- | 56.6 | 115.5 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6$, M211 | 37 | 89 | 37 | 89 | 49 | 106 | 49 | 106 |
| Truck, dump, 2112 -ton, $6 \times 6$, M215 | 36 | 89 | 36 | 92 | 45 | 108 | 45 | 110 |
| Truck, water tank, $211 / 2$-ton, $6 \times 6$, M222 | -- | -- | 37 | 94 | -- | -- | 48 | 113 |
| Truck, tractor, 21/2ton, $6 \times 6$, M275A2 | 38 | 66 | 38 | 70 | -- | -- | -- | - -- |
| Truck, van, expansible, $21 / 2$-ton, $6 \times 6$, M292A5 | -- | -- | 58 | 125 | -- | -- | 65 | 143 |
| Truck, dump, 21/2-ton, $6 \times 6$, M342A2 | 42 | 89 | 42 | 93 | 50 | 110 | 50 | 113 |
| Truck, cargo, 21/2-ton, $6 \times 6$, M602 | 38 | 84 | 37.5 | 88 | 48 | 109.5 | 48 | -112.5 |


|  | Curb weight |  |  |  | $\qquad$ <br> With payload evenly distributed with winch without winch |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | a bove ground (in.) | rear of centerline of front axle (in.) | above ground (in.) | rear of centerline of front axle (in.) | above ground (in.) | rear of centerline of front axle (in.) | above ground (in.) | rear of centerline axle (in.) axle (in. |
| Truck, tractor, 21/2ton, $6 \times 6$, M607 | -- | -_ | 38 | 70 | -- | -- | 105 | 105 |
| Truck, van, shop, $21 / 2-$ ton, $6 \times 6$, M609A1 | 45.5 | 94.5 | 46 | 98.5 | 52 | 113 | 52 | 114 |
| Truck, tank water, 1,000-gal., $21 / 2$-ton, $6 \times 6$ | -- | -- | 41 | 89 | -- | -- | 50 | 109 |
| ```Truck, tank, fuel servicing 1,200-gal., 21/2-ton, 6\times6, M611C``` | -- | -- | 41 | 92 | -- | -- | 50 | 113 |
| Truck, van, shop, 2112ton, $6 \times 6$, M613 | 47 | 95 | 48 | 99 | 56.5 | 114.5 | 56.5 | 115.5 |
| Truck, dump, $21 / 2$-ton, $6 \times 6$, M614 | 42 | 92 | 42 | 96 | 49 | 112 | 49 | 115 |

## 3-5. Stowage Capacity of Cargo Truck Bodies

| Vehicle | Cargo hody stowage capacitie |  | (cu ft)* |
| :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & \text { Under } \\ & \text { bows } \end{aligned}$ | Top of side racks | Top of steering wheel |
| 3/4-ton capacity |  |  |  |
| M37 | 134.9 abc | $84.3{ }^{\text {a }}$ | $66.7{ }^{\text {ac }}$ |
| M37B1 | 146.1ab | $95.7{ }^{\text {a }}$ | 78.0a |
| 11/4-ton capacity |  |  |  |
| M561 | $235.0{ }^{\text {de }}$ | $152.4{ }^{\text {d }}$ | $130.1{ }^{\text {df }}$ |
| M715 | 186.69h | 131.49 | 82.2 g |
| 21/2-ton capacity |  |  |  |
| M34 | 389.0ijk |  | $245.9{ }^{\text {i }}$ |
| M35 | $442.6 i$ | 273.2 | 215.6 |
| M35A1 | $442.6{ }^{j}$ | 273.2 | 215.6 |
| M35A2 | $442.6{ }^{j}$ | 273.2 | 215.6 |
| M35A2C | $442.6 j$ | 273.2 | 215.6 |
| M36 | 761.5l | 385.0 | 318.7 |
| M36A2 | $761.5 l$ | 385.0 | 318.7 |
| M135 | $391.0{ }^{\text {m }}$ | 337.7 m | $229.5{ }^{\text {m }}$ |
| M211 | $442.6 j$ | 273.2 | 194.6 |
| 5-ton capacity |  |  |  |
| M41 | $446.2{ }^{\text {nopk }}$ |  | 275.0 ${ }^{\text {no }}$ |
| M54 | $494.8{ }^{\text {r }}$ | 289.79 | 225.59 |
| M54A2 | 494.8 rar | 289.79 | 225.59 |
| M55 | $751.5^{8}$ | 453.5 | 350.1 |
| M55A2 | 751.58 | 453.5 | 350.1 |
| M656 | $539.9{ }^{\text {r }}$ | 227.9 | $t$ |
| 10-ton capacity |  |  |  |
| M125 | $590.6{ }^{u v}$ | 398.14 | 216.0 ${ }^{u}$ |
| M125A1 | 590.6 vv | $398.1{ }^{\text {u }}$ | 216.0u |
| *See footnotes at | paragraph 3 |  |  |

## 3-6. Stowage Capacity of Dump Truck Bodies

|  | Cargo body loading capacities (cu ft)* |  |  |
| :---: | :---: | :---: | :---: |
| Vehicle | Top of body sides | Top of side racks | Top of cah shield |
| 21/2-ton capacity |  |  |  |
| M47 | $k$ | 118.1 | 212.2 |
| M59 | $k$ | 115.9 | 214.4 |
| M215 | $k$ | 115.9 | 245.0 |
| M34A2 | $k$ | 138.6 | 266.5 |
| 5-ton capacity |  |  |  |
| M51 | $k$ | 157.6 | 297.6 |
| M51A2 | $k$ | 157.6 | 297.6 |

## 3-7. Stowage Capacity of Cargo Trailer Bodies

|  | Cargo body loading capacities (cu ft) |  |  |
| :---: | :---: | :---: | :---: |
| Vehicle | ${ }_{\text {Under }}^{\text {Unew }}$ | Top of side racks | ToD of side panel |
| $1 / 4$-ton capacity |  |  |  |
| M100 | None | None | $29.7{ }^{10}$ |
| M416 | None | None | 31.8w |
| 3/4-ton capacity |  |  |  |
| M101 | $170.5^{x}$ | 114.7x | $60.9 x$ |
| M101A1 | $170.5^{x}$ | 114.7 x | $60.9 x$ |
| 11/2-ton capacity |  |  |  |
| M104 | $273.2 y z$ | 207.8u | 79.1y |
| M104A1 | $273.2 y z$ | $207.8 y$ | 79.18 |
| M105 | $276.6{ }^{\text {y }}$ | $206.0 y$ | $79.0{ }^{\text {y }}$ |
| M105A1 | $276.6{ }^{\text {y }}$ | $206.0 y$ | $79.0{ }^{\text {y }}$ |
| M105A2 | $276.6{ }^{\text {y }}$ | $206.0 y$ | $79.0{ }^{\text {y }}$ |

a Cubic capacity reduced 6.6 cuhic feet for wheel wells.
$b$ Cuhic capacity reduced 3.3 cuhic feet for curve of how.
$c$ Cuhic capacity reduced 11.3 cuhic feet for spare tire and carrier
in cargo body.
d Cubic capacity reduced 16.8 cuhic feet for wheel wells.
0 Cuhic capacity reduced 4.6 cuhic feet for curve of how.
$f$ Top of hood is higher than steering wheel.
$g$ Cuhic capacity reduced 2.3 cuhic feet for wheel wells.
$h$ Cubic capacity reduced 3.9 cubic feet for curve of bow
$i$ Cubic capacity reduced 12.7 cubic feet for wheel wells.
j Cubic capacity reduced 6.6 cubic feet for curve of bow.
$k$ Use cube indicated under column headed 'top of steering wheel."
$l$ Cubic capacity reduced 8.5 cubic feet for curve of bow. $m$ Cubic capacity reduced 10.7 cubic feet for wheel wells. $n$ Cubic capacity reduced 24.0 cubic feet for wheel wells.

## 3-8. Stowage Capacity of Cargo Semitrailer Van Bodies

| vehicle | $\begin{gathered} \text { Cargo body } \\ \text { Ioading } \\ \text { capacitieb (cu ft) } \\ \text { Van body } \end{gathered}$ |
| :---: | :---: |
| 6 -ton capacity |  |
| M119 | 1018.1 |
| M119A1 | 1018.1 |
| 12-ton capacity |  |
| M128A1C | 1356.4 |
| M128A2C | 1356.4 |
| M129 | 1356.4 |
| M129A1 | 1356.4 |
| M129A1C | 1356.4 |
| M129A2C | 1356.4 |

## 3-9. Stowage Capacity of Semitrailer Stake Cargo Bodies

## 3-10. Dimensional Data for Cargo Truck Bodies

| Cargo deck (in.) <br> Width | Height <br> above ground | Cargo body <br> Under bows | loading weights <br> Top of silde <br> racks | (in.) <br> Top of steer- <br> ing wheel |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |
| 64.0 | 35.2 | 54.0 | 35.4 | 29.3 |
| 64.0 | 35.2 | 54.0 | 35.4 | 29.3 |
|  |  |  |  |  |
| 81.0 | 31.8 | 62.4 | 41.1 | 37.7 a |
| 64.0 | 33.8 | 55.5 | 38.5 | 25.5 |
|  |  |  |  |  |
| 80.0 | 44.0 | 60.0 | 36.5 | 38.0 |
| 88.0 | 51.7 | 60.0 | 36.5 | 38.0 |
| 88.0 | 52.2 | 60.0 | 36.5 | 28.8 |
| 88.0 | 52.5 | 60.0 | 36.5 | 28.8 |
| 88.0 | 52.5 | 60.0 | 36.5 | 28.8 |
| 88.0 | 50.7 | 72.0 | 36.0 | 29.8 |
| 88.0 | 50.7 | 72.0 | 36.0 | 29.8 |
| 80.0 | 44.5 | 60.0 | 36.5 | 35.3 |
| 88.0 | 51.0 | 60.0 | 36.5 | 26.0 |
|  |  |  |  |  |
| 88.0 | 49.2 | 60.0 | 36.5 | 38.8 |
| 88.0 | 56.5 | 61.3 | 36.5 | 29.0 |
| 88.0 | 56.5 | 61.3 | 36.5 | 29.0 |
| 88.0 | 56.5 | 61.3 | 36.5 | 29.0 |
| 88.0 | 56.5 | 61.3 | 36.5 | 29.0 |
| 88.0 | 55.8 | 61.3 | 36.5 | 29.0 |
| 88.0 | 61.3 | 61.3 | 36.5 | 29.0 |
| 88.0 | 54.0 | 60.0 | 25.0 | $b$ |
|  |  |  |  |  |
| 96.0 | 68.0 | 62.0 | 42.0 | 23.8 |

[^3][^4]
## 3-11. Dimensional Data for Dump Truck Bodies



## 3-12. Dimensional Data for Cargo Trailer Bodies

|  | Cargo deck (in.) |  |  | Cargo body | loading height (in.) Top of sideracks | Top ofside panels |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Vehicle | Length | Width | Height |  |  |  |
| 1/4-ton capacity |  |  |  |  |  |  |
| M100 | 71.5 | 37.8 | 24.5 | None | None | 18.0 |
| M146 | 72.0 | 41.3 | 26.0 | None | None | 18.0 |
| 3/4-ton capacity |  |  |  |  |  |  |
| M101 | 94.8 | 65.3 | 31.7 | 49.0 | 33.3 | 18.3 |
| M101A1 | 94.8 | 65.3 | 31.7 | 49.0 | 33.3 | 18.3 |
| 11/2-ton capacity |  |  |  |  |  |  |
| M104 | 110.0 | 74.0 | 38.3 | 59.3 | 45.3 | 18.0 |
| M104A1 | 110.0 | 74.0 | 38.3 | 59.3 | 45.3 | 18.0 |
| M105 | 109.8 | 74.0 | 37.0 | 60.0 | 45.0 | 18.0 |
| M105A1 | 109.8 | 74.0 | 37.0 | 60.0 | 45.0 | 18.0 |
| M105A2 | 109.8 | 74.0 | 37.0 | 60.0 | 45.0 | 18.0 |

## 3-13. Dimensional Data for Semitrailer Stake Cargo Bodies

| Vehicle | Cargo deck (in.) Length | Width | Cargo body loading height (in.) Top of side racks |
| :---: | :---: | :---: | :---: |
| 6-ton capacity |  |  |  |
| M118 | 268.8 | 88.8 | 48.0 |
| M118A1 | 268.8 | 88.8 | 47.5 |
| 12-ton capacity |  |  |  |
| M127 | 335.8 | 88.8 | 47.8 |
| M127A1 | 335.8 | 88.8 | 47.8 |
| M127A1C | 335.8 | 88.8 | 48.0 |
| M127A2C | 335.8 | 88.8 | 48.0 |

## 3-14. Dimensional Data for Cargo Semitrailer Van Bodies

$\left.\begin{array}{lccc}\begin{array}{c}\text { Vehicle }\end{array} & \begin{array}{c}\text { Cargo deck (in.) } \\ \text { Length }\end{array} & \text { Width } & \text { Cargo body loading height (in.) } \\ \text { Under top }\end{array}\right)$

## Section III. OPERATIONS

3-15. Outline of Standing Operating Procedures for Motor Transport Movements Within Divisions, Logistical Commands, and Higher Echelons
a. General. Policies and factors involved in movements are-
(1) Highway regulation. Purpose, application or scope, responsibilities, methods and procedures for accomplishment.
(2) Convoy clearance. Minimum vehicle requirements, convoy symbols, procedures, format for requesting and furnishing clearance, routing, halts, convoy composition, restrictions on tracked, overweight, or outsized vehicles.
(3) Highway regulation 'points.' Purpose, basis of establishment, responsibilities and procedures for operations, required records.
(4) Traffic control. Responsibilities, relationship to highway regulation, coordination measures effected with provost marshal.
(5) Return loads. Policies, methods, and procedures for securing and reporting.
(6) Convoy commanders. Appointment, responsibilities, and functions; relationships with transportation personnel; instructions to be furnished.
(7) Halts. Types, policies; procedures, and responsibilities for establishment and conduct of halts; area policing.
(8) 'Security. Responsibilities and methods of conducting defensive measures.
(9) Records and reports. Responsibilities and methods for maintenance of required records, reference to reports to be submitted.
(10) Communications. Responsibilities and means of communication.
b. Supply Movements.
(1) Releases. When required, methods of obtaining, formats, dissemination, actions required.
(2) Diversions and reconsignments. Authority to effect diversions with consideration for various command areas, procedures for initiating requests, and execution.
(3) Records and reports. Types of records required to be maintained on: supply movements, reference to reports to be submitted.

3-16. Outline of Standing Operating Procedure for Motor Transport Service
a. General. Policies involved in control, operation, and maintenance of facilities, équipment, and installation; command responsibility; technical supervision required and agencies involved.
b. Mission. Service provided, extent of operation.
c. Functions.
(1) Scheduled and nonscheduled operations.
(2) Maintenance of equipment-responsibilities, procedures, facilities, and inspection practices.
d. Operational Planning. Computation of troop and equipment requirements, capability estimate, communication procedure and requirements, rehabilitation requirements.
e. Operations. Operational procedures and controls, pooling and utilization of equipment.
f. Maintenance. Responsibilities and procedures for maintenance, regulations, and reports.
g. Supply Procedure. Responsibilities for supplies, authorized levels, requisitioning procedures, accounting methods, disposal of excesses.
h. Intelligence and Reconnäissance. Responsibility for collection, collation, evaluation, and dissemination of highway transportation intelligence and reconnaissance information.
i. Security. Responsibilities, plans-disaster and defense, convoy and cargo security, equipment and facilities.
j. Records and Reports. Responsibility, operational and personnel status reports, technical reports, miscellaneous.
k. Training. Responsibility-unit and 'technical training.

## 3-17. Vehicle Commitment Format

Routine commitment of vehicles requires the type of information outlined below. Those items not required for a particular unit should be eliminated. For nonroutine commitment and

## C 3, FM 55-15

commitment of an entire unit for a substantial period of time, consideration should be given to the use of the five-paragraph operation order (FM 101-5).
a. Heading. The headquarters receiving the commitment, its location, and the date and hour of receipt.
b. Task (or Request).
(1) Request number
(2) Received from
(3) To transport $\underset{\text { (tons) (type of cargo) (No. pers). }}{\text { (name and rank) (org) (phone) }}$

Cube Peculiarities $\qquad$
From To
(shape, etc.)
(4) Recommended number and type of vehicles
(5) Terminal capabilities.

Origin
Est load time $\qquad$
Destination
Est unload time
(6) Vehicle report to:
$\qquad$ .

Location (name, rank, title)

Time and date: Spot Move $\qquad$
(7) On arrival at destination, report to:
$\longrightarrow$, location
(name, rank, title)
c. Coordinating Instructions.
(1) Type of commitment:

One-time: $\qquad$
Recurring: $\qquad$
If recurring, from
Through
(2) Road information: $\qquad$ special routing
weather effects, limitations, etc.
(3) Shipment (has) (has not) been coordinated with consignor and consignee, regarding (reference to paragraph numbers above or enter special information).
(4) It (is) (is not) an emergency movement. If emergency authorized by
(name, rank, title, org)

Phone $\qquad$ _-.
(5) Trailer pickup, movement, and delivery schedule.
(Spot) Pickup trailers at origin at
Move trailer from
to $\quad$ (date-time)
By date-time
Move trailer from
to
By date-time
Deliver trailers to destination for (un-
loading) (return loading) (return)
at
d. Administrative and Logistical Matters.
(1) Class III: (available origin) (available destination) (unit provide own).
(2) Meals and billets: (available origin) (available destination) (not available).
(3) Remarks: $\qquad$
e. Command and Signal.
(1) Reports required:
(2) Highway clearance requested received
clearance number $\qquad$ (date-time)
(3) Special instructions: $\qquad$

## 3-18. Convoy Briefing

Before a convoy departs on a mission the convoy commander briefs all members of the convoy. The following outlines the areas which should be covered. Adjustments may be made to suit local situations.
a. Situation.
(1) Friendly forces.
(2) Support units.
(3) Enemy situation.
b. Mission.
(1) Type of cargo.
(2) Origin.
(3) Destination.
c. Execution.
(1) General organization of the convoy.
(2) Time schedule.
(3) Routes.
(4) Convoy speed.
(5) Catchup speed.
(6) Vehicle distance.
(7) Emergency measures.
(a) Accidents.
(b) Breakdowns.
(c) Separation from convoy.
(d) Ambush.

1. Action of convoy personnel in the event of ambush.
2. Action of security personnel during ambush.
(e) Medical support.
d. Administration and Logistics.
(1) Control of personnel.
(2) Billeting arrangements.
(3) Messing arrangements.
(4) Refueling of vehicles.
(5) Servicing of vehicles.
e. Command and Signal.
(1) Location of convoy commander.
(2) Designation of assistant convoy commander.
(3) Action of the security forces commander.
(4) Serial commanders' responsibility.
(5) Arm and hand signals.
(6) Other prearranged signals.
(7) Radio frequencies and call signs for
(a) Control personnel.
(b) Security force commander.
(c) Fire support elements.
(d) Reserver security elements.
(e) Medical evacuation support.

## f. Safety.

(1) Hazards of route and weather conditions.
(e) Defensive driving.

## 3-19. Convoy Commander's Checklist

If each item listed below is checked and acted upon carefully by the convoy commander before departure time, the chances of neglecting some important arrangement will be minimized.
a. Where is start point? $\qquad$ Release point?
b. What route is to be used?
c. Has reconnaissance been made and condition of route determined?
d. Can bridges and defiles safely accommodate all loaded and/or tracked vehicles? $\qquad$
$e$. Are critical points known and listed on strip maps?
$f$. Has the size of serials been determined?
g. Has the size of march units been determined?
$h$. What will be the rate of march? $\qquad$
$i$. What is the vehicle interval on an open road? $\qquad$ In built-up areas? $\qquad$ At halt?
j. Type of column?
$k$. Has provision been made for refueling if required?
$l$. Has a suitable bivouac site been selected if required?
$m$. Have suitable rest and mess halt areas been selected if required?
$n$. Is road-movement table needed?
Prepared?
Submitted? $\qquad$
o. Have convoy clearances been obtained? What date?
$p$. Is escort required and has it been requested?
$q$. Are spare trucks available for emergencies?
$r$. Are vehicles fully serviced, clean, and ready for loading?
$s$. Is load proper, neat, and balanced?
$t$. Are drivers properly briefed?
By whom, when?
Strip maps furnished?
$u$. Is convoy marked front and rear of each march unit?
v. Are guides in place? ___ Have arrangements been made to post guides?
w. Are blackout lights functioning? $\qquad$
$x$. Are maintenance services alerted? $\qquad$
$y$. Is maintenance truck in rear?
Are medics in rear? casualties?

Plan for
z: Are all interested parties advised of ETA?
aa. Is officer at rear of convoy ready to take necessary corrective action, such as investigating accidents and unusual incidents and changing loads? $\qquad$ Who is trail officer?
$a b$. Is there an entracking plan? $\qquad$
Who is responsible?
ac. Is there a detracking plan?
Who is responsible?
ad. Has a plan been made for feeding personnel?
ae. Have times been established for entrucking or loading?
$a f$. Has time been established for formation of convoy? $\qquad$
ag. Have times been established for detrucking or unloading?
ah. Has time been established for releasing trucks? Who is responsible?
ai. Is there a carefully conceived plan known to all personnel in the convoy that can be used in case of attack? $\qquad$
$a j$. Is a written operation order on hand if required?
$a k$. Will a $\log$ of road movement be required at end of trip? $\qquad$ Are the necessary forms on hand?
al. Has weather forecast been obtained?
am. Do all personnel have proper clothing and equipment? $\qquad$
$a n$. Is there a communications plan? $\qquad$

## 3-20. Convoy Commander's Report

The convoy commander prepares this report after a move has been completed and normally submits it to his immediate superior officer. The sample report below may be used as a guide. However, the report may be submitted in the form of a strip map with an appropriate legend attached.

Forward Load
420 Trans Bn
(Trk)

7A26FEB23 Twelve 21/2-Ton Trucks 16 Feb 72 (Convoy No.) (No. and type of (Date) task vehicles)

Time

Convoy departed starting point (SP) .. 0621
Convoy departed 1st loading point . ... . 0800
Convoy arrived at 1st loading point ... 0630
Time at 1st loading point .... 1 hr 30 min
Arrived at highway regulation point (HRP)

1200
Departed HRP ... .... .... ... 1205
Time at 1st unloading point .... .. $\quad 33 \mathrm{~min}$
Supplies and Personnel
Cargos (short tons) . . .. . . 50.2
Class of supplies . .. .. . . I
Personnel . .. ... .... .. .. .. ..... .. 0
Distance*
Speedometer reading of lead vehicle
(1st loading point)
21,324
$\begin{array}{lll}\text { Speedometer reading of lead vehicle } \\ \text { (SP) } & \text {.. } & 21,322\end{array}$
Total forward (no load) .. .. . . 2
Speedometer reading of lead vehicle
(1st unloading point) 21,381
Total forward (loaded) .. ... ... . 57
Remarks
SP—Company area, RJ 124/167
Weak bridge 6.4 miles east of 1st loading point. Road generally in poor condition between SP and 1st unloading point.

## Return Load

Time
Departed 2d loading point . . 1300
Arrived at 2d loading point (same
as 1st unloading point)
1245
Time at 2d loading point. 15 min
Departed 2d unloading point . ... . 1415
Arrived at 2d unloading point . . 1400
Time at 2d unloading point .. .. 15 min
Supplies and Personnel
Cargo (short tons) .. . ... . 10
Class of supplies . . II and IV
Personnel . ... .. . . 120
Distance*
Speedometer reading of lead vehicle
(2d unloading point)
21,396
*For explanation, see end of this sample report.

Speedometer reading of lead vehicle
(2d loading point)
21,381

Total return (loaded) .. ........... .. .. 15
Speedometer reading of lead vehicle (SP) 12,346
Total return (no load) . . . .. . . ... 40
Remarks
Road in excellent condition between 2d loading point and SP. Round-Trip Data
Time
Time returned to SP .. . .. ........ 1654
Total round-trip time . . ... 10 hr 33 min
Total travel time (including halts) .. 8 hr
Total loading time . . ... 1 hr 45 min
Total unloading time . .. .. 48 min
Supplies and Personnel
Cargo (short tons of class I) ... . 50.2
(short tons of class II and class
IV)10

Personnel ..... 120

Distance*

Total distance (loaded) .. .. ..... .. . 72
Total distance (unloaded) ... .... . .. 42
Total round-trip distance . .. . 114
Remarks
s/Thomas A. Yound
(Signature-convoy commander)
2d Lt, 4401 Trans Co (Lt Trk)
(Rank or grade and organization)

## 3-21. Convoy Clearance

A convoy clearance request usually is required from a unit or organization that is planning a move by convoy. The information required varies according to local SOP and regulations. In CONUS, DD Form 1265 should be used (para 3-24). In a field army, the traffic headquarters prescribes the form, determines routes to be used, and issues road clearances. The sample outline below shows the information usually required by any authority that issues road clearances.

[^5]
## Convoy Clearance Request

From: S3 1429 TTBn
Phone: Barkersville 1429
Time and date: 261530 Oct 61
Authority for movement: MO 341, HQ TALOG, dated 19 Oct 61

Convoy No.: 12B
Unit name or serial No.: 4406 T Car Co
Personnel: 4 Off, 98 EM
Total number of vehicles: 51 trks, 31 tlrs
Type and number of vehicles: thirty-eight $1 / 4$-ton trks, twenty-five $1 / 4$-ton tlrs, one $3 / 4$-ton trk, four $11 / 2$-ton trks, eight $21 / 2$-ton trks, six 1-ton tlrs

No. of serials: 3
Vehicles by type and number in serials (Do not show control, mess, or maintenance vehicles.):
(1) Two $21 / 2$-ton trks, twelve $1 / 4$-ton trks, one $1 / 2$-ton trk, two 1 -ton tlrs, eight $1 / 2$-ton tlrs
(2) Same as 1 st serial
(3) Same as 1 st serial

Vehicle distance: $\underset{\text { (yards) }}{60}$ (meters) $_{55}$
Average length of vehicles and/or com-
binations: $\underset{\text { (yards) }}{10} \quad 9 \quad 9$
Gap between serials:
Distance $\underset{\text { (yards) }}{2,935} \underset{\text { (meters) }}{2,684}$ Time $\underset{\text { (min) }}{5}$
Total length of convoy :
Distance $-\underset{\text { (yards) }}{8,840} \mathbf{( \text { meters } )} \mathbf{8 , 0 4 3}$ Time_- $15-1$ (min)
Cargo and tonnage: ${ }^{1} 36$ tons of baggage and organizational equipment.

Outside or overweight loads: None
SP: Barkersville
Scheduled time and date of departure: 290700 Oct 72

Proposed route: Barkersville, RJ 261, Kennedy, Kleburg, Exeter

Destination: Exeter
Estimated time and date of arrival: 291900 Oct 72

Rate of march: $\quad 20 \quad 32$
Scheduled halts : 15 min RJ 261; 1 hr Kennedy; 15 min Kleburg

[^6]Scheduled bivouacs: Arrive NA depart: NA POL points (determined by staff transportation officer) : NA

Highway regulation (determined by staff transportation officer): Advised Sgt Harris in office of staff transportation officer, 261015 Oct 72. Clearance granted by Lt Brown, office of staff transportation officer, 261230 Oct 72. Critical points:

| Name of Point | ETA | ETD |
| :--- | :--- | :--- |
| RJ 261 | 0900 | 0915 |
| Kennedy | 1215 | 1315 |
| Kleburg | 1615 | 1630 |
| Exeter | 1900 |  |

## Remarks: ${ }^{2}$

1. POL points not needed. Convoy will be refueled by tankers during halt at Kennedy.
2. Unit commander will insure strict compliance with all SOP and with all highway regul-
lation and control procedures issued by competent authority.
s/George A. Harkins
(Signature)
GEORGE A HARKINS
$\frac{\text { Capt, S3 } 1429 \text { TTBn }}{\text { (Grade, title, and organization) }}$

## 3-22. Vehicle Loading

a. Responsibility. The driver is responsible for his vehicle being loaded properly.
b. Rules for Loading (Fig. 3-1).
(1) Place heavy supplies at the bottom of the load and distribute evenly over cargo floor.

[^7]

WRONG


RIGHT

The right vehicle for the right job.


This overloads trailer rear wheel.s, brakes will not brake properly, rubber scuffs away. Distribute the load over the full trailer floor.


WRONG
This overloads one spring and set of tires. Brakes lock on the light side, cause skids.


RIGHT
Nothing overloaded; frane will not twist ano loosen crossmember rivets.


WRONG


RIGHT

This overloads and shortens tire life, bends the truck rear-axle housing. Applyinc the trailer brakes may lock the wheels and cause flat spots and skidding.

Figure 3-1. How to load a truck.


Tires, axles, frame, etc., are designed to carry a load distributed as above.


Distribute trailer loads equally between the rear tires and the fifth wheel. This transfers the load to the tractor.


WRONG
This will bend the frame, overload front tires, making steering harder.


RIGHT
Place heavy part of load near rearaxle for proper tire loading and to keep frame from bending.


WRONG
This kind of weight distribution bends the frame, overloads rear tires, and makes steering almost impossible.


RIGHT
Set a concentrated load just ahead of the rear axle with, if possible, the longest side on the floor.
iFigure 3 -1-Continued.
(2) Place the load so that it will not shift; distribute the weight equally.
(3) Do not distribute load loosely or build it up too high. High, loosely distributed loads cause swaying, make the vehicle difficult to handle, and increase the danger of losing the cargo or overturning the vehicle.
(4) If the truck has an open body, put a tarpaulin, when practicable, over the cargo to protect it against sun, dust, rain, and pilferage.
(5) If possible, place barrels and drums on their sides-parallel with the length of the truck-and brace and pyramid them. If the
possibility of leakage does not permit this placement, set the drums upright. This latter arrangement does not permit the loading of as many drums in the same space.
(6) Combine boxed, crated, and packaged cargo, as far as possible, with like items or items of combining shapes.
(7) Load sacked cargo separately or so as not to risk its being punctured by oddshaped items; stack it in overlapping layers to prevent shifting.

## 3-23. Vehicle Size and Weight Limits

The tables below may be used as planning guides. Size and weight limits are changed periodically as a result of road and bridge construction. Planners must check with local military and/or civilian agencies to verify local limits and methods of clearance or exemption before putting vehicles on the road. Maximum allowable axle load, gross weight, and dimensions are contained in tables 3-1, $3-2$, and 3-3.

$\qquad$




| ser 1,19 |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| mortheasienn staris |  |  |  |  |  |  |  |  |  |  |  |  |
| stare | Reciprocity authority(Interstate or International Carriers) | Height | Lengt in feet |  |  |  |  | $\begin{gathered} \text { axe } \\ \text { ane } \\ \text { noics } \end{gathered} .$ | $\begin{array}{\|l\|l\|l\|l\|l\|l\|l\|l\|l\|l\|} \substack{\text { andert } \\ \text { Appit }} \\ \hline \end{array}$ | Cross Weight in Pounds |  |  |
|  |  |  | truck | $\pm$ | r.s.t | т.S.r. | (tame |  |  | 3axe t. S . |  |  |
| comn |  | ${ }^{13} 6^{\prime \prime}$ | ${ }_{5}$ | ns. | ${ }^{55}$ | n.p. | n.p. | ${ }_{\text {2 }}^{\text {2 }}$ (1000 | ${ }_{\substack{36,000 \\ \text { (10) }}}$ | ${ }_{53,800}{ }_{\text {(N) }}$ |  | 73,000 |
| Del | full receivecoty (c) | ${ }^{13}{ }^{16^{\prime \prime}}$ | ${ }^{40}$ | ${ }^{40}$ | ${ }_{\text {(k5) }}^{\text {(k) }}$ | ${ }^{65}$ | ${ }^{65}$ | 20,000 | 36,000 | Table | Table |  |
| D. . | full reaprocity | ${ }^{12} 6^{\prime \prime}$ | 40 | N.R. | 55 | N.P. | 55 | 22.000 | 38,000 | Table | Table |  |
| Me. | full | ${ }_{(13)}^{138^{\prime \prime}}$ | 56.5 | 45 | ${ }_{\substack{56,5 \\(86)}}$ | ${ }^{\text {mp. }}$ | 56.5 | 22,000 | ${ }_{\substack{\text { 32000 } \\ \text { (1) }}}$ |  |  |  |
| ${ }^{\text {ma }}$ | Full recirococit (c) | ${ }^{13} 6^{6}$ | ${ }^{40}$ | 55 | ${ }_{(85)}^{\text {(8) }}$ | ${ }_{\text {(4) }}^{(65}$ | ${ }^{55}$ | 22,000 | 40,000 |  |  |  |
| Mass | full reiprocoity ( ${ }^{\text {c }}$ | ${ }^{13} 3^{6 \prime}$ | ${ }^{35}$ | NR. | ${ }^{55}$ |  | N.P. | ${ }^{22,400}$ | 36,000 | Table | ${ }_{\substack{\text { Tople } \\ 73,000 \\ \text { max }}}^{\text {a }}$ |  |
| N.H. | Finlireiproty exceet | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | N. R . | ${ }_{\text {(185) }}^{59}$ | ${ }^{55}$ | 55 | 22,400 | ${ }_{\substack{3,000 \\(E)}}$ |  |  |  |
| N. | ful reeir irocity (c) | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ |  | ${ }_{5}$ | 55 | 55 | ${ }_{\substack{2,2,000}}^{(i)}$ | ${ }_{\substack{\text { 320, } \\ \text { (V) }}}$ |  | Limited by | 73.280 |
| Nr. |  | ${ }^{13} 6{ }^{\prime \prime}$ | ${ }^{35}$ | (ff) | ${ }_{\text {(4) }}^{\text {(k) }}$ | ${ }_{\text {S }}$ (M) | 55 | 22,400 | 36,000 |  |  |  |
| Pa | Full reioiocity (c) | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | ${ }^{\text {Ns }}$ | ${ }^{55}$ | ${ }^{\mathrm{NP}}$ | 55 | ${ }_{22}^{22,00}$ | ${ }_{\substack{36 \\ \text { (0) }}}$ | ${ }_{\substack{\text { So.000 } \\ \text { (ia) }}}^{\text {a }}$ | (6.0.00 ( 4 ax) | 73,280 |
| R.1. | PuTV. | ${ }^{13} 6^{\prime \prime}$ | 40 | ${ }_{\text {(ff) }}$ | 55 | N.P. | 55 | 22,000 | 36,000 | 50,000 | 67,400 (w) | ${ }^{73,80}$ |
| vt | full | ${ }^{13} 6^{\prime \prime}$ | 55 | n.s. | 55888 | N.P. | 55 | ${ }^{22800}$ | 36.000 | Table | Table | ${ }^{73,280 \mathrm{Max}}$ |
| Southen stares |  |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{\text {Ala }}$ |  | ${ }^{13} 6^{\prime \prime}$ | ${ }^{40}$ | n.s. | ${ }^{55}$ | N.P. | n.p. | (18,000 | ${ }^{36,000}$ | Tale | Tale |  |
| Ark |  | ${ }^{13} 6^{6}$ | ${ }^{40}$ | n.s. | 55 | ${ }^{65}$ | ${ }^{65}$ | 18.000 | 32,000 | cin | Limited |  |
| ${ }^{\text {fia }}$ | Finl fetipeoty eneept | ${ }^{13} 6^{1 /}$ | ${ }_{\text {ck }}^{35}$ | (ff) | 55 | N.P. | 55 |  | ${ }_{\substack{40 \\ \text { 4ij) }}}$ | Taple (U) | Tabie (u) |  |
| ${ }^{\text {ca }}$ | Femil | ${ }^{13} 6^{\prime \prime}$ | 55 | 55 | ${ }_{\text {(kK) }}^{5}$ | 55 | 55 | 20,30 | 40.680 |  | $\xrightarrow{\text { Limited }}$ demt | ${ }^{73.280 ~ M \times x}$ |
| ${ }_{\text {ky }}$ |  |  | ${ }^{35}$ |  | $\begin{aligned} & 5.5 \\ & \binom{\text { seb }}{\hline} \end{aligned}$ | ${ }_{\text {(m) }}^{65}$ | (55) | $\begin{array}{\|c} 18.000 \\ (0) \\ (0) \\ \hline \end{array}$ | $\begin{array}{\|l\|l\|} \hline 32,000 \\ \text { in } \\ \hline 10 \end{array}$ | $\pm$ |  |  |
| ${ }^{\text {La }}$ | fuil reipiracity ( $($ c | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | ${ }^{\text {NR. }}$ | ${ }_{60}$ | N.P. | ${ }^{65}$ | ${ }^{18.000}$ | 32,000 | $\underbrace{\text { and }}_{\substack{\text { Linited by } \\ \text { axe meigh }}}$ | $\underset{\substack{\text { Limited by } \\ \text { axe might }}}{\text { atem }}$ | ${ }_{\text {cosem }}^{68.000}$ |
| Miss |  | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | Ns. | ${ }_{5} 5$ | ${ }_{5} 5$ | ${ }^{55}$ | 18.000 |  | table | Table |  |
| nc. |  | ${ }^{13}{ }^{3} 6^{\prime \prime}$ | ${ }_{\text {3 }}^{35}$ | n.R. | ${ }^{55}$ | N.P. | ${ }^{55}$ | ${ }_{\text {c }}^{18,000}$ | ${ }_{\text {cosem }}^{35000}$ | ${ }^{47} \mathbf{4} \times 50$ |  | ${ }^{70.000}$ |
| s.c. |  | ${ }^{13} 6^{\prime \prime}$ | ${ }_{\text {ck }}^{35}$ | N. S . | ${ }_{\text {(k) }}^{\text {(k) }}$ | ${ }^{\mathrm{NP}}$ | ${ }^{55}$ | $\underset{\substack{\text { ciono } \\ \text { (k) }}}{\substack{\text { a }}}$ |  | ${ }_{\substack{\text { Sopen } \\(1,0)}}$ |  |  |
| Tenn. | Full reieirocoity ( $)$ | ${ }^{13} 6^{\prime \prime}$ | 40 | N. . | ${ }_{\text {(65) }}{ }^{\text {(6) }}$ | N.P. | ${ }^{55}$ | 18.000 | 32,000 | bimaxe | Limited | ${ }^{73,288 \mathrm{max}}$ |
| Tenas | Fin | ${ }^{13} 6^{\prime \prime}$ | ${ }^{40}$ | Ns | ${ }^{65}$ | ${ }^{65}$ | ${ }^{65}$ | 18,000 | 32,000 | Table | Table |  |
| $\mathrm{v}^{2}$ |  | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | ns. | ${ }^{55}$ | ${ }^{\mathrm{N} . \mathrm{P} \text {. }}$ | 55. | 18,000 | 32.000 | Table | Table |  |
|  | ${ }_{\text {cole }}^{\text {fill }}$ | ${ }^{13}{ }^{13} \mathrm{~m}^{6 \prime \prime}$ | ${ }_{3}^{35}$ | n.S. | ${ }_{\text {c }}^{\text {(m) }}$ | N.P. | (m) | cis.000 | $\underbrace{\substack{32000}}_{\text {cien }}$ | Talie | rable |  |
| Canaoan provinces |  |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{\text {Alb }}$ | Full recipoctity | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | $n \mathrm{~ns}$. | ${ }^{65}$ | ${ }^{65}$ | ${ }^{65}$ | 18,000 | 32.000 | 45, 4.000000 ( | ${ }^{59,000}$ (M) | 74,000 (m) |
| ${ }^{\text {a.c. }}$ | Promion ony | ${ }^{13^{3} 6}$ | ${ }^{35}$ | ${ }_{\text {che }}^{4}$ | ${ }_{\text {c }}^{65}$ | (65) | (65) | 20,000 | 35.000 | 52,000 (00) |  | 110,000(00) |
| Man. | Full reeiprocity | ${ }^{13} 6^{\prime \prime}$ | ${ }^{40}$ | ${ }^{\text {n }}$ S | 60 | ${ }^{65}$ | ${ }^{65}$ | 18,000 | 32,000 | 46,000 |  | 74.000 |
| ${ }^{\text {N. }}$. 5 |  | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | ${ }^{45}$ | ${ }^{65}$ | ${ }^{65}$ | ${ }^{65}$ | 20.000 | 35,010 | 50,000 |  | ${ }^{80} 1200000000000$ |
| ${ }^{\text {M } 5 .}$ |  | ${ }^{13}{ }^{\prime \prime} 6^{\prime \prime}$ | ${ }^{40}$ | ${ }^{4}$ | ${ }^{65}$ | N.P. | ${ }^{65}$ | $\underset{\substack{18000}}{\text { chen }}$ | ${ }_{\substack{\text { 32, } \\ \text { Pram }}}$ |  |  | ${ }_{\text {7 }}^{1}$ |
| 0 m | Linited Reierocoity | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | ${ }_{\text {(k) }}^{4}$ | ${ }^{65}$ | ${ }^{65}$ | ${ }^{65}$ | 20,000 | 35.00 | 50,000 |  | ${ }_{\text {cose }}^{135000}$ |
| P.E. |  | ${ }^{144^{\prime \prime}}$ | ${ }^{40}$ | N. | ${ }^{70}$ | 70 | 70 | ${ }^{20,000}$ | 35.000 | 50,000 |  | 80.000 |
| Que |  | ${ }_{\text {13 }}^{13}$ | ${ }^{35}$ |  | ${ }^{65}$ | ${ }^{65}$ | ${ }^{65}$ | 22,000 | $\underset{\substack{38,000 \\ \text { (i1) }}}{\text { cien }}$ | $\underbrace{50,00}_{\substack{\text { S4, } \\ \text { ili) }}}$ |  | $\underset{\substack{86,000 \\ \text { ili }}}{ }$ |
| Ssask. |  | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | N.R | 65 | ${ }^{65}$ | 65 | 18.000 | 32,000 | Table | Table |  |


| miowestern states |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| state | leciprocity autherlty (Interstate or Inter antional Carriers. | Height | Length in feet |  |  |  |  | $\begin{gathered} \text { Axled } \\ \text { iniob } \\ \text { inios } \end{gathered}$ | $\begin{gathered} \text { andeen } \\ \substack{\text { ande } \\ \text { AAle } \\ \text { Alart }} \end{gathered}$ | Gross weight in Punds |  |  |
|  |  |  | Truck | $\pm$ | t.s. | t.S.r.i | ${ }_{\text {coser }}^{\substack{\text { Other } \\ \text { comb }}}$ |  |  | 3 axte T.S.I | Axters.s. | Higrest weipht |
| "II |  | ${ }^{13} 6^{6}$ | ${ }^{42}$ | ${ }_{42}$ |  | ${ }_{\text {(M) }}^{65}$ | 60 | 18.000 | ${ }^{32} 200$ | rave | Table |  |
| ${ }^{\text {Ind }}$ | Full reciprocity except P.S.C. Filing Fee (c) | ${ }^{13} 6^{\prime \prime}$ | ${ }^{36}$ | n.s. | (ks) | ${ }^{65}$ | ${ }^{55}$ | (18000 | $\underbrace{\text { a }}_{\substack{32.000 \\ \text { (x) }}}$ | (limied by |  | ${ }^{73,280}$ Max |
| Iowa |  | ${ }^{13} 6^{6}$ | ${ }^{35}$ | n.s. | ( 5 | ${ }^{60}$ | ${ }_{\text {(6) }}^{55}$ | (18.000 | $\underbrace{20}_{\substack{32000 \\ \text { (2) }}}$ | ${ }_{\text {coil }}^{\text {rable }}$ | Table |  |
| Kans |  | ${ }^{13} 6^{\prime \prime}$ | 42.5 | ${ }^{\text {F }}$ | ${ }_{\substack{55 \\ \text { (kk) }}}$ | ${ }^{65}$ | ${ }^{65}$ | ${ }^{18.000}$ | ${ }^{32.000}$ | Table | Table |  |
| mich |  | ${ }^{13} 6^{\prime \prime}$ | 40 | N. ${ }^{\text {. }}$ | ( ${ }_{\text {ck }}^{\text {(k) }}$ | (65) | ${ }_{5} 5$ | ${ }^{18.000}$ | (il) | ${ }_{\text {Limite }}^{\substack{\text { Lime } \\ \text { axie loas }}}$ | Limied by |  |
| min. | Ful reciprocity (c) (M) | ${ }^{13} 6^{\prime \prime}$ | ${ }^{40}$ | ${ }_{(0)}^{40}$ | 55 | N.P. | ${ }^{55}$ | 18.000 | 32.000 | Table | roble |  |
| Mo |  | ${ }^{13} 6^{\prime \prime}$ | ${ }^{40}$ | ns. | ( ${ }_{\text {ck }}$ | ${ }_{\text {(4) }}{ }_{\text {(1) }}$ | ${ }_{\text {(4) }}{ }_{\text {(4) }}$ | 18.000 | 32.000 | rable | Table |  |
| Neb | $\begin{aligned} & \text { Full reciprocity } \\ & \left(\begin{array}{l} (1)(1)(i)(i) \end{array}\right. \end{aligned}$ | ${ }^{3} 6^{\prime \prime}$ | ${ }^{40}$ | (f) | 60 | 65 | ${ }^{65}$ | (18.000 | (incoin | rape | ${ }_{\text {rable }}^{\text {rable }}$ | $\begin{aligned} & \text { Table (Q) } \\ & 71,146 \text { Max }, 1 \end{aligned}$ |
| n. 0. |  | ${ }^{13} 6^{17}$ |  | NR | ${ }^{60}$ | ${ }_{6}^{65}$ | ${ }^{50}$ | ${ }^{18.000}$ | ${ }^{32} 200$ | 750(1+40) | $750(1+40)$ |  |
| anio |  | ${ }^{13^{3} 6^{\prime \prime}}$ | ${ }^{40}$ | ns. | ${ }_{5}$ | ${ }^{65}$ | ${ }^{65}$ | 19.000 | $\begin{aligned} & 24,000 \\ & \hline 0.00 \\ & 0.0 \end{aligned}$ | $\underset{\substack { 38.000 \\ \begin{subarray}{c}{3000 \\ (0,0){ 3 8 . 0 0 0 \\ \begin{subarray} { c } { 3 0 0 0 \\ ( 0 , 0 ) } }\end{subarray}}{\substack{0}}$ |  | $\begin{aligned} & 38.000+ \\ & 18 \times 900) \\ & 78.000 \mathrm{Max}(Q) \end{aligned}$ |
| Oka |  | ${ }^{3} 6^{\prime \prime}$ | ${ }^{40}$ | N.s. | ( ${ }_{\substack{55 \\ \text { (kk) }}}$ | ${ }^{65}$ | ${ }^{65}$ | 18.000 | 32.000 | Table | Table |  |
| s.0. |  | ${ }^{3} 6^{\prime \prime}$ | ${ }^{35}$ | n.s. | 65 | ${ }_{\text {(m) }}^{65}$ | ${ }_{\text {(M) }}^{65}$ | 18.000 | 32.000 | table | rabe |  |
| wisc | $\xrightarrow{\text { Ful }}$ | ${ }^{13^{\prime} 6^{\prime \prime}}$ | ${ }^{35}$ | $\underset{\substack{35 \\ \text { (14H) }}}{ }$ | ${ }_{\substack{\text { Sk } \\ \text { (k) }}}$ | N. | 55 | 19.500 | 32.000 | Table | tabe | ${ }_{\substack{\text { apole } \\ 73.000}}^{\substack{\text { max }}}$ |
| western states |  |  |  |  |  |  |  |  |  |  |  |  |
| Alasta | Full reciprocity | ${ }^{136} 6^{\prime \prime}$ | ${ }^{40}$ | ${ }^{40}$ | ${ }^{60}$ | ${ }^{65}$ | ${ }^{60}$ | 20.000 | 34,000 |  |  |  |
| Ariz. | Proration only (ryc) | ${ }^{13} 6^{60}$ | ${ }^{40}$ | N. R . | ${ }^{65}$ | ${ }^{65}$ | ${ }^{65}$ | 18.000 | 32.000 | Table | Table |  |
| Calit | Full reciprocity except Bd. of Equal. fees $(Y)(C)$ | ${ }^{14}$ | ${ }^{40}$ | ${ }^{40}$ | (60 | ${ }^{65}$ | ${ }^{65}$ | 18.000 | ${ }^{32,000}$ | Table | rable |  |
| ${ }^{\text {colo }}$ | Reciprocity on registra tion: none on P.U.C. $\&$ <br> mileage ta $x$ (Y) (C) | ${ }_{\text {(13) }}^{136^{\prime \prime}}$ | ${ }^{35}$ | n.s. | ${ }_{\text {( }}^{65}$ | ${ }_{\text {( }}^{65}$ | ${ }^{65}$ | 18.00 | 35.000 | ${ }^{800(4+40 ;}$ | $800(1+400)$ | $800(1+40)$ |
| Haw. | full reciprocity | ${ }^{136^{\prime \prime}}$ | 40 | n.s. | 55 | 65 | 65 | 24.000 | 32.000 | $800(1+40)$ | $800(4+40)$ | $800(1+40)$ |
| ${ }^{\text {Iasano }}$ | Authority for full recipro- city but agreements are for proration $(Y)(L)(C)$ | ${ }^{14}$ | ${ }^{35}$ | N.R. | ( | ${ }_{\text {(4) }}^{65}$ | ${ }^{65}$ | 18.000 | ${ }^{32,000}$ | Table | rable |  |
| mont | $\begin{aligned} & \text { Full reciprocity except } \\ & \text { on gross operating } \\ & \text { revenue tax }(Y)(C) \end{aligned}$ | ${ }^{13} 6^{\prime \prime}$ | ${ }^{35}$ | n.s. | ${ }_{\substack{60 \\(1)}}^{\text {(1) }}$ | ${ }_{\text {(0) }}^{65}$ | ${ }^{65}$ | 18.000 | 32.000 | Toole | rable |  |
| Nev. | Reciprocity on registra. tion fees: none on P.S.C. fee or mileage tax. (Y)(C) | n.s. | ${ }^{40}$ | n.s. | ${ }^{70}$ | 70 | ( ${ }_{(0)}$ | 18.00 | ${ }^{32} 000$ | table | Toble |  |
| N.M. | $\begin{aligned} & \text { Authority for full reci- } \\ & \text { procity: new agreements } \\ & \text { on proration. }(Y) \text { (C) } \end{aligned}$ | ${ }^{13} 6^{\prime \prime}$ | ${ }^{40}$ | N.R. | ${ }^{65}$ | ${ }^{65}$ | ${ }^{65}$ | 21,600 | ${ }^{34.320}$ | rable | rable |  |
| Ore. | $\begin{aligned} & \text { Reciprocity on license } \\ & \text { fees: none on } P . U . C . \\ & \text { plates or mileage tax. }(Y) \end{aligned}$ | ${ }_{(13)}^{13)^{6 \prime 1}}$ | ${ }^{35}$ | ${ }_{\text {(c) }}$ | (50) | ${ }_{\text {(c) }}^{65}$ | (50) | ${ }_{\text {l }} 18.000$ | ${ }_{\substack{32,000 \\ \text { (CC) }}}$ | Tale | table |  |
| Utan |  | ${ }^{14}$ | ${ }^{45}$ | ${ }^{45}$ | ${ }^{60}$ | (65) | ${ }_{\text {cos }}^{65}$ | 18.00 | ${ }^{33.000}$ | Tople | rable |  |
| Wash | Reciprocity on reglstraand gr . wt. fees. Y (C) | ${ }^{13}\left(3^{\prime \prime}\right)^{\prime \prime}$ | ${ }^{35}$ | 45 | 65 | ${ }^{65}$ | ${ }^{65}$ | 18,000 | 32,000 | Table | Table |  |
| wo. | $\begin{aligned} & \text { Reciprocity on registra. } \\ & \text { tion fees; none on mile- } \\ & \text { age tax. (C) } \end{aligned}$ | ${ }^{14}$ | 50 | n. s | 75 | 75 | ${ }^{75}$ |  | 36,000 | taple | тobe |  |
| mexica |  |  |  |  |  |  |  |  |  |  |  |  |
| Mex | None | ${ }^{13^{\prime} 6^{\prime \prime}}$ | ${ }^{37}$ | Ns. | (MM) | N.P. | ${ }^{60}$ | 20.000 | ${ }^{32.000}$ | 52.000 |  | 84.000 |






(AF) Sems.













Table 3-3. Turnpike or Toll Road ExceptionsMaximum Allowed Under Special Permit

| Length | Gross <br> weight | Number of <br> vehiclesinin <br> combina- <br> tion |  |
| :--- | ---: | :---: | :---: |
| Florida Turnpike | 110 ft | $138,271 \mathrm{lb}$ | 3 |
| Indian Toll Road | 98 ft | $127,400 \mathrm{lb}$ | 3 |
| Kansas Turnpike | 105 ft | $130,000 \mathrm{lb}$ | 3 |
| Massachusetts |  |  |  |
| $\quad$ Toll Road | 98 ft | $127,400 \mathrm{lb}$ | 3 |
| New York Thruway | 108 ft | $124,400 \mathrm{lb}$ | 3 |
| Ohio Turnpike | 98 ft | $127,400 \mathrm{lb}$ | 3 |
| Pennsylvania Turnpike | 70 ft | $73,280 \mathrm{lb}$ | 3 |

*Combinations exceeding 73,280 pounds must have written special hauling permit from Turnpike Commission.

Source: American Trucking Associations, Incorporated. (By permission.)

## 3-24. Requests for Convoy Clearance and Special Hauling Permits (CONUS)

a. Request for convoy clearance must be submitted on DD Form 1265 (Request for Convoy Clearance) (fig. 3-2) through the local transportation officer at the point of origin to the appropriate CONUS Army or Military District of Washington, US Army official; the appropriate official is designated in the "Directory of Defense and State Officials Authorized to Request and Issue Permits for Oversized, Overweight or other Special Movement on Public Highways," published by the Military Traffic Management and Terminal Service. DD Form 1265, a copy of the operation order, and a strip map of the proposed convoy route must be submitted in quadruplicate. An additional copy of each document must be added for each state to be traversed. These
documents must be submitted in time to reach the CONUS Army headquarters or Military District of Washington, US Army 7 workdays prior to the date of movement.
b. Requests for permits to move oversize or overweight vehicles over public roads are submitted in quadruplicate, with one copy added for each state to be traversed, in accordance with procedures outlined in a above, on DD Form 1266 (Request for Special Hauling Permit) (fig. 3-3) by the moving unit.

## 3-25. Safe Operating Distances Between Vehicles

The chart below shows average values which may be used in determining safe gaps between vehicles at various speeds on average, hardsurfaced roads. Since well-trained drivers can reduce the distance traveled during the perception and reaction periods, the planner should consider the physical condition and the state of training of drivers for a particular operation, keeping in mind that rain, snow, distances are based on the assumption that the vehicles are loaded and have good brakes, tires, and traction. Total distances have been determined from the standpoint of safety only; the tactical situation may require larger or smaller gaps. In the absence of definite information, the following rule-of-thumb method may be used for certain speeds to determine the gap between vehicles in a convoy: speedometer reading ( mph ) $\times 2=$ gap in yards, or speedometer reading (kmph) $\times 1.2=$ gap in meters. This method should be used only for the speeds marked with an asterisk in table 3-4.

## C 3, FM 55-15

| REQUEST FOR CONVOY CLEARANCE |  |  |  |  |  | $\begin{array}{r} \text { Date } \\ 1 \text { May } 1972 \\ \hline \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| SECTION I-GENERAL |  |  |  |  |  |  |
| 508th Trans Co (Mdm Trk) |  |  | Fort Eustis, Virginia$23604$ |  |  | 3. CONYOY COMMANDER John J. Jones UW, TC |
| 4. PERSOMNEL STREMGTM <br> C. OFFICEA <br> 1 |  | 5. POINT OR ORIGIN <br> Fort Eustis, Virginia |  |  | Camp A. P. Hill, Virginia |  |
| 7. date amd time |  |  |  |  |  |  |
| SECTION II - CONYOY COMPOSIT ION |  |  |  |  |  |  |
| 9. NUMEER OFEACH TYPE OF VENICLE AND OEICRIPTION (LTctuch Lownd aqutpment) <br> 1 1/4-Ton Truck, Utility <br> 20 5-Ton Tractor W/19 Stake and Platform Semitrailers (1 Bobtail) <br> 1 5-Ton Wrecker |  |  |  |  |  |  |


14. PROPOEED ROUTINE (Pndicate US Routet, State Reatee, ate)

Interstate 64, State Route 168, State Route 33, Interstate 64, Interstate 95, State Route 207, U. S. 301 to Camp A. P. Hill

ETA AND ETD AT STATELINES, MANOR ROAD JUNCTIONS, MAJOR BRIDOES AND TUNMELS, METROPOLITAN AREAS AND


| LOCATION | ETA | Date | cro | oate |
| :---: | :---: | :---: | :---: | :---: |
| I-64 Rt \# 168 Mt \# 33 $I-64$ $I-95$ $207-301$ | 0700 <br> 0732 <br> 0754 <br> 0835 <br> 0859 <br> 0857 |  | 0705 0737 0814 0840 0904 1002 | 15 May 72 |



Class I (packaged rations)

Figure 3-2. DD Form 1265 (Request for Convoy Clearance).


ETA is the time the first vehicle clears the referenced point.
ETD is the time the last vehicle clears the referenced point.

| 21. REGUESTINE MEENCY 508th Trans Co (Mdm Trk) |  | 22. APPROVINE AOENCY |  |
| :---: | :---: | :---: | :---: |
| 21. REQUIESTEOBY (Typed name, drade and iffe) CHARLES <br> C. CHESNUT |  | 24. APP noveo er (Typed name, fredo and eftle) |  |
| $\begin{aligned} & \text { 25. oate } \\ & 1 \text { May } 72 \end{aligned}$ | 26. sionatume | 27. DATE | 25. SIONATUAE |
| INSTRUCTIONS, | In cases where bon-fide emergencles erist, the information contained on DD Form 1265 and DD Form 1266 may be trensmitted to the appropriate hadquartere hy telephone or electric tranamiasion. In this event, reforence will be made to item numbers in the sequence in which they appear on the form. Items which do not apply will be so indicated. |  |  |

Figure 3-2-Continued.


DD .
Figure 3-3. DD Form 1266 (Request for Special Hauling Permit).


Figure 3-3-Continued.

Table 3-4. Average Distance Required for Stopping

| mph | Speed kmph | $\mathrm{ft} / \mathrm{sec}$ |  | meters |  | meters | feet | Braking meters | feet | Total ${ }^{1}$ yards | meters |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Passenger vehicles ${ }^{2}$ |  |  |  |  |  |  |  |  |  |  |  |
| 20* | 32.2* | 29.3 | 22 | 6.7 | 22 | 6.7 | 25 | 7.6 | 69 | 33 | 21.0 |
| 25* | 40.3* | 36.7 | 28 | 8.5 | 28 | 8.5 | 35 | 10.7 | 91 | 30 | 27.7 |
| 30* | 48.3* | 44.0 | 33 | 10.0 | 33 | 10.0 | 48 | 14.6 | 114 | 38 | 34.6 |
| 35* | 56.3* | 51.3 | 39 | 11.9 | 39 | 11.9 | 67 | 20.4 | 145 | 48 | 44.2 |
| 40* | 64.4* | 58.7 | 44 | 13.4 | 44 | 13.4 | 90 | 27.4 | 178 | 59 | 54.2 |
| 45* | 72.4* | 66.0 | 50 | 15.3 | 50 | 15.3 | 117 | 35.7 | 217 | 73 | 66.3 |
| 50* | 80.5* | 73.4 | 55 | 16.8 | 55 | 16.8 | 148 | 45.2 | 258 | 86 | 78.8 |
| 55 | 88.5 | 80.7 | 61 | 18.6 | 61 | 18.6 | 185 | 56.4 | 307 | 102 | 93.6 |
| 60 | 96.6 | 88.0 | 66 | 20.1 | 66 | 20.1 | 228 | 69.6 | 360 | 120 | 109.8 |
| 65 | 104.6 | 95.4 | 72 | 21.9 | 72 | 21.9 | 275 | 83.9 | 419 | 140 | 127.7 |
| 70 | 112.6 | 102.7 | 77 | 23.5 | 77 | 23.5 | 332 | 102.5 | 486 | 162 | 149.5 |

Single-unit vehicles with gross weight less than 10,000 pounds

| $20^{*}$ | $32.2^{*}$ | 29.3 | 22 | 6.7 | 22 | 6.7 | 30 | 9.2 | 74 | 25 | 22.6 |
| :--- | :--- | :--- | :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $25^{*}$ | $40.3^{*}$ | 36.7 | 28 | 8.5 | 28 | 8.5 | 42 | 12.9 | 98 | 33 | 29.8 |
| $30^{*}$ | $48.3^{*}$ | 44.0 | 33 | 10.0 | 33 | 10.0 | 58 | 17.7 | 124 | 41 | 37.7 |
| $35^{*}$ | $56.3^{*}$ | 51.3 | 39 | 11.9 | 39 | 11.9 | 80 | 24.4 | 158 | 53 | 48.2 |
| $40^{*}$ | $64.4^{*}$ | 58.7 | 44 | 13.4 | 44 | 13.4 | 106 | 31.4 | 194 | 65 | 58.2 |
| $45^{*}$ | $72.4^{*}$ | 66.0 | 50 | 15.3 | 50 | 15.3 | 138 | 42.1 | 238 | 79 | 72.7 |
| 50 | 80.5 | 73.4 | 55 | 16.8 | 55 | 16.8 | 177 | 54.0 | 287 | 96 | 87.6 |
| 55 | 88.5 | 80.7 | 61 | 18.6 | 61 | 18.6 | 222 | 67.5 | 344 | 115 | 104.7 |
| 60 | 96.6 | 88.0 | 66 | 20.1 | 66 | 20.1 | 273 | 83.3 | 405 | 135 | 123.5 |

Single-unit, 2-axle vehicles with gross weight of 10,000 pounds or more

| $20^{*}$ | $32.2^{*}$ | 29.3 | 22 | 6.7 | 22 | 6.7 | 40 | 12.2 | 84 | 28 | 25.6 |
| :--- | :--- | ---: | :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $25^{*}$ | $40.3^{*}$ | 36.7 | 28 | 8.5 | 28 | 8.5 | 64 | 19.5 | 120 | 40 | 36.5 |
| $30^{*}$ | 48.3 | 44.0 | 33 | 10.0 | 33 | 10.0 | 92 | 28.0 | 158 | 53 | 48.0 |
| 35 | 56.3 | 51.3 | 39 | 11.9 | 39 | 11.9 | 126 | 38.4 | 204 | 68 | 62.2 |
| 40 | 64.4 | 58.7 | 44 | 13.4 | 44 | 13.4 | 165 | 50.3 | 253 | 84 | 77.1 |
| 45 | 72.4 | 66.0 | 50 | 15.3 | 50 | 15.3 | 208 | 63.4 | 308 | 103 | 94.0 |
| 50 | 80.5 | 73.4 | 55 | 16.8 | 55 | 16.8 | 256 | 78.1 | 366 | 122 | 111.7 |
| 55 | 88.5 | 80.7 | 61 | 18.6 | 61 | 18.6 | 310 | 94.5 | 432 | 144 | 131.7 |
| 60 | 96.6 | 88.0 | 66 | 20.1 | 66 | 20.1 | 372 | 113.5 | 504 | 168 | 153.7 |

Single-unit vehicles with more than 2 axles and combination of vehicles (tractor truck, semitrailer, and trailer) with gross weight of 10,000 pounds or more

| $20^{*}$ | $32.2^{*}$ | 29.3 | 22 | 6.7 | 22 | 6.7 | 50 | 15.3 | 94 | 32 | 28.7 |
| :--- | :--- | :--- | :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 25 | 40.3 | 36.7 | 28 | 8.5 | 28 | 8.5 | 80 | 24.4 | 136 | 45 | 41.4 |
| 30 | 48.3 | 44.0 | 33 | 10.0 | 33 | 10.0 | 115 | 35.1 | 181 | 60 | 55.1 |
| 35 | 56.3 | 51.3 | 39 | 11.9 | 39 | 11.9 | 157 | 47.9 | 235 | 78 | 71.7 |
| 40 | 64.4 | 58.7 | 44 | 13.4 | 44 | 13.4 | 205 | 62.5 | 293 | 98 | 89.3 |
| 45 | 72.4 | 66.0 | 50 | 15.3 | 50 | 15.3 | 260 | 79.3 | 360 | 120 | 109.9 |
| 50 | 80.5 | 73.4 | 55 | 16.8 | 55 | 16.8 | 320 | 97.6 | 430 | 143 | 131.2 |
| 55 | 88.5 | 80.7 | 61 | 18.6 | 61 | 18.6 | 388 | 118.3 | 510 | 170 | 155.5 |
| 60 | 96.6 | 88.0 | 66 | 20.1 | 66 | 20.1 | 465 | 141.9 | 597 | 199 | 182.1 |

[^8]
## 3-26. Route Reconnaissance

a. Route Reconnaissance Overlay. Information obtained by either a hasty or a deliberate reconnaissance can be conveyed to interested personnel on a route reconnaissance overlay. The route reconnaissance overlay is an accurate and concise report of the conditions affecting traffic flow along a specified route and is the preferred method of preparing a route reconnaissance report. An overlay normally satisfies the requirements of hasty route reconnaissance. If, however, more detail is required to support the reconnaissance, the overlay is supplemented with written reports describing critical route characteristics in more detail. For additional information, see FM $5-36$. An example of a route reconnaissance overlay is shown in figure 3-4.
b. Route Reconnaissance Checklist. To insure that critical terrain data are not overlooked during route reconnaissance and to aid in the preparation of reconnaissance reports, a checklist based on the characteristics of the area of operations is recommended. The following items should be considered when preparing reconnaissance reports:
(1) Identification and location of the rec-
onnoitered route.
(2) Distance between points easily recognized both on the ground and on the map.
(3) Percent of slope and length of grades which are 7 percent or greater.
(4) Sharp curves whose radii are 100 feet ( 30 m ) or less.
(5) Bridge military load classifications and limiting dimensions, suitable bypasses.
(6) Locations and limiting data of fords and ferries.
(7) Route restrictions, such as underpasses, which are below minimum standard and, if appropriate, the distances such restrictions extend.
(8) Locations and limiting dimensions of tunnels, suitable bypasses.
(9) Suitable areas for short halts and bivouacs which offer drive-off facilities, adequate dispersion, cover, and concealment.
(10) Areas of rockfalls and rockslides which may present a traffic hazard.
c. Route Reconnaissance Symbols. Figure $3-5$ provides a summary of standard route reconnaissance and related symbols. In addition, references which explain the symbol in greater detail are provided for each entry.


Figure 3-4. Example of route reconnaissance overlay.

| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Civil or military route designation |  | Designation written in parentheses along route. | STANAG 2253 SOLOG 96 |
| Critical point |  | To be numbered and described in legend. Critical points may be used to point out features not adequately covered in other reconnaissance symbols. | $\begin{aligned} & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Limits of sector |  | Limits of reconnoitered sector of route. | $\begin{aligned} & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Route classification formula | $\begin{aligned} & 10.5 \mathrm{~m} \times 120 \\ & 6 \mathrm{mZ} 8(0 B) \\ & 9 \mathrm{my} 20(08)(\mathrm{W}) \end{aligned}$ | Expressed in order of: width, type, military load classification, obstructions, if present, and regular flooding or snow blockage: <br> X - all weather route <br> Y - all weather route (limited traffic) <br> Z - fair weather route <br> (T) - regular snow blockage <br> (W) - regular flooding | ```FM 5-36 (Sec I, Ch 2) NATO and CENTO STANAG 2015 SOLOG 53``` |
| Grades |  | Arrows point in uphill direction; to the right of symbol is shown the actual percent of slope; length of errow represents length of grade if map scale permits. | ```FM 5-36 (Sec III, Ch 2) STANAG 2253 SOLOG }9``` |


| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Sharp curve |  | Vertex of triangle points to map location of curve. Figure indicates radius in meters. | $\begin{aligned} & \text { FM 5-36 (Sec II, } \\ & \text { Ch 2) } \\ & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Series of sharp curves |  | Left figure indicates number of curves; right figure the radius in meters of the sharpest curve. | $\begin{aligned} & \text { FM 5-36 (Sec II, } \\ & \text { Ch 2) } \\ & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Full bridge symbol |  | Arrow extends to map location of bridge; minimum width is placed below, overhead clearance to the left, and overall length to the right of basic symbol. Lower portion of symbol indicates bridge serial number; upper portion, military load classification data. Underlined values are those below minimum standard. All linear distances are in meters. | ```FM 5-36 (Sec VII, Ch 2) DA Form 1295 STANAG 2096 STANAG 2253 SOLOG }9 SOLOG }10 SEASTAG 2096``` |
| Abbreviated bridge symbol |  | Arrow extends to map location of bridge. Lower portion of symbol indicates bridge serial number; upper portion, military load classification. Class number must be underlined if width or overhead clearance is below minimum standard. | ```FM 5-36 (Sec VI, Ch 2) DA Form 1294 STANAG }209 STANAG 2253 SOLOG 96 SOLOG }10 SEASTAG }209``` |
| Bypass easy |  | Used in conjunction with bridge and tunne ${ }^{1}$ reconnaissance symbols. | $\begin{aligned} & \text { FM 5-36 (Sec VII, } \\ & \text { Ch 2) } \\ & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Bypass difficult |  | Used in conjunction with bridge and tunnel reconnaissance symbols. | $\begin{aligned} & \text { FM S-36 (Se= VII, } \\ & \text { Ch 2) } \\ & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |



| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Ferry |  | Arrow extends to map location. Data above symbol is expressed in order of ferry serial number and ferry type. Data inside symbol is expressed in order of military load class of deck and dead weight capacity in tons; data below symbol is turn around time in minutes. Question mark indicates unknown information. Difficult approaches are represented by zigzag lines corresponding in position to shore where approach is located. <br> FERRY TYPE <br> V-vehicular <br> P -pedestrian | ```FM 5-36 (Sec V, Ch 2) DA Form 1252 STANAG 2096 STANAG 2253 SOLOG 96 SOLOG }10 SEASTAG 2096``` |
| Width constriction |  | Route constriction. The figure to the left indicates the width of the constriction; that to the right the total constricted length; both dimensions are in meters. | ```FM 5-36 (Sec IV, Ch 2) STANAG 2253 SOLOG 96``` |
| Arch underpass constriction |  | Width to left of symbol, overhead clearance to the right, both in meters. Both minimum and maximum overhead clearances, if different, will be given. | ```FM 5-36 (Sec V, Ch 2) STANAG 2253 SOLOG 96``` |


| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Rectangular underpass constriction with sidewalks |  | Width of traveled way followed by total width including sidewalk to left of symbol, overhead clearance to right, dimensinns in meters. | $\begin{aligned} & \text { FM 5-36 (Sec IV, } \\ & \text { Ch 2) } \\ & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Tunnel with sidewalks |  | Arrow extends to map location. Serial number is placed inside the symbol. The width of the travelled way followed by total width including sidewalks (in meters) is placed below the symbol. Overhead clearance is placed to the left of the symbol and total tunnel length to the right, both in meters. A question mark represents unknown information. Bypasses are shown by standard symbol notations. | FM 5-36 (Sec IV, Ch 2) DA Form 1250 STANAG 2096 STANAG 2253 SOLOG 96 SOLOG 107 SEASTAG 2096 |
| Railroad grade crossing |  | Level crossing; passing trains will interrupt traffic flow. The figure indicates height, in meters, of power line (if any) above the ground. | STANAG 2253 SOLOG 96 |
| Concealment $\quad *$. | $\begin{array}{l\|l} 0 & \hat{\wedge} \\ 0 & \hat{\wedge} \\ 0 & \hat{\imath} \end{array}$ | Road lined with trees; deciduous trees (left) and evergreen (right) | STANAG 2253 SOLOG 96 |
| Concealment |  | Woods bordering road; deciduous trees (left), evergreen trees (right). | STANAG 2253 SOLOG 96 |


| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Possibility of driving off road. <br> The symbol may be amplified as follows: <br> a. Wheeled vehicle <br> b. Tracked vehicle <br> c. A length of road exceeding 1 km where driving off is possible |  | Arrow indicates direction of turnoff. <br> The figure indicates the length in meters of the turnoff. | $\begin{aligned} & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Roadblock, craters, and blown bridges <br> a. Proposed <br> b. Prepared but passable <br> c. Completed |  | Center of the symbol indicates position of block. | FM 21-30 NATO and CENTO STANAG 2019 SOLOG 28 SEASTAG 2019 |
| Lateral route | $-\overline{(32)}-$ | Broken lines; identified by even number. | FM 5-36 (Sec I, Ch 2) NATO and CENTO STANAG 2151 |
| Axial route | $(57)$ | Solid line; identified by odd number. | FM 5-36 (Sec I, Ch 2) NATO and CENTO STANAG 2151 |
| Unknown or doubtfill information | $?$ |  | FM 21-30 <br> NATO and CENTO <br> STANAG 2019 <br> SOLOG 28 <br> SEASTAG 2019 |
| Parking area |  |  | FM 21-30 <br> NATO and CENTO <br> STANAG 2019 <br> SOLOG 28 <br> SEASTAG 2019 |
| Traffic control post |  |  | FM 21-30 <br> NATO and CFNTO <br> STANAG 2019 <br> SOLOG 28 <br> SEASTAG 2019 |
| Traffic control headquarters |  |  | FM 21-30 <br> NATO and CENTO <br> STANAG 2019 <br> SOING 28 <br> SEASTAG 2019 |

Figure 3-5-Continued.

## 3-27. Traffic Circulation Plans

a. Traffic circulation plans (maps) (fig. 3-6) are used to indicate a road net system of routes and to give necessary information and pertinent traffic restrictions.
b. The circulation plan establishes one-way, two-way, and alternating routes of traffic flow. Care must be taken to insure that routes are available for a circuitous flow in the required directions. A one-way route normally requires a compensating route in the opposite direction
for the return of vehicles. Adequate access and egress routes must be provided along all routes. Where the balance between main routes and access and/or egress routes is not maintained, the capability of main routes may be limited to the capability of the access or egress facilities.
c. Traffic circulation plans show the road net that is to be used and how it will be used. Normally it contains route designations and the most restrictive route features; direction


Figure 3-6. Traffic circulation plan.
of movement; location of boundaries, units, highway regulation points, traffic control posts, and principal supply activities; major geographic features; and light lines, if applicable.
d. Circulation plans frequently consist of a standard map and an overlay which together give the needed information. If the necessary information is too much to put on one overlay, separate overlays may be used to show different types of information. The sketch in figure 3-6 is one example of a traffic circulation plan. When making a traffic circulation plan, the planner or operator must be guided by what information is required by users of the plan.

## 3-28. Route Classification

For the purpose of classification, routes are designated by their ability to withstand the effects of weather. Route type is determined by the worst section of the route. Routes as classified by types are-
a. Type $X$. All-weather route is any which, with reasonable maintenance, is passable throughout the year to traffic never appreciably less than maximum capacity. The roads on this type route normally have waterproof surfaces and are only slightly affected by precipitation or temperature fluctuations. At no time is the route closed to traffic by weather effects other than temporary snow or flood blockage.
b. Type Y. All-weather route (limited traffic due to weather) is any route which, with reasonable maintenance, can be kept open in all weather but sometimes only to traffic considerably less than maximum capacity. The roads on this type route usually do not have waterproof surfaces and are considerably affected by precipitation or temperature fluctuations. Traffic may be completely halted for short periods. Heavy, unrestricted use during adverse weather may cause complete collapse of the surface.
c. Type Z. Fair weather route is any route which quickly becomes impassable in adverse weather and cannot be kept open by maintenance short of major construction. This category of route is so seriously affected by weather that traffic may be brought to a halt for long periods.

## 3-29. Military Load Classification

The military load classification system is a load-capacity rating system based on vehicle type, weight, and effect on routes and bridges. In this classification system, whole numbers are assigned vehicles, bridges, and routes. (For detailed discussion, see FM 5-36.) Most allied military vehicles are externally marked with their respective classification number. Bridges and routes are assigned military load classification based on their safe load capacity and physical dimensions.
a. Route Classification. Normally, the lowest bridge military load classification number regardless of vehicle type or conditions of traffic flow determines the military load classification of a route. Selection of the lowest bridge classification number insures that the route will not be overloaded. When a proposed route has a lower military load classification than that of the vehicles which must traverse it, this fact is shown on the route reconnaissance overlay, and a special reconnaissance is made to determine if a change in traffic control procedures, such as a single-flow crossing, would make it safe for use by such vehicles. If no bridge is located on the route and the roads are particularly bad, the worst section of road governs the route's classification.
b. Obstructions to Traffic Flow. Route obstructions are factors which restrict the type and amount or speed of traffic flow. Route obstructions, with the exception of bridge capacities, which are reported separately as a military load classification, are indicated in the route classification formula (para 3-30) by the abbreviation OB. Moreover, reconnaissance symbols are used to describe the nature of each obstruction on the route reconnaissance overlay. Obstructions to be reported include-
(1) Overhead obstructions, such as bridges, tunnels, underpasses, overhead wires, and overhanging buildings whose overhead clearance is less than 14 feet ( 4.25 m ).
(2) Reduction in traveled-way widths which are below standard minimums prescribed for the type of traffic flow (single or double, wheeled or tracked, see FM 5-36). Examples are bridges, tunnels, craters, lanes through
mined areas, and projecting buildings or rubble.
(3) Gradients (slopes) of 7 percent or greater.
(4) Curves whose radii of curvature are less than 100 feet ( 30 m ).
(5) Ferries.
(6) Fords.

## 3-30. Route Classification Formula

The route classification formula is developed from notations expressed in the standardized sequence of minimum traveled-way width, route type, lowest military load classification, and obstruction(s) if present. The formula briefly describes a specific route and is used together with a route reconnaissance overlay. If an obstruction(s) appears in the route classification formula, it is necessary to refer to the route reconnaissance overlay in order to determine the exact nature and location of the obstruction(s). Illustrative formulas are shown in a through $d$ below.
a. 20 Ft $Z$ 10. This example formula describes a fairweather route with a minimum traveled way of 20 feet and a military load classification of 10 . This route, based on its minimum width of traveled way accommodates both wheeled and tracked, single-flow traffic without obstruction. Minimum route widths, according to STANAG 2151, for wheeled and tracked vehicles in single and double flow traffic are tabulated below.

| $\begin{gathered} \text { Traffic } \\ \text { flow possibilities } \end{gathered}$ | Route Widths (STANAG 2151) wheeled vehictes | Widths for tracked vehicles |
| :---: | :---: | :---: |
| Single flow | 18 to 3 feet ( 5.5 to 7 m ). | $\begin{aligned} & 19.5 \text { to } 26 \text { feet } \\ & (6 \text { to } 8 \mathrm{~m}) . \end{aligned}$ |
| Double flow | Over 23 feet $(7 \mathrm{~m}) .$ | Over 26 feet $(8 \mathrm{~m})$ |

b. $20 \mathrm{Ft} Z 10$ (OB). This example formula describes a route with similar characteristics as in $a$ above, but with obstruction (s). It should be noted that 20 feet of traveled way limits this route to single-flow traffic without a width obstruction. If the route is to be used for doubleflow traffic, however, 20 feet of traveled way constitutes an obstruction and is indicated in the formula both as a minimum traveled-way width ( 20 ft ) and as an obstruction.
c. $7 M Y 50$ ( $O B$ ). This example formula describes a limited all-weather route with a minimum traveled-way width of 7 meters and a military load classification of 50 with obstruction(s). The traveled-way width of this route is adequate for wheeled, but not tracked, vehicles in double-flow traffic. Therefore, this width construction is indicated as (OB) in the route classification formula if the route is to be used for both types of vehicles.
d. $10.5 \times 120(O B)$. This example formula describes an all-weather route with a minimum traveled-way width of 10.5 meters, which is suitable for double-flow traffic of both wheeled and tracked vehicles, a military load classification of 120 with obstruction(s).

## 3-31. Bridge Signs

a. Circular Signs (Figs. 3-7 and 3-8). These are placed at bridges to indicate the bridge classification. The signs have a yellow background; the bridge classification and appropriate symbol are in black.
b. Rectangular Signs (Figs. 3-9 and 3-10). These signs give additional instructions and technical information. Minimum size is 16 inches by 16 inches. They have a yellow background and black symbols and lettering.


For single-lane fixed bridge.


For single-lane floating bridge.


Two-way sign limiting vehicle classes on a two-lane bridge when used as a two- or as a single-lane bridge.

Figure 3-7. Typical bridge-class and information signs.


Figure 3-8. Typical dual-class bridge signs.


Figure 3-9. Typical arrangement of road-guide information and two-lane bridge-class signs.


Figure 3-10. Typical arrangement of road-guide information and single-lane bridge-class signs.

## 3-32. Bridge and Vehicle Weight Classification

a. Posting Bridges. Every military bridge is posted with a number indicating the highest vehicle weight class that can cross safely. Vehicles of higher weight class are barred except for special crossings; for example, reduced speed or limited number of vehicles. Fixed bridges may also be marked with the length in feet of the span to which the posted capacity applies.
b. Marking Vehicles. Self-propelled vehicles in class 3 or higher and towed vehicles in
class 1 or higher are marked to indicate the class, except that prime movers are marked with either their own class or the class of the normal combination of prime mover and trailer or semitrailer. Markings on the front of the trucks should be on the right front, on or above the bumper, but below the driver's vision. Examples of vehicle marking are shown in figure 3-11. Weight classifications listings of vehicles are given in FM 5-36.

## $3-33$. Basic March Formulas

a. General. There are three basic march factors: distance ( $D$ ), rate ( $R$ ), and time ( $T$ ).


COMBINATION VEHICLES
Figure 3-11. Vehicle weight classification marking.

When two are known, the third can be found by using the formula below. Corresponding units of measure must be used throughout.

$$
R=\frac{D}{T} T=\frac{D}{R} D=R T
$$

## b. Rate Factors.

Rate $($ yards per minute $)=\frac{\text { length (yards) }}{\text { pass time (minutes) }}$
Rate $\left(\right.$ meters per minute) $=\frac{\text { length (meters) }}{\text { pass time (minutes) }}$
Rate (miles in the hour (mih)) $=\frac{\text { road distance (miles) }}{\text { time distance (hours) }}$
Rate (kilometers in the hour (kmih))
$=\frac{\text { Road distance (kilometers) }}{\text { time distance (hours) }}$
c. Time Factors.
$\begin{aligned} \text { Pass time (minutes) }= & \frac{\text { length (yards) }}{\text { rate (yards per minute) }} \\ & =\frac{\text { length (meters) }}{\text { rate (meters per minute) }} \\ \text { Time lead (minutes) }= & \frac{\text { lead (yards) }}{\text { rate (yards per minute) }} \\ & =\frac{\text { lead (meters) }}{\text { rate (meters per minute) }}\end{aligned}$
Time gap (minutes) $=\frac{\text { gap (yards) }}{\text { rate (yards per minute) }}$

$$
=\frac{\text { gap (meters) }}{\text { rate (meters per minute) }}
$$

Time space (hours) $=\frac{\text { road space (miles) }}{\text { rate }(\mathrm{mih})}$
$=\frac{\text { road space (kilometers) }}{\text { rate (kmih) }}$
Pass time (hours) $=\frac{\text { road distance }( }{\text { rate (mih) }}$
$=\frac{\text { road distance kilometers }}{\text { rate }(\mathrm{kmih})}$

## d. Distance Factors.

Length (yards) $=$ rate (yards per minute) $\times$ pass time (minutes)
Length (meters) $=$ rate $($ meters per minute $) \times$ pass time (minutes)
Lead (yards) $=$ rate (yards per minute) $\times$ time lead (minutes)
Lead (meters) $=$ rate (meters per minute) $\times$ time lead (minutes)
Gap (yards) $=$ rate (yards per minute) $\times$ time gap (minutes)
Gap (meters) $=$ rate (meters per minute) $\times$ time gap (minutes)

Road space (miles) $=$ rates $(m i h) \times$ time space (hours)
Road space (kilometers) $=$ rate $(\mathrm{kmih}) \times$ time space (hours)
Road distance $($ miles $)=$ rate $(\mathrm{mih}) \times$ time distance (hours)
Road distance (kilometers) $=$ rate (kmih) $\times$ time distance (hours)
e. Time-Distance Factors (Fig. 3-12). When the speed in miles or kilometers per hour is known, the time in minutes or the distance in miles or kilometers traveled can be quickly determined from a time-distance graph (fig. 3-13). For example, if a convoy moves at a speed of 15 miles per hour ( 24.14 kmph ) for a 2 -hour period, the distance traveled can be determined by-
(1) Locating the oblique line marked 15 mph ( 24.14 kmph ).
(2) Locating the horizontal line, extending from the left margin, representing the 2 hours traveled.
(3) Determining the point at which these two lines intersect and reading the distance in miles or kilometers from scale along the bottom (miles) or top (kilometers) margin of the graph. For this example, the distance traveled would be 30 miles ( 48.27 km ).

## $f$. Conversions.

(1) The following factors may be converted into distance or rate by arithmetic:

Length + gap = lead
Pass time (time length) + time gap $=$ time lead
Distance (miles) $\times 1,760=$ distance (yards)
Distance (kilometers) $\times 1,000=$ distance (meters)
Time (hours) $\times 60=$ (minutes)
Rate (mih) $\times 30=$ approximate yards per minute
Rate (kmih) $\times 17=$ approximate meters per minute
(2) These factors are substituted in the basic formulas in a through $d$ above.
For example:
Pass time $($ minutes $)=\frac{\operatorname{miles} \times 1,760}{\operatorname{mih} \times 30}=\frac{\text { kilometers } \times 1,000}{\mathrm{kmih} \times 17}$

$$
\begin{gathered}
\text { Speed (yards per minute) } \frac{\text { miles } \times 1,760}{\text { hours } \times 60} \\
\text { Speed (meters per minute) } \frac{\text { kilometers } \times 1,000}{\text { hours } \times 60}
\end{gathered}
$$

## 3-34. Basic Lengths

The length of any column or element of a coiumn is the length of roadway which it occupies, measured from front to rear, inclu-


Figure s-12. Space and time factors.
sive. For planning purposes, the average length of one motor transport vehicle is 10 yards (approximately 9 meters).

## 3-35. Road-Movement Graph

a. Definition. A road-movement graph (fig. $3-14$ ) is a time-space diagram used in controlling both foot and road marches and in preparing or checking road-movement tables. The graph helps the planner to foresee possible conflicts and discrepancies in planning.
b. Uses. Road-movement graphs may be used to indicate-
(1) Position of various mixed traffic on a route at a particular time.
(2) Scheduled passing of various elements of traffic at a particular point.
(3) Conflicts between various elements of traffic at junctions, intersections, bridges, and defiles.
(4) Deviations of columns from prescribed schedule.
(5) Reversing directions of march, either by simultaneous turn of all elements of a column or by circling about.
(6) Two-way traffic over a route and alternating traffic through defiles.
(7) Variations in actual running speeds and in the traffic flow and traffic density of a route.
c. Construction.
(1) Analyze the route on the map. Note important points, such as cities, towns, road junctions, bottlenecks, etc., to be passed through


Figure 3-18. Time-distance graph.
and the distance between major points along the route.
(2) Select graph paper with enough squares to plot distance and time involved. Across bottom left to right, place scale of time. In left margin, from bottom to top, place scale of distance.
(3) If the origin and destination, rate of march, and time of departure of a movement are known, schedule the head of the column as follows:
(a) Assume that a unit is to march from Mount Royal ( 25 miles ( 40.2 km )) on the vertical scale, leaving at 0700 hours and proceeding at 15 miles in the hour ( 24.1 kmih ) to a point 5 miles ( 7.4 km ) beyond Tavistock. The distance is 60 miles ( 96.5 km ). At 15 miles in the hour, it will take 4 hours to cover the 60 miles.
(b) Place a dot at the point where the line representing the place of departure (Mount Royal) at 25 miles ( 40.2 km ) on the vertical scale intersects the line representing the hour
of departure ( 0700 hours on horizontal scale).
(c) Place a second dot at the point where the line representing the destination ( 5 miles past Tavistock at the 85 -mile ( 136.7 km) mark on the vertical scale) intersects that of hour of scheduled arrival of the head of the column at the destination ( 1100 hours on the horizontal scale or 0700 plus 4 hours).
(4) Unless the unit is very small, usually it is desirable to show the schedule of the tail of the column as well as the head. After charting the schedule of the head, schedule the tail if the time length of the column is known or can be computed. Assuming that the time length of the column, including extra time allowance, is 30 minutes, a line drawn from the point representing the clearance of the column at origin ( 0730 hr ) and at the destination ( 1130 hr ) will be shown the schedule of the tail of the column past all points en route.
(5) To determine what time the column must start to complete the movement and arrive at the destination at a certain hour reverse the above procedure.
d. Analysis. Length of column, pass time (time length), rate of march, and other factors may be determined from the road-movement graph as follows:
(1) Length of column. A vertical line connecting the head and tail lines, measured by the scale of miles or kilometers, will show the planned length of the column on the road at the prescribed rate of march at any hour during the movement, provided that the extra time allowance, if any, converted to distance is subtracted from the measurement.
Example: When the head of the column is at Stevens ( 45 miles ( 72.4 km ) on vertical scale), the tail will be at approximately the 38 -mile ( 61.1 km ) mark.
(2) Pass time (time length). A horizontal line connecting the head and tail lines, measured by the scale of hours, will show the planned pass time of the column as it passes any point on the road.
Example: If the head of the column arrives at Tavistock at 1040 hours, the tail will not clear that point until half an hour iater, at 1110 hours.


Figure 3-14. Road-movement graph.
(3) Rate of march. The diagonal line of the graph indicates the rate of march.
Example: The distance (mile or kilometer scale) between the intersection of the diagonal line with any two vertical lines spanning a 1-hour period (time scale) indicates the distance in that hour.
e. Multiple Movements.
(1) A number of serials or columns over the same route can be scheduled by using a road-movement graph. The commander of a large unit or the highway regulation officer can keep accurate records of the location of each serial by having information sent to him as each serial reaches or clears highway regulation points along the route of march. This information is indicated by filling in the space between the lines representing the scheduled head and tail of each column with color or tape. This enables the headquarters to see at a glance the location of each serial, to follow the progress of each movement, to correct situations which may cause congestion and
delay, and to know where each serial can be reached in order to issue new orders if necessary.
(2) Colored pencils, crayons, ink, or adhesive tape may be used to indicate various schedules and the relative priority of movements or to plot movements in progress. For example, the head and tail schedule may be outlined by black lines, progress of each serial may be filled in with green, and failure to adhere to the schedule may be shown in red.
(3) Figure $3-15$ shows the plotted progress of serials scheduled in figure $3-14$. Note the changes and adjustments in schedules that had to be made. This is what happened-
(a) Serial A. Went through as scheduled.
(b) Serial B. Change in orders required that serial B continue on to Dundalk. It continued on schedule, and the head of the column arrived at its new destination at noon.
(c) Lateral movement. Because of a change of orders for serial B , arrangements


Figure 3-15. Deviations from schedules.
had to be made to hold the lateral movement at McLean. It made its noon halt and crossed the route 3 hours behind its original schedule, not clearing until 1830 hours.
(d) Serial C. At 1200 hours it became obvious that if serial $C$ continued on schedule, it would conflict with the delayed lateral movement at about 1730 hours. Serial C also had lost priority, because of the arrival of serial $B$ at Dundalk with critically needed supplies. Therefore, serial $C$ was halted for 2 hours (from 1200 to 1400 hours). It continued at a slower rate of march until 1700 hours, when it was halted again to let serial $D$ pass.
(e) Serial $D$ ( $D-1, D-2, D-3$ ). All elements went through on schedule.

## 3-36. Traffic Density and Traffic Flow

a. Traffic density is the average number of vehicles that occupy 1 mile or 1 kilometer of road space. It is expressed as vehicles per mile (vpm) or vehicles per kilometer (vpk)
as appropriate. This factor is based upon an average vehicle length and a constant vehicle gap.
b. Traffic flow is the total number of vehicles which will pass a designated point along a road or route of march in a given period of time, normally an hour. Traffic flow is expressed as vehicles per hour (vph). This is based upon a constant operating speed as well as an average vehicle length and a constant vehicle gap. With a constant vehicle gap, traffic flow increases as speed increases and decreases as speed is reduced.
c. Any traffic density desired for dispersion or for maintaining the maximum capacity of a route may be arrived by selecting an appropriate intervehicular gap and using the following formulas:

1 mile in yards
Desired intervehicular gap in yards + avg length of 1 veh $=$ vehicles per mile

1 kilometer in meters
Desired intervehicular gap in meters
$\overline{+ \text { avg length of } 1 \text { veh }}=$ vehicles per kilometer
Example: If vehicles are dispersed every 100 yards ( 91.4 m ), density is-

$$
\begin{aligned}
& \frac{1,760}{100+10}=16 \text { vehicles per mile } \\
& \frac{1,000}{91.4+9}=10 \text { vehicles per kilometer }
\end{aligned}
$$

$d$. When the speed and speedometer multiplier are known, traffic density may be determined by using the following formulas:

```
            1 mile in yards
(Speed in \(\mathrm{mph} \times\) speedometer multiplier)
                            \(\overline{+}\) avg length of 1 veh \(=\) vehicles per mile
                            1 kilometer in meters
(Speed in \(\mathrm{kmph} \times\) speedometer multiplier)
```

$$
\overline{+ \text { avg length of } 1 \text { veh }}=\text { vehicles per kilometer }
$$

Example: If the speed of a column is 20 miles per hour ( 32.19 kilometers per hour) and a speedometer multiplier of 2 for miles or 1.2 for kilometers is used, traffic density is-

$$
\begin{gathered}
\frac{1,760}{(20 \times 2)+10}=35 \text { vehicles per mile } \\
\frac{1,000}{(32.19 \times 1.2)+9}=21 \text { vehicles per kilometer }
\end{gathered}
$$

$e$. At a constant speed, traffic density can also be determined by counting the number of vehicles passing a given point in a period of time. Use the following formulas:
Vehicles per hour passing point
Speed in miles per hour
$\frac{\text { Vehicles per hour passing point }}{\text { Speed in kilometers per hour }}=$ vehicles per kilometer
Example: If 500 vehicles pass a given point in $1 / 2$-hour at 20 miles per hour ( 32.19 kilometers per hour), traffic density is determined as follows:

500 vehicles per $1 / 2$ hour $=1,000$ vehicles per hour

$$
\begin{aligned}
& \frac{1,000}{20}=50 \text { vehicles per mile } \\
& \frac{1,000}{32.19}=31 \text { vehicles per kilometer }
\end{aligned}
$$

$f$. Traffic flow may be determined by using the following formula:
$\frac{\text { Traffic speed ( } \mathrm{mph} \text { ) } \times 5,280 \text { (feet in } 1 \mathrm{mile} \text { ) }}{\text { Vehicle lead (from front of first to front }}=$ traffic flow to following vehicle)
Example:

$$
\frac{30 \times 5,280}{88}=1,800 \text { vehicles per hour }
$$

g. Table 3-5 provides the motor transport planner and/or operator with a convenient means of determining either or both, the traffic flow and the traffic density for planned or actual movements operating over the road at various speeds and gaps.
(1) To use table 3-5 to determine either traffic flow or traffic density, two operating factors must be known; these factors are vehicle gap and operating speed for the operation under consideration. These factors are applied by-
(a) Reading across the bottom scale to the column indicating the appropriate vehicle gap.
(b) Reading up that vehicle gap column to the block opposite the appropriate speed. This block at the intersection of these known data provides the desired answer concerning traffic density and traffic flow.
Example No. 1: Assume that a convoy is to move over a road with a vehicle gap of 40 yards and at a speed of 25 miles per hour ( mph ). By reading across the bottom scale (vehicle gap) to the 40 -yard column, and then reading up that column to where it intersects the horizontal scale (speed) at 25 mph , you come to a box that reads


The figure in the upper diagonal indicates traffic density (number of vehicles per mile of roadway) for this operation; the figure in the lower diagonal indicates traffic flow (the number of vehicles that will pass a given point in 1 hour for this operation.
(2) The same procedure as outlined in (1) above is followed when vehicle gap and speed are expressed in the metric system (meters and kilometers). However, the traffic density figures on the chart indicate vehicles per mile and this must be coverted to vehicles per kilometer; this is done by multiplying the


Notes:

1. Figures in upper diegonels of boxes denote TRAFFIC DENSITY; figures in lower diegonals of boxes denote TRAFFIC FLOW.
2. Traffic density figures reprasent VEHICLES PER MILE (VPM); o convart to VEHICLES PER KILOMETER (VPK) multiply
by .62
given traffic density figure by .62. No adjustment is required for the traffic flow since this is based on a constant time factor of 1 hour and on a given point along the route or road. Example No. 2: Assume that a convoy is to move over a road with a vehicle gap of 32 meters and at a speed of 32 kilometers per hour ( kmph ). By reading across the bottom scale (vehicle gap) to the 32 -meter column, and then reading up that column to where it intersects the horizontal scale (speed at 32 kmph ), you come to a box that reads


The figure in the uper diagonal indicates traffic density (number of vehicles per mile of roadway) for this move. To determine the number of vehicles per kilometer of roadway, the traffic density is multiplied by . 62 -if the answer contains a fraction of .50 or greater, the answer is raised to the next higher full number. For this example, $39 \times .62=24.18$ or 24 vehicles per kilometer. Since the figure in the lower diagonal represents traffic flow and is based on a time factor, no adjustment is required for this figure.
(3) Table $3-5$ has other applicationsfor example, it may be used by the motor transport planner and/or operator to determine appropriate vehicle gaps and operating speeds compatible with restrictions imposed on an operation with which he is concerned. Thus, if instructions from higher headquarters or if operating conditions dictate that only a given number of vehicles per hour arrive at a designated point, such as a critical road junction, a river crossing point, or a loading or unloading point (example 3) or that traffic density on a certain route be limited to a specific number of vehicles per mile (example 3), these restrictive figures may be correlated with those contained in the table and suitable operating gaps and speeds may be determined.
Example No. 3: Assume that the planner or operator is informed by higher headquarters that forward moving traffic passing a critical point on a route is restrained to no more than 400 vehicles per hour and he is to maintain
that flow as nearly as possible. By scanning the traffic flow figures of the table he can determine that there are several speed and gap combinations which will meet this restriction (for example, 10 mph at a 35 -yard vehicle gap- $390 \mathrm{vph} ; 15 \mathrm{mph}$ at 60 -yard vehicle gap- $375 \mathrm{vph} ; 20 \mathrm{mph}$ at 80 -yard vehicle$400 \mathrm{vph} ; 25 \mathrm{mph}$ at 100 -yard vehicle gap400 vph ). Based on this guidance and considering other operational factors involved, he can determine a suitable speed and gap for his operation.
Example No. 4: Assume that the planner or operator is informed by higher headquarters that traffic density over a given route is restricted to no more than 30 vehicles per mile and no less than 25 vehicles per mile and he is to maintain this density as nearly as possible. By scanning the traffic density figures of the table, he can determine the vehicle gaps which will meet this restriction. (At a vehicle gap of 50 yards, traffic density is 29 vehicles per mile; at a vehicle gap of 55 yards, traffic density is 27 vehicles per mile; and at a gap of 60 yards, traffic density is 25 vehicles per mile.) This information provides guidance to him in determining the vehicle gap for the operation with which he is involved.
(4) Although this table is set up in speed increments of 5 miles or 8 kilometers per hour, traffic flows for intermediate speeds may be determined if desired. This is done by dividing the difference in traffic flow between two consecutive speeds by either 5 , for miles per hour (example No. 5), or 8, for kilometers per hour (example No. 6). The result is the number of vehicles to be added to the lesser of the traffic flow figures used, for each additional mile or kilometer per hour desired above the lesser figure. (Carry any fractions through third step, then raise any fraction in result of third step to next higher number.)
Example No. 5: Assume that a planner or operator wishes to determine the traffic flow for a motor move to be conducted at a speed of 23 mph and at a vehicle gap of 50 yards between vehicles. He must-

First, determine the difference in traffic flow between 20 mph and 25 mph at a vehicle gap of 50 yards :

725 (vph at 25 mph )

- 580 (vph at 20 mph )

145
Then, divide the result by 5 (the numerical difference between 20 and 25 mph ) to determine the traffic flow for 1-mile-per-hour steps between these speeds.

$$
\frac{145}{5}=29
$$

Then, multiply this result by 3 (numerical difference between 20 and 23 mph ).

29

$$
\frac{\times 3}{87}
$$

Finally, add this resulting figure to the traffic flow indicated for 20 mph to determine the traffic flow at 23 mph .

$$
\begin{array}{r}
580 \\
+87 \\
\hline 667 \\
(\mathrm{vph} \text { at } 23 \mathrm{mph})
\end{array}
$$

Example No. 6: Assume that a planner or operator wishes to determine the traffic flow for a motor move to be operated at a speed of 45 kmph and at a vehicle gap of 64 meters between vehicles. He must-

First, determine the difference in traffic flow between 40 kmph and 48 kmph at a vehicle gap of 64 meters.

$$
\begin{aligned}
& 660(\mathrm{vph} \text { at } 48 \mathrm{kmph}) \\
& \frac{550}{110}(\mathrm{vph} \text { at } 40 \mathrm{kmph})
\end{aligned}
$$

Then, divide this result by 8 (the numerical difference between 40 and 48 kmph ) to determine the traffic flow for 1-kilometer-per-hour steps between these speeds.

$$
\frac{110}{8}=13.6
$$

Then, multiply this result by 5 (the numerical difference between 40 and 45 kmph ).

$$
\begin{array}{r}
13.6 \\
\times 5 \\
\hline 68
\end{array}
$$

Finally, add this resulting figure to the traffic flow indicated for 40 kmph to determine the traffic flow at 45 kmph .

550
$\frac{+68}{618}(\mathrm{vph}$ at 45 kmph$)$

## 3-37. Road-Movement Table

a. A road-movement table is a convenient means of transmitting to subordinates information about schedules and other essential details. This is particularly so if the inclusion of such details in the body of the operation order would tend to complicate it or make it unduly long. Tables frequently require a wider distribution than normal operation orders because copies are issued to convoy operating personnel, traffic regulating personnel, and traffic control posts. For security reasons, it may not be desirable to include dates or locations. Security classification is given in accordance with contents of the table; it is not necessarily the same : as that of the operation order. If the table is issued by itself and not as an annex to a more detailed operation or administrative order, it must be signed and/or authenticated in the same manner as other orders.
$b$. The beginning of the table includes general information common to two or more serials, e.g., security classification, maps, average speed, traffic density, halts, main routes to the start and release points, and information about other critical points. Information concerning the routes and critical points is normally described by grid references, code words, etc., and, if necessary, may be numbered or lettered for ease of reference to the columns in the table. The remainder of the table includes information concerning each individual serial and is arranged in tabular form. Table 3-6 is a sample road movement table.

## 3-38. Strip Map

A strip map (fig. 3-16) may be published as an annex to an operation order. When a strip map is used, its details should correspond to the data in the road movement table, and it should be distributed to the lowest practical level.

## TBble 3-6. Sample Road Movement Tsble

Mapa $\qquad$

1. Average apeed
2. Traffic denalty
3. Hslts
4. Routea (between start points and release pointa may be indicsted by code--red, green, etc.)
5. Critical points ${ }^{1}$
a. Start pointa
b. Release pointits
c. Other criticsl points

Annex $\qquad$ to $\qquad$ (Formation/Linlu) Operstion Order No. $\qquad$ (
$\qquad$

These routes snd points may be described by grid references, code worda, etc., and if necessary, numbered or lettered for ease of reference in the columns below.

| $\text { Serisi }{ }^{2}$$\text { ( } \mathrm{s})$ | Dste <br> (b) | Unit formation(c) | No. of vehiclea (d) | Load clasa of heavieat vehiclea (e) | From <br> (f) | To$\text { ( } \mathrm{L})$ | Route <br> (h) | Route to etart point (1) | Critical pointal |  |  | ```Route from release point (n)``` | $\text { Remarka }{ }^{3}$ <br> (o) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  | Ref (k) | $\begin{gathered} \text { Due } \\ \text { (hrs) } \\ (1) \\ \hline \end{gathered}$ | Clear (hra) (ㄹ) |  |  |
| 1 | 23 Oct | 46 Trana Co 51 Trans Co (Lt Trk) | 90 | 21 | Maraellle | Montelimar | $\begin{aligned} & \text { N } 113 \\ & \text { N } 538 \\ & \mathrm{~N} 7 \end{aligned}$ | City | Marseille | 0800 | 0818 | N 540 | Return to Marseille imediately after unloading as Serisl 1A. |
|  |  |  |  |  |  |  |  |  | Salon | 0935 | 0935 |  |  |
|  |  |  |  |  |  |  |  |  | Plan-Orgon | 1016 | 1034 |  |  |
|  |  |  |  |  |  |  |  |  | Avignon | 1059 | 1117 |  |  |
|  |  |  |  |  |  |  |  |  | Orange | 1150 | 1208 |  |  |
|  |  |  |  |  |  |  |  |  | Plerralatte | 1250 | 1308 |  |  |
|  |  |  |  |  |  |  |  |  | Montelimar | 1330 | 1346 |  |  |
| 2 | 23 0ct | $\begin{aligned} & 67 \text { Trana Co } \\ & 70 \text { Trans Co } \\ & \text { (Lt Trk) } \end{aligned}$ | 120 | 21 | Maraeille | Montelimar | N 113 <br> N 538 <br> N 7 | City | Maraeille | 0820 | 0851 | N 540 | ```Relleved from at- zschment upon closing in Mar- aeille.``` |
|  |  |  |  |  |  |  |  |  | Salon | 1003 | 1026 |  |  |
|  |  |  |  |  |  |  |  |  | Plan-Orgon | 1044 | 1107 |  |  |
|  |  |  |  |  |  |  |  |  | Avignon | 1127 | 1150 |  |  |
|  |  |  |  |  |  |  |  |  | Orange | 1218 | 1241 |  |  |
|  |  |  |  |  |  |  |  |  | Pierralatte | 1318 | 1341 |  |  |
|  |  |  |  |  |  |  |  |  | Montelimar | 1358 | 1421 |  |  |
| 3 | 23 0ct | 89 Trans Co 90 Trana Co (Med Trk) | 115 | 21 | Maraeille | Montelimar | $\begin{aligned} & \text { N } 113 \\ & \text { N } 538 \\ & \text { N } 7 \end{aligned}$ | N 8 | Maraeille | 0901 | 0925 | N 540 |  |
|  |  |  |  |  |  |  |  |  | Salon | 1036 | 1100 |  | Halt in place aouth of Avignon. Resumic. march at 1335 hours. |
|  |  |  |  |  |  |  |  |  | Plan-Orgon | 1117 | 1141 |  |  |
|  |  |  |  |  |  |  |  |  | Avignon | 1201 | 1359 |  |  |
|  |  |  |  |  |  |  |  |  | Orange | 1426 | 1450 |  |  |
|  |  |  |  |  |  |  |  |  | Pierralatte | 1526 | 1550 |  |  |
|  |  |  |  |  |  |  |  |  | Montelimer | 1605 | 1629 |  |  |

[^9]

Figure 3-16. Sample strip map.

## Section IV. MOTOR TRANSPORT PLANNING

## 3-39. General Planning Factors

a. Motor transport planning, particularly in its earliest stages, must often be based on broad planning factors and assumptions. However, because of the varied services performed, the type of loads carried, and the varied terrain features over which motor transport operations are conducted, general planning factors should be used with caution and only in the absence of specific data on the local situation.
$b$. When specific data is not available, the following factors are used in motor transport planning to compute vehicle and truck company requirements.
(1) Average number of assigned task vehicles not in maintenance and therefore available for daily operations:

Operational short range- 83 percent (maximum sustained effort; used only for all-out effort, and then only for
periods of less than 30 days). Long range planning- 75 percent.
(2) Anticipated payload per vehicle: Off-road-rated cargo capacity of vehicle (except tank semitrailers which are rated at 3,000 -gallon capacity for off-road operations).
Highway-rated cargo capacity plus 50 percent for trailers or semitrailers and 100 percent for tactical wheeled vehicles (except tank semitrailers which have a maximum load capacity of 5,000 gallons).
(3) Daily round trips that a vehicle averages (these vary with running time and delay times) :

Line haul-one per operating shift.
Local haul-four per day (2 per operating shift).
(4) One-way distance cargo is to be
hauled, from which round trip mileage may be computed:

Line haul- 90 miles one way per operating shift.
Local haul- 15 miles one way per trip.
(5) Average number of miles covered in an hour, including short halts during the period of movement:

Poor roads- 10 miles in the hour.
Good roads- 20 miles in the hour
Note. Under road conditions, not only surface must be considered but also terrain, whether, and hostile activity which may affect rate of march.
(6) Turnaround time-time consumed round-trip movement, including delays.
(7) Delay-time consumed in loading and unloading and/or relay time in line haul relay operations. (Time for halts and delays en route, such as mess halts, ferrying operations, etc., which can be anticipated but are not included in the rate of march, must be included in delay time.)

Straight trucks-2.5 hours loading and unloading time per round trip (straight haul).
Semitrailers-2.5 hours loading and unloading time per round trip (straight haul).
Truck tractors in semitrailer relay operations-1 hour per relay (round trip per line-haul leg).
(8) Number of hours per day in which vehicles with drivers are normally employedOne shift- 10 hours.
Round-the-clock (two shifts) - 20 hours.
(9) Unit lift and daily lift-unit lift is the amount of cargo a truck company can move at one time; daily lift is that which it can move in a day, making a number of trips.
(10) Ton miles and passenger miles-the product of the number of tons or passengers times the number of miles moved.

## 3-40. Unit and Vehicle Capability Estimates

a. Unit Capability. For planning purposes and in the absence of other specific operational data, motor transport unit capability estimates, based on tables of organization and equipment (TOE) capabilities, are shown in tables 3-7 through 3-10.

Table 8-7. Unit Tonnage Capability EstimatesLocal Hauls
(Vehicle availability times average tons per vehicle times trips per day $=$ short ton capability per day.) Light truck company

| ( $21 / 2$-ton truck) | $45 \times 4 \times 4=$ | 720 |
| :---: | :---: | :---: |
| Light truck company |  |  |
| (5-ton truck) | $45 \times 6 \times 4=$ | 1,080 |
| Medium truck company (cargo) |  |  |
| 12 -ton stake and platform | $45 \times 12 \times 4=$ | 2,160 |

Medium truck company (petroleum)
( 5,000 -gallon tanker) - --- $45 \times 5,000 \times 4=900,000 \mathrm{gal}$.
Medium truck company (reefer)
( $71 / 2$-ton reefer van) --.------ $45 \times 6 \times 4=1,080$
Heavy truck company
( 50 -ton semitrailer) --------- $18 \times 40 \times 4=2,880$
Light-medium truck company:
$21 / 2$-ton truck ---------------- $\quad 45 \times 4 \times 4=720$
12 -ton stake and platform … $8 \times 12 \times 4=r \quad 384$

Table 3-8. Unit Passenger Capability Estimates--
Local Hauls
(Vehicle availability times passengers per vehicle times
trips per day = passenger capability per day.)
Light truck company
( $21 / 2$-ton truck)
Light truck company
(5-ton truck) ------------------ $45 \times 20 \times 4=3,600$
Medium truck company
(cargo) ${ }^{a}$------------------------- $\quad 45 \times 50 \times 4=9,000$
$21 / 2$-ton truck -------------------- $\quad 45 \times 20 \times 6^{b}=5,400$
12 -ton stake and platform ${ }^{a} \ldots \ldots \quad 8 \times 50 \times 6^{b}=7,800$
Total $=13,200$

[^10]Table 3-9. Unit Tonnage Capability EstimatesLine Hauls
(Vehicle availability times average tons per vehicle times trips per day $=$ short ton capability per day.) Light truck company
( $21 / 2$-ton truck) --------------- $45 \times 4 \times 2=360$
Light truck company
( 5 -ton truck) --------------- $45 \times 6 \times 2=540$
Medium truck company (cargo)
( 12 -ton stake and platform) - - $45 \times 12 \times 2=1,080$
Medium truck company (petroleum)
( 5,000 -gallon tanker) - $45 \times 5,000$ gal. $\times 2=450,000$ gal.
Medium truck company (reefer)

| ( $71 / 2$-ton reefer van) | $45 \times 6 \times 2=$ | 540 |
| :---: | :---: | :---: |
| Heavy truck company |  |  |
| ( 50 -ton semitrailer) | $18 \times 40 \times 2=$ | 1,440 |
| Light-medium truck company: |  |  |
| 21/2ton truck | $45 \times 4 \times 2=$ | 360 |
| 12-ton stake and platform | $8 \times 12 \times 2=$ | 192 |
|  | Total | 552 |

## Table 3-10. Unit Passenger Capability Estimates-

 Line Hauls(Vehicle availability times passengers per vehicle times trips per day = passenger capability per day.)
Light truck company

b. Vehicle Capabilities. Vehicle capabilities given in table 3-11 may be used in conjunction with other planning factors.

[^11]Table 3-11. Vehicle Payload Capacities for General Planning


C 3, FM 55-15

| Nomenclature | $\begin{aligned} & \text { Off-road } \\ & \text { (tons) } \end{aligned}$ | Highway average (tons) | Highway maximum (tons) | $\begin{gathered} \text { Towing cap } \\ \text { Highway } \end{gathered}$ | city (tons) Crosscountry | Passengers ${ }^{\text {a }}$ | Cargo space |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Trk, shop, van, $21 / 2$-ton, $6 \times 6$, M220 | 21/2 | $31 / 2$ | $31 / 2$ | 4 | 3 |  |  |
| Trk, shop, van, $21 / 2$-ton, $6 \times 6$, M292 | $21 / 2$ | $21 / 2$ | 21/2 | 4 | 3 |  |  |
| Trk, tk, gas, $21 / 2$-ton, $6 \times 6$, M217 | 750 gal. | 1,200 gal. | 1,200 gal. |  |  |  |  |
| Trk, tk, water, $21 / 2$-ton, $6 \times 6 \mathrm{M} 222$ | 1,000 gal. | 1,000 gal. | 1,000 gal. |  |  |  |  |
| $\begin{aligned} & \text { Trk, cgo, 5-ton, } 6 \times 6 \\ & \text { (single tires) } \end{aligned}$ | 5 | 6 | 71/2 | 15 | 71/2 | $20^{\prime}$ | 550 cu ft |
| Trk, cgo, 5 -ton, $6 \times 6$ (dual tires) | 5 | 6 | 10 | 15 | 71/2 | $20^{f}$ | 550 cu ft |
| Trk, dump, 5 -ton, $6 \times 6$-- | 5 | 71/2 | 71/2 | 15 | 71/2 | $15^{\text {c }}$ | 135 cu ft |
| Trk, cgo, prime mover, 10ton, $6 \times 6$, M125 | 10 | 10 | 15 | 25 | 15 |  | 496 cu ft |

a Based on 18 inches per man. Does not include driver or assistant.
$b$ Less individual field equipment.
$c$ Recommended for emergency use only. No troop seats provided.
d Not generally used for this type of operation.
c For short hauls: reduce to 16 for long hauls.
$f$ For short hauls; reduce to 18 for long hauls.
c. Specific Loads. A transport mission may require the movement of a number of specific loads consisting of one or more items which may or may not be packaged (aircraft engines, missile components) and which because of their peculiarities in either size, shape, cube, or weight, involve a variation of the normal planning process to determine vehicle requirements for the operations. In such a case, vehicle requirements may be determined through test loading or by using operational data available from previous similar operations. If test loading is not feasible or operational data is unavailable, vehicle requirements may be determined using the following method:
(1) First, determine the number of items that can be transported by one vehicle. This can be computed by using either cargo weight ( (a) below) or cargo cube ( (b) below), or if the circumstances warrant, by using both methods to arrive at an optimum figure.
(a) Vehicle payload capacity
weight of item
$=$ number of items, by weight, that may be loaded onto one vehicle
(b) $\frac{\text { Vehicle cargo compartment cube }}{\text { cube of item }}$
$=$ number of items, by cube, that may be loaded onto one vehicle
(2) Secondly, using the appropriate single vehicle load (the lesser of ( $a$ ) and ( $b$ ) above)
when vehicle capacity is figured both ways, compute the number of vehicles required as follows:
$\frac{\text { Number of items to be transported }}{}{ }^{*}$ Number of items that can be loaded $_{\text {( }}^{\text {vehicles }}$ required onto one vehicle

Note. When the vehicle load capacity is computed both ways, use the lesser of the results obtained by using methods described as ( $a$ ) and ( $b$ ) under (1) above because: If ( $a$ ) is the lesser, it indicates that the weight of the computed load will exceed the vehicle payload capacity before all available cargo space is filled. If ( $b$ ) is the lesser, it indicates that the computed cargo load will "cube out" (exceed the cubic cargo space available in the vehicle) before it exceeds the vehicle payload capacity.
d. Vehicle Payload Capacity. The vehicle payload (off-road or on-highway as applicable) and the cubic capacity of the vehicle cargo compartment may be obtained from the vehicle data plate, vehicle technical manual, or tables $3-7$ through $3-11$ in this chapter. The weight and/or cubic volume of the specific item or load to be transported can be obtained from the shipper, the service representative, or the technical manual applicable to the particular item of equipment to be transported.

[^12]
## 3-41. Highway Tonnage Capabilities

a. In selecting the routes over which cargo is to be hauled, considerations must be given to the capabilities of the roads and bridges to sustain the operation. The gross weight of the heaviest loaded vehicle should not exceed the rated tonnage capacity of the weakest bridge unless it is determined that such bridges will be strengthened. It is difficult to determine the exact tonnage capabilities of highways for sustained operations because of the number of varying conditions which may prevail. Also, the volume of tactical, administrative, and local traffic traveling over the supply routes may exceed the number of cargo-
hauling vehicles which further restricts the capabilities of highway transport.
b. Table 3-12 may be used as a guide in the absence of more accurate data for estimating the supply suport tonnage capabilities of highways under varied conditions, assuming that operations are sustained, adequate road maintenance is provided, and the road bears twoway traffic. In using the table of reductions, when more than one limiting factor is involved, apply the narrow roadway factor first; then to the new capability, apply one of the next three on terrain; finally to the latter adjustment, apply the weather factor if the conditions are for a sustained period.

Table 3-12. Highway Tonnage Capabilities

|  | Daily tonnage forward (short tons) |  |  | Reductions applicable to various conditiona (percentage) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Highway type | Optimum dispatch route only | Supply traffic communications zone | Supply traffic combat zone | ```Narrow roadwey (less than 24 ft or 7.20 meters)``` | Rolling terrain | Hills with curves | Mountainous | Seasonal bad weather |
| Concrete | 60,000 | 36,000 | 8,400 | 25 | 10 | 30 | 60 | 20 |
| Bituminous | 45,000 | 27,000 | 7,300 | 25 | 10 | 30 | 60 | 30 |
| Bituminous treated -- | 30,000 | 18,000 | 5,800 | 25 | 20 | 40 | 65 | 40 |
| Gravel | 10,150 | 6,090 | 3,400 | 25 | 20 | 50 | 70 | 60 |
| Dirt ---------------- | 4,900. | 2,940 | 1,600 | 25 | 25 | 60 | 80 | 90 |

## 3-42. Formulas for Determining Unit and Vehicle Requirements

The following formulas are applied in computing unit or vehicle requirements on the basis of planning data discussed in paragraphs 3-39 and 3-40, actual operational data, or a combination of both. The number of units or vehicles required for workloads expressed in gallons, persons, or other units of measure can be determined by subsituting that unit of measure for tons in the formulas.
a. One-Time Lifts. To determine the number of truck companies or vehicles required to move a given number of tons in one lift, substitute appropriate figures in the following formula:

Companies required
> tons to be lifted
> tons per vehicle $\times$ vehicles available per company Vehicles required $=\frac{\text { tons to be lifted }}{\text { tons per vehicle }}$
> b. Turnaround Time. To determine turn-
around time, use the following formula. (Caution must be exercised to make sure that the delay factor is accurate. Turnaround time should be rounded off to the nearest tenth for use in computations.)

$$
\text { Turnaround time }=\frac{2 \times \text { distance }}{\text { rate of march }(\text { mih })}+\text { delays }
$$

c. Distance Between Truck Terminals or Trailer Transfer Points. When locating truck terminals or trailer transfer points, the following formula is used to determine the appropriate distance between these installations in order to obtain a specific turnaround time:
Distance

$$
=\frac{\text { hours per operating shift }- \text { delays } \times \text { rate }(\text { mih })}{2}
$$

d. Sustained Openations. The following formula is used to determine the number of truck companies required to move a given daily tonnage in sustained operations. (This formula is applicable to both local and line-haul operations.

The number of vehicles required can be determined by omitting vehicles available per company from formula) :
Companies required $=\frac{\text { daily tonnage } \times \text { turnaround time }}{\begin{array}{l}\text { tons per vehicle } \times \text { vehicles avail- } \\ \text { able per company } \times \text { operational } \\ \text { day }\end{array}}$

## 3-43. Line-Haul Operational Planning Exercise

The following procedure demonstrates the method of planning and setting up a motor transport line-haul move involving trailer transfer operations. For the purpose of planning this exercise, the location of support facilities involved, the routes to be used, and the distances between points over which the operations will be conducted are shown in figure 3-17.


Figure 3-17. Route and facilities diagram.
a. Tonnages to be moved by Motor Transport.
(1) Information provided by the staff movements officer establishes tonnages to be moved by highway as follows :

3,600 short tons from Port Alpha to Depot 301
2,400 short tons daily from Red Beach to Depot 101

1,500 short tons daily from 101 to Depot 301.
(2) A graphic portrayal of the daily tonnages to be moved between activities and the routes over which these tonnages will move in this operation are illustrated in figure 3-18. The daily movement of 3,600 short tons from Port Alpha forward and of the 1,500 short tons from Depot 101 have been combined at the point on the route where these forward movements coincide. This provides a realistic picture of the flow of tonnages over the road and a working aid in planning for an operation of this type.


Figure 3-18. Tonnage information diagram.
b. Openational Planning Factors. The following operational factors will govern the planning for this operation:
(1) Round-the-clock operation-two 10hour shifts.
(2) Vehicles available per unit-42.
(3) Load per $21 / 2$-ton truck- 3.5 tons.
(4) Load per 12 -ton cargo semitrailer- 10 tons.

Note. Cargo to be transported is of a type that permits vehicles to be loaded to rated weight capacities without exceeding cube capacities of cargo compartments.
(5) Rate of march: 20 mih-main supply route between origin and destination terminals.
15 mih-Port Alpha to origin terminal, Depot 101 to origin terminal, destination terminal to Depot 301.

10 mih-Red Beach to Depot 101.
(6) Delay times:
2.5 hours per round trip for loading and unloading straight ( 1.25 hours for loading and 1.25 hours for unloading).

1 hour per relay (round trip per leg) for truck tractors engaged in line haul operations and/or shuttle operations between terminals and supported agencies.
c. Location of Truck Terminals. Because the operation involves a line haul and the distances and operating factors dictate the establishment of short haul and/or shuttle tractor operations in conjunction with a trailer relay operation, it is necessary to determine the approximate locations of the origin and destination truck terminals for the line haul task in order to separate the line haul from local operations and to identify specific workloads and tasks.
(1) The origin truck terminal should be centrally located near the road intersection between Port Alpha and Depot 101, provided a suitable site is available.
(2) The destination truck terminal should be located near the intersection north of Depot 301 to be near the cargo's destination and to be on the main route to allow for expansion forward without relocation (fig. 3-19).
d. Location of Trailer Transfer Points. Before determining and computing the type and number of truck units required for each task for the line haul, the location of trailer transfer points to divide the line haul into legs must be determined so that total delays and total turnaround time for the entire line haul can be computed. The distance to allow between trailer


Figures ®-1 $^{\text {19. Location of truck terminals. }}$
transfer points to obtain a turnaround time of 10 hours (one shift in the operational day) is obtained as follows: (the 1-hour delay in the formula is to 1 -hour relay time per line haul leg).
Distance
$=\frac{10 \text { hours per operating shift }-1 \text { hour delay } \times 20 \mathrm{mih}}{2}$ $=\frac{(10-1) \times 20}{2}=90$ miles between trailer transfer points
Trailer transfer points are then located as shown in figure 3-20. In addition of the consideration of distance to allow for the most desirable turnaround time, the planner must consider suitable sites for locating these facilities. Note that the short leg ( 53 miles) has been placed forward. This is to avoid relocating any but the most forward trailer transfer point if the operation is expanded.
e. Types of Units Required. Based on thepreceding information, specific tasks, workloads, and the types of units required to perform the various transport missions of this operation can now be determined. A study of the overall operation including the types of hauls involved, the operating areas, and the daily tonnage requirements indicates that the


Figure 3-20. Location of trailer transfer points.
following types of units would be most suitable, for the missions as indicated:
(1) Line haul from the truck terminal to Depot 301: 5,100 short tons, medium truck companies.
(2) Port Clearance from Port Alpha to origin truck terminal: 3,600 short tons, medium truck companies.
(3) Beach Clearance from Red Beach to Depot 101: 2,400 short tons, light truck companies ( $21 / 2$-ton).
(4) Delivery of cargo from Depot 101 to origin truck terminal: 1,500 short tons, medium truck companies.
(5) Delivery of cargo from destination truck terminal to Depot 301: 5,100 short tons, medium truck companies.
f. Computing for Medium Truck Companies Required for Line-Haul Tasks.

Daily tonnage: 5,100
Turnaround time
$=\frac{2 \times 233}{20 \mathrm{mih}}+3$ hours delay (1 hour for each relay),
$\begin{gathered}3 \text { relays for each leg of the line-haul, } \\ 1 \text { operating (10-hour) shifts }=26.3 \text { hours }\end{gathered}$ Tons per vehicle (12-ton semitrailer): 10 short tons Vehicles available per company: 42 Operational day: 20 hours

Thus
Companies required

$$
\begin{aligned}
& =\frac{5,100 \text { short tons } \times 26.3 \text { hours }}{10 \text { short tons } \times 42 \text { vehicles } \times 20 \text { hours }} \\
& =15.93 \text { or } 15.9 \text { medium truck companies } \\
& \text { required }
\end{aligned}
$$

g. Computing for Medium Truck Companies Required for Local Hauls.
(1) Movement of 5,100 short tons from destination truck terminal to direct support activity (Depot 301) :
Daily tonnage: 5,100 short tons
$\begin{aligned} \text { Turnaround time } & =\frac{2 \times 10 \text { miles }}{15}+1 \text { hour delay (1 hour } \\ & =2.33 \text { hours relay time) }\end{aligned}$
Tons per vehicle (12-ton semitrailer) : 10 short tons
Vehicles available per company: 42
Operational day: 20 hours
Thus
Companies required $=\frac{5,100 \text { short tons } \times 2.33}{10 \text { short tons } \times 42 \times 20}$

$$
=1.41 \text { or } 1.5 \text { medium truck com- }
$$ panies required

(2) Movement of 3,600 short tons from Port Alpha to the origin truck terminal:
Daily tonnage: 3,600 short tons
Turnaround time $=\frac{2 \times 15 \text { miles }}{15 \mathrm{mih}}+1$ hour delay ( 1 hour relay time)

$$
=3 \text { hours }
$$

Tons per vehicle ( 12 -ton semitrailer) : 10 short tons Vehicles available per company: 42
Operational day: 20 hours
Thus
Companies required
$=\frac{3,600 \text { short tons } \times 3 \text { hours }}{10 \text { short tons } \times 42 \text { vehicles } \times 20 \text { hours }}$
$=$
$=1.28$ or 1.3 medium truck companies
required
(3) Movement of 1,500 short tons from Depot 101 to the origin truck terminal:

Daily tonnage: 1,500 short tons
Turnaround time $=\frac{2 \times 5 \text { miles }}{15 \mathrm{mih}}+\dot{1}$ hour delay ( 1 hour

$$
=1.66 \text { hours }
$$

Tons per vehicle ( 12 -ton semitrailer) : 10 short tons
Vehicles available per company: 42
Operational day: 20 hours

Thus
Companies required $=\frac{1,500 \text { short tons } \times 1.66 \text { hours }}{10 \text { short tons } \times 42 \times 20 \text { hours }}$

$$
=.29 \text { or } .3 \text { medium truck companies }
$$

h. Total Medium Truck Companies Required.
(1) The total medium truck companies required for local and line-haul tasks are as follows:
15.9 line haul
1.5 destination truck terminal to Depot 301
1.3 Port Alpha to origin truck terminal

3 Depot 101 to origin truck terminal
19.0 truck companies
(2) Thus 21 medium truck companies are required to accomplish all tasks for which medium companies have been selected. In this operation the workload is shared among all medium truck companies since all are connected with the semitrailer relay operation. Therefore, the fractional part of the unit requirement for each task is retained and included in the total, and the total is then rounded off to the next higher number of units. However, where the workload cannot be shared among units doing varied tasks, the unit requirement for each task must be rounded off to the next higher whole number. (Each of the medium truck companies requires two semitrailers per tractor since all units will be involved in semitrailer relay operations.)
i. Computing for Light Truck Companies Required for Beach Clearance. Computation of the number of light truck companies required for moving 2,400 short tons daily from Red Beach to Depot 101 is as follows:

Daily tonnage: 2,400 short tons
Turnaround time $=\frac{2 \times 15 \text { miles }}{10 \mathrm{mih}}+2.5$ hours delay (2.5 hours per round trip for loading and unloading straight trucks) $=5.5$ hours
Tons per vehicle ( $21 / 2$-ton truck) : 3.5 short tons
Vehicles available per day: 42
Operational day: 20 hours
Thus

$$
\begin{aligned}
\text { Companies required }= & \frac{2,400 \text { short tons } \times 5.5 \text { hours }}{3.5 \text { short tons } \times 42 \times 20 \text { hours }} \\
= & 4.48 \text { or } 5 \text { light truck companies } \\
& \begin{array}{l}
\text { (fraction raised to next higher } \\
\text { number) }
\end{array}
\end{aligned}
$$

Note. Three teams, GD, light truck squad (TOE 55-540) may be used as augmentation to meet the transport capability required by the .48 percent required over four companies. This would eliminate the need to assign a full five companies to the operation.
j. Control Units Required. Based on the preceding computations, 19 medium truck companies and either four light truck companies with augmentation or five full light truck companies are required for the operation. In addition, four teams (team GF, TOE 55-540) are required to move the two trailer transfer points and the transfer operations in the truck terminals. For command and control of these units, four motor transport battalions and one motor transport group are required. (See FM 101-10-2, for basis of allocation.) The group commander has overall responsibility for the operation and assigns a specific geographic area to each battalion. The responsibility for operating each truck terminal is assigned to a specific battalion.

## 3-44. Maintenance Organization

Category
Organizational

That maintenance normally authorized for, performed by, and the responsibility of a using unit on equipment in its possession. This maintenance consists of functions and repairs within the capabilities of authorized personnel skills, tools, and test equipment as prescribed in unit's TOE or TD.
(Formerly known as 1 st and 2d echelon maintenance.)

Direct support
Maintenance normally authorized for, performed by, and the responsibility of designated maintenance activities. Direct support maintenance units provide support where feasible by on-site repair, replacement of assemblies and components, delivery of parts to the user, and technical assistance. Normally, TOE and TD of direct support organizations specify this unit as having a maintenance mission and provide using units with on-site repairs.
(Formerly known as 3d echelon maintenance.)

## Scope

Care taken of, and maintenance performed on equipment to keep it in a serviceable condition in accordance with applicable DA publications, such as TM's, TB's, LO's, and equipment serviceability criteria. These functions consist of: inspections, servicing, adjustments, lubrication, scheduled services, minor repairs, proper operation, records, and equipment serviceability criteria. All repair parts, replacements, and levels must be in accordance with prescribed load list and levels as prescribed by TOE and TD.

Provide for replacement of major parts, components, assemblies, and end items. Arrange for the evacuation of unserviceable equipment from user to an activity where repairs can be accomplished or to a collection or salvage facility. Assist in the performance of maintenance inspections of equipment and of organizational maintenance operations of the user to ascertain the condition of equipment and the effectiveness of organizational maintenance. Provide repair parts support, technical advice to units supported, maintenance float items, and inspection personnel.

Performed by
Operator of crew and organizational mechanics.

Responsibility of Unit commander.

Army commander, division commander, installation commander.

General support

Depot

Maintenance normally performed by semimobile units in support of the supply system or when required, to support direct support units in the maintenance and repair for return to user

Maintenance normally performed by permanent installations using extensive equipment.

Provide for the repair of end items and assemblies for return to the supply system or maintenance float. The performance of maintenance is accomplished through use of maintenance standards. This includes the overhaul and repair of end items and components for return to stock. Provide inspection personnel.
Provide for overhaul and repair of economically repairable materiel, augment the procurement program in satisfying overall Army requirements and when required, provide for repair of materiel beyond the capability of general support maintenance organizations and the maintenance of depot stock in a ready-for-issue condition.

Units having GSU respon- Army field commanders. sibility.

Depot maintenance units. Chief of Army Materiel Command.

## 3-45. Biyouac Defense

a. General. The security of a truck company's bivouac area is primarily the responsibility of the company commander. Since the success of any defense plan depends upon the training of the men and their ability to react rapidly when attacked, intensive training in defense is also a unit commander's responsibility. Both active and passive defense are employed to protect a truck company bivouac area. Active defense is generally employed against ground attack. A unit employs limited offensive action and counterattacks to deny the bivouac site to a hostile force. Passive defense is used primarily against air attack; a truck company uses such protection as that offered by concealment, dispersion, and deception to protect itself without taking the offensive.
b. Active Defense. Active defense of a truck company's site does not include aggressiveness beyond the perimeter of the bivouac area. Except for those who man machineguns and observations and listening posts, members of the unit do not penetrate beyond the bivouac boundaries. Because ground forces may strike a truck company at several points simultaneously or in concert with airborne forces before mobile defense forces can reach the company commander, the company commander must be prepared to employ his own forces effectively at all times. Consequently, it is assumed in this text that the defense of the unit will be handled by the truck unit without outside assistance. A typical bivouac is illustrated in figure 3-21.
(1) Two-stage alert. The alarm system for a truck company usually provides for a twostage alert. The first stage, attack-likely, warns unit personnel by audible or unusual signals that an attack will probably take place, troops are positioned in pairs with one man remaining alert at all times. If the situation permits, the other member of the team may sleep. During the attack-likely alert, those who are not actively performing duties which are a part of the unit's primary function man their defensive positions. At this time, every effort should be made to continue with the unit's normal mission. When the second stage alarm is given, attack-imminent, all personnel discontinue their routine duties and man their defensive posi-
tions. The reserve force is not committed at this time, but is held in position, usually near the command post, until deployed by the company commander. Personnel remain in their defensive postions until the all-clear signal is given.
(2) Firing on the enemy. When enemy forces are observed advancing on the bivouac, they are fired on by the longest range weapons available. This fire must cover the withdrawal of outposts when the enemy threatens their security. Attacks must be kept under accurate fire as they approach; when they are within assaulting distance, approximately 150 yards or less, they should be hit with maximum volume from all weapons available. Defensive troops should not engage in close combat before attacking forces reach the prepared defensive positions. Enemy combat elements sighted in the vicinity should not be fired upon when it is apparent that they intend to bypass the truck company bivouac. However, information of enemy troops in the area should be expeditiously forwarded to the nearest senior commander of friendly forces.
(3) Counterattacking. Every effort to destroy the enemy must be made if he penetrates the perimeter defense and threatens the unity of internal defense. Failing this, the commander may use his reserve forces to destroy attackers and restore the integrity of the company's position and block farther advance by the enemy. Without supporting artillery and air defense and lacking the shock of armor, the advantage of counterattacking must be weighed against the advantages of continuing the fight from positions which offer some cover from enemy fire. A counterattack is launched only when there is a reasonable chance of destroying the enemy forces or driving them outside the perimeter defense. Defense of the area does not include pursuit of hostile forces.
(4) Withdrawing. When confronted with a superior force which threatens large-scale defeat or destruction, support units are normally not bound to defend their areas at all costs; they may withdraw with approval of the next higher command. However, unit defense plans include provisions for adequate striking forces for counterattacks to make with-


COMPANY AREA: 0959 SQ MILES OR 61.4 ACRES COMPANY FRONT: 1,900 YD (1,737 MTERS) PLATOON FRONT: 630 YD (576 METERS) CP AREA: 75-YD ( 69 METERS) RADIUS

Figure 3-21. Truck bivouac area organized for defense against ground attack.
drawal unnecessary. When withdrawal is necessary, the commander must make the decision and execute it before the defending force is heavily engaged with the attacking force. When contact with the enemy has been established, a small detachment is detailed to cover the withdrawal. Before withdrawing from the area, all equipment, supplies, and ammunition that may be of value to the enemy must be destroyed. When possible, the retreating detachment is provided with motor transportation.

During periods of active engagement with the enemy, the company commander should be continuously advised with situation and status reports from elements engaged. All means of communication should be used in keeping the company commander informed so that he may make logical decisions to cope effectively with the situation.
(5) Passive defense. Concealment and dispersion are important passive defense measures against attack, especially from the air.

The unit commander directs the construction of two-man foxholes with adequate overhead concealment immediately after occupying a site. Foxholes are usually camouflaged with growth from the surrounding area. The use of wooded areas, smoke, blackout lights, cover for reflective surfaces, protective shadows, and limiting movements are means of concealment. Dispersion reduces the amount of personnel and equipment which can be damaged by a single projectile. The enemy can be deceived about the location of a bivouac by making vehicle tracks into an unoccupied wooded area and concealing tracks leading to the true location of the bivouac.

## 3-46. Typical Truck Terminal

Figure 3-22 shows a typical origin truck terminal. Arrangement of facilities may deviate from the illustration, but the facilities indicated should be considered the minimum necessary for effective operation of the terminal.

## 3-47. International (Geneva Convention) Road Signs

The road signs discussed in this paragraph were agreed upon at the United Nations Conference on Road and Motor Transport in 1949. Although these signs are not military, Army personnel should be familiar with them since they are used in oversea areas.
a. Dimensions of Signs. Dimensions of various signs are standardized in each country to insure maximum uniformity. In general, two sizes are used for each type of sign-a standard size and a reduced size for use where conditions do not permit or the safety of road users does not require erection of the standard size. In exceptional circumstances, a small sign may be used inside built-up areas or for repetition of the main sign.
b. Danger Signs (Class I) (Fig. 3-23). Danger signs are in the shape of an equilateral triangle with one point upward, except in the case of the sign PRIORITY ROAD AHEAD which has one point downward. These signs have red borders with white or yellow backgrounds. Symbols are black or some other dark color. For signs of standard size, the length of each side of the triangle is not less than two
feet 11.4 inches $(0.90 \mathrm{~m})$, and, for the reduced size, not less than 1 foot 11.6 inches ( 0.60 m ). Signs are not more than 7 feet 2.6 inches (2.20 m ) above the ground at the highest point. Away from built-up areas, they are not less than 1 foot 11.6 inches ( 0.60 m ) above the ground at the lowest point. Signs are so placed that they are clearly visible but do not impede pedestrians.
c. Signs Giving Definite Instructions (Class II). The signs of this class indicate an order, which may be in the nature of either a prohibition or an obligation (fig. 3-24). They are circular with a diameter of at least 1 foot 11.6 inches ( 0.60 m ) for signs of standard size, and at least 1 foot 3.7 inches ( 0.40 m ) for signs of reduced size. They are placed in the immediate vicinity of the point where the prohibition or obligation begins and at intervals along the route. They are not more than 7 feet 2.6 inches $(2.20 \mathrm{~m})$ above the ground at the highest point, and not less than 1 foot 11.6 inches ( 0.60 m ) above the ground at the lowest point.
(1) Prohibitory signs (class II A). These signs are white or light yellow with red borders, and the symbols are black or some other dark color. Examples of signs in this category are-
(a) Prohibitions for all traffic.
(b) Prohibitions for certain classes of vehicles.
(c) Restrictions on the dimensions, weight, or speed of vehicles.
(2) Mandatory signs (class II B). These signs are blue with white symbols. Examples of mandatory signs are-
(a) A direction to be followed.
(b) Where cyclists must ride.
d. Informative Signs (Class III) (Fig. 3-25). Signs of this class are rectangular. Where the colors are not specifically prescribed, red does not dominate.
(1) Indication signs (class III A). Signs of this type are used to indicate parking areas, hospitals, first aid stations, telephones, filling stations, and priority roads. These signs have blue backgrounds, except those indicating priority roads. Signs indicating priority roads are diamond-shaped and are white with black or dark rims on the outside and have yellow cen-
to destination terminal

1. LINE HAUL DISPATCH POINT
2. INCOMING TRAILER PARK AND INSPECTION AREA
3. POL AREA AND TRACTOR INSPECTION AREA
4. MAINTENANCE AREA
5. BIVOUAC AREA FOR TERMINAL PERSONNEL
6. LOCAL TRACTOR READY LINE
7. MESS AND ADMINISTRATIVE AREA
8. LOCAL HAUL DISPATCH POINT
9. LINE HAUL READY LINE
10. bivouac area for line HAUL DRIVERS
11. MARSHALING YARD

10

LEGEND
LINE HAUL TRACTOR
LOCAL TRACTOR
LOADED TRAILER
$\square$ EMPTY TRAILER

(5)


uneven road

dangerous bend


RIGHT BEND


LEFT BEND

double bend (FIRST TO The Right)


OPENING BRIDGE


CHILDREN


LEVEL R.R. CROSSING WITH GATES


BEWARE OF ANIMALS

NTERSECTION WITH' NONPRIORITY ROAD


DANGEROUS HILL


ROAD WAY NARROWS

Figure s-2s. International road signs-danger.


STOP AT INTERSECTION


BICYCLES PROHIBITED


NO ENTRY FOR VEHICLES WITH AN AXLE WEIGHT EXCEEDING $\qquad$ TONS


NO PASSING


TURN LEFT


NO RIGHT TURN


NO ENTRY FOR VEHICLES HAVING OVERALL WIDTH EXCEEDING $\longrightarrow$ METERS


STOP--CUSTOMS


NO STOPPING OR WAITING


NO ENTRY FOR VEHICLES EXCEEDING __GROSS WEIGHT


NO ENTRY FOR GOODSGARRYING VEHICLES EXCEEDING_TONS LADEN WEIGHT


NO ENTRY FOR ALL VEMICLES


NO PARKING

Figure 3-24. International road signs-definite instructions.



PARKING PERiaitTED


PRIORITY ROAD


HOSPITAL


FILLING STATION


END OF PRIORITY ROAD

Figure 3-25. International road signs-informative.

APPROACH TO END OF PRIORITY ROAD

ters. Priority road signs are square with one point downward. The side of the square is at least 1 foot 11.6 inches ( 0.60 m ) for the standard size and at least 1 foot 3.7 inches ( 0.40 m ) for the reduced size. For signs repeated within builtup areas, the side of the square is 9.8 inches ( 0.25 m ).
(2) Advance direction signs and direction signs (class III B). The size of these signs is such that the indication can be understood easily by drivers in time to enable them to comply. They have either light backgrounds with dark lettering or dark backgrounds with light lettering. Advance direction signs are placed at a distance of between 328 feet ( 100 m and 820 feet ( 250 m ) from the intersection on normal roads. On special roads, e.g., concrete multilane roads, this distance is increased to 1,640 feet ( 500 m ). Direction signs are rectangular with the longer side horizontal and end in an arrowhead. Names of places lying in the same direction may be added to the sign. Colors of these signs are the same as for advance direction signs. When distances are indicated, the figures giving distances are inscribed between the name of the place and the arrowhead.
(3) Place identification signs (class IIIC). Signs indicating a locality are rectangular with the longer side horizontal. They are of such size and location that they are visible at night. They have either light backgrounds with dark lettering or dark backgrounds with light lettering. They are placed before the beginning of a built-up area and at other points necessary to indicate place locations.

## 3-48. NATO Military Road Signs

To facilitate the movement of armed forces of the North Atlantic Treaty Organization (NATO) in any territory controlled by operational military command or by a national authority, a standard system of military route signs has been adopted by member governments. This system includes signs which the Geneva Convention already prescribes (para $3-47$ ) and others not included in the Geneva Convention. Standard NATO signs are hazard signs, regulatory signs, and guide signs. Examples are shown in figure 3-26.
a. Hazard Sign. This sign indicates a traffic hazard and is used only in areas under military authority. A hazard sign is square and is placed with one corner pointing downward. A purely military sign not included in the international (Geneva Convention) system or host country's system has a yellow background with the legend or symbol in black. If the sign is included in the international system or host country's system, the international or host country's sign is used on the same yellow background instead of the black symbol or legend.
b. Regulatory Sign. This sign is used to regulate and control traffic and to define the light line. A regulatory sign is square. It has a black background on which the legend is superimposed in white with the following exceptions: bridge classification signs, stop signs, no entry signs, blackout signs, and signs erected by the military to control civilians under specified conditions. Descriptions of the expected regulatory signs are contained in STANAG NO. 2010 and STANAG NO. 2012, Edition No. 2.
c. Guide Sign. A guide sign is used to indicate locations, distances, directions, routes, and similar information.
(1) A guide sign for a route is rectangular with the long side vertical. The legend or symbol and route number are superimposed in white on a black background. Odd numbers are used for axial routes, and even numbers designate lateral routes.
(2) A directional disk is used as a supplement to other guide signs to indicate the direction of a route or as an appendage to any major unit sign to indicate the route to that unit. The disk is less than 16 inches ( 0.41 m ) in diameter and has a black arrow, with or without bar, on a white background. Eight equally spaced holes around its circumference allow the disk to be nailed with the arrow pointing in any direction. Battalions and lower units are not permitted to install directional disks.
(3) A guide sign for a casualty evacuation route is either rectangular or cross-shaped with symbols in red on a white background.
(4) A detour sign has a white arrow, barred or not, on a blue square. The sign is placed so that one corner of the square points downward.


## DESTOUR



Figure 3-26. NATO military road signs.

## 3-49. Marking Contaminated or Dangerous Land Areas

Roads and areas within NATO nations containing contamination, minefields, boobytraps, or unexploded bombs will be marked by triangular signs in accordance with the details of the agreement of STANAG NO. 2002. Examples are shown in figure 3-27.

## 3-50. NATO Markings for Military Vehicles

a. General. The armed forces of NATO have agreed to use the standard markings for vehicles described below. (SEATO Military Vehicle Markings are prescribed by CSTAG 20-27.) The markings listed are not necessarily used at all times, but when they are used, vehicles are marked in accordance with the following paragraphs. The rear of a trailer is marked in the same as its prime mover; there is no need to mark the front of a trailer. When necessary for security reasons, vehicle markings may, by direction of the field com-

CHEMICAL MINEFIELDS

mander or his superior authority, be covered or removed.
b. Registration Numbers. The marking of vehicles for registration is as required by the nation concerned. Registration markings consist of numbers or a combination of letters and numbers.
c. National Symbols. National symbols are used to identify the vehicles of each country. At a minimum, symbols are shown front and rear. Service symbols may be superimposed upon the national distinguishing symbols or shown separately by an additional symbol.
d. Speed Limits. Speed limit markings are placed on vehicles as directed by the nation concerned.
e. Tactical Markings. Tactical markings serve in general as identification markings within units; they consist of stripes and geometrical figures or combinations thereof and may also include a name. Colors may be used. Markings should be large enough to make


BOOBY TRAPS


## UNEXPLODED BOMB

Figure 3-27. Markings of contaminated or dangerous land areas (STANAG NO. 2002).

## C 3, FM 55-15

ground-to-ground identification of vehicles possible; they are used primarily for easy battlefield recognition. The design and position of these markings are prescribed by the field commander directing their use. They are removed when vehicles are permanently released from the jurisdiction of the commander who prescribed their use.
f. Ground-to-Air Recognition. Equipment for these markings consists of red and yellow fluorescent panels equipped with tie cords. Panel dimensions are approximately 6 feet by 2 feet 3 inches ( 1.80 m by 0.68 m ). Panels are draped on vehicles in a standard, unchanging pattern that differs from the displays prescribed for other recognition purposes (frontlines, targets, etc.). Theater commanders prescribe the arrangement of panels and the conditions under which they will be used.
g. Special. Military police vehicles and other traffic control vehicles are identified, front and rear, with the prescribed markings. Ambulances and other vehicles used exclusively for medical purposes are marked according to the rules of the Geneva Convention. Such markings consist of one red cross or crescent on a square white background painted on the side body panels, roof of body, roof of driver's cab, and rear door (s) or panel.
h. Bomb Disposal Units. Vehicles of bomb disposal units have all fenders painted red.
i. Danger. A red flag flown from any vehicles indicates DANGER.
j. Priority Vehicles. Any vehicle which for any reason (special liaison officer, signal vehicles carrying priority dispatches, damage assessment personnel, etc.) requires priority over all other vehicles may be so marked by any commander concerned. The markings consist of equilateral triangles with red borders and symbols on white backgrounds on the front and rear of the vehicle (fig. 3-28). A single priority sign may be used if visible from both front and rear. The size of a priority sign should be as large as the dimensions of the vehicle permit. The symbol inside the triangle indicates the commander authorizing use of this priority sign. This sign must be removable in order to avoid misuse and is used only on direct orders or the commander concerned.

## k. Organization of Columns.

(1) A column of vehicles is a group of at least 10 vehicles moving under a single commander, over the same route, in the same direction.
(2) To facilitate control, large columns may be broken down to serials and march units.
(3) Each column and each organized element must include the following:
(a) A commander whose place in the column varies.
(b) A pace setter in the first vehicle in the first element of a column who leads it and regulates its speed.
(c) A trail officer in the last vehicle of the last element who deals with problems that occur at the tail of the column.
$l$. Identification of Columns.
(1) Each column is identified in accordance with STANAG NO. 2027, i.e., blue flag on leading vehicle green flag on last vehicle. In addition, when movement is being carried out at night, the leading vehicle shows a blue light and the last vehicle shows a green light. The vehicle of the column commander displays a flag that is bisected by a diagonal line to form two triangles. The upper triangle is white; the lower is black. In areas where vehicles drive on the left side of the highway, the flags are mounted on the right side of the vehicle; otherwise, they are mounted on the left side.
(2) Each column is identified by a number known as a movement number or identification serial number which is allocated at the same time as the movement credit by the authority organizing the movement ( $m$ below). This number identifies the column during the entire movement.
(3) The number is placed on both sides and, if possible, on the front of all vehicles composing the column so as to be clearly visible. It is composed of the following:
(a) Two figures indicating the day of the month on which the movement is due to commence.
(b) Three or four letters indicating the authority organizing the movement. The first two letters are the national symbols shown in STANAG NO. 1059 (Edition No. 2).


Figure 3-28. Vehicle priority sign.
(c) Two figures indicating the serial number allocated by the authority responsible for the movement. For example, 03-USV-08 indicates that column No. 8, composed of V corps vehicles, will be moved by United States authority on the third day of the current month.
(d) The elements of a column may be identified by adding a letter behind the movement number.

## m. Movement Credit.

(1) A movement credit is the time allocated to one or more vehicles to move over a supervised, dispatch, or reserved route.
(2) Besides the allocation of a movement number or identification serial number, a movement credit includes the indication of times at which the first and last vehicle of a column are scheduled to pass-
(a) The entry point-where the column enters the controlled route.
(b) The exit point-where the column leaves the controlled route.

## 3-51. Preparation of Vehicles for Air Movement

a. Units which must be ready for immediate movement by air should make preparations well in advance to avoid delays in the loading of vehicles into the transporting aircraft. Essential items of information that must be available are-
(1) Weight of vehicle with load.
(2) Dimensions of vehicle.
(3) Center of gravity of loaded vehicle.
$b$. The dimensions of the vehicle may be obtained from the vehicle technical manual. Since unit equipment is loaded on vehicles for air shipment in accordance with a prescribed loading plan, the center of gravity has to be computed for each vehicle. Actual weighing and computation may be made during loading plan tests. After a vehicle has been loaded in accordance with the unit loading plan, its center of gravity should be marked on the exterior of the vehicle with crayon or waterproof tape.
c. Figure 3-29 illustrates method of determining the weight and center of gravity location of single- and multi-unit vehicles.

## 3-52. Vehicle Weight and Dimension Card

The NATO Armed Forces have agreed to adopt for the transportation of their vehicles the card shown in figure 3-30.
a. The front is printed in white on a black background. (When printed forms are not immediately available, a substitute card printed and completed in black on a white background is used.)
$b$. The border of the front is gummed so as to facilitate affixing to windshields.
$c$. The card is printed in both the official NATO languages (English and French) and in the language of the country of origin if other than English or French.
$d$. The size of the card is $91 / 2$ inches ( 24 cm ) $\times 71 / 4$ inches ( 18 cm ).
$e$. Instructions for using the card are shown on the reverse side of each card (fig. 3-30).

## 3-53. Transportation Motor Pool Layout and Facilities (Fig. 3-31)

The basic layout of motor pools varies depending on space and existing conditions. The typical motor pool should include the facilities described below. In cases of new construction, the use of a single structure is advocated. This promotes substantial economies in construction costs and operations.
a. Office. The motor pool office should be located in the motor pool operations area.
b. Dispatch Office. All vehicular operations are controlled through this office. If at all possible, it should be located at the exit of the motor pool, thereby allowing the dispatcher to visibly check vehicles leaving the parking area.
c. Driver's Room. For convenience, the driver's room should be located in the vicinity of the dispatch office and for orderly operation, separate from the main dispatch office.
d. Emergency Repair Facility. This facility performs minor and emergency repairs that are not serious enough to warrant removal of the vehicle from operation. It is usually located in a section of the general repair shop or at the POL point.
e. Vehicle Washing Facilities. Such facilities should be available for use under all weather conditions. Facilities should be so located that
drainage is away from parking areas and buildings. The use of automatic washing facilities should be considered when feasible.
f. Preventive Maintenance and General Repair Shop. The number of vehicles to be serviced is a deciding factor in the type of shop used. The primary function of the shop should be the accomplishment of regularly scheduled preventive maintenance, lubrication, and general repair activities.
g. Allied Trade Shops. Shops for spot painting, minor body work, carpentry, and welding are set up at the motor pool. Because of the fire hazard existing in some trade shops, segregation of this facility is often required. For
example, painting and welding activities should not be performed in close proximity.
h. Supply and Parts Room. This facility is centrally located within the main shop building to provide easy access to parts and tools. Parts, bins, tool racks, and an appropriate issue counter should be provided.
i. Public Address System. A public address system facilitates control of the motor pool or parking area. Interoffice communication between the dispatch office and key locations within the pool area eliminates many unnecessary, time-consuming trips and contributes to more orderly execution of assigned duties.


$$
X=\frac{L W_{2}}{W}
$$

## WHERE

$\mathbf{X}=$ Distance from front axle to unit ccnter-of-gravity location
$\mathbf{L}=$ Wheelbase
$w_{1}=$ Front axie load
$w_{1}=$ Rear axie load
$\mathbf{W}=$ Total weight of unit

## TO LOCATE CARGO UNIT CENTER OF GRAVITY, DETERMINE $X$

1. Determine axle loads by weighing all axles (w, and $w_{2}$ ).

## Note

Vehicle must be level when weighing.
2. Determine toral weight of unit (W) by adding axle loads ( $w$, and $w_{1}$ ).
3. Determine wheelbase (L).
4. Determine rear axle moment about front axle by multiplying rear axle load ( $w_{1}$ ) by wheelbase (L).
5. Determine center-of-gravity distance from front axle (X) by dividing rear axle moment by eotal weight (W).


## VEHICLES

Figure 3-29. Determining cargo unit center of gravity, single-unit vehicle.

$$
x=\frac{L_{1} w_{2}+L w_{3}}{W}
$$

## WHERE

$X=$ Distance from front axle to unit center-of gravity location
$w_{1}=$ Front axle load
$\mathbf{L}_{\mathbf{1}}=$ Tractor wheelbase
$w_{z}=$ Tractor rear axle load
$\mathbf{L}_{2}=$ Trailer wheelbase
$w_{s}=$ Trailer axle load
$L=$ Toral wheelbase of unit
W $=$ Total weight of unit


TO LOCATE CARGO UNIT CENTER OF GRAVITY, DITERMINE $x$

1. Determine axle loads by weighing all axles ( $w_{1}$, $w_{2}$, and $w_{3}$ ).

## Note

Vehicle must be level when weighing
2. Determine total weight of unit (W) by adding all axle loads.
3. Determine tractor wheelbase ( $L_{1}$ ) and trailer wheelbase ( $\mathrm{L}_{2}$ ).
4. Determine total wheclbase of unic (L).
3. Determine tractor rear axle moment about front axle by multiplying tractor wheelbase ( $\mathrm{L}_{1}$ ) by tractor rear axle load ( $\mathrm{w}_{\mathbf{z}}$ ).
6. Determine trailer axle moment by multiplying cotal wheelbase (L) by trailer axle load (ws).
7. Determine cocal moment about front axle by adding trailer axle moment and tractor rear axle moment.
8. Determine center-of-gravity distance from front axle (X) by dividing total moment by cotal weight (W).

## Noter

As an aid to load planning, it may be desirable co know relationship of vehicle center of gravity to vehicle extremities. To determine distance from front bumper to center of gravity, add distance between frone bumper and front axle co value determined in step 8 . To determine distance between aft end of vehicle and center of gravity, suberact value determined in step 8 from distance between froat axle and aft end of vehicie.

## SAMPLE PROBLEM

## GIVEN: A multiple-unit vehicle.



Prowlem: Determine center-of-gravity location.

## SOLUTION:

1. $w_{1}=9.580$ pounds $w_{z}=20,850$ pounds $w_{s}=13,730$ pounds
2. $\mathbf{w}=9.580+20,850+13,730=44,160$ pounds
3. $L_{1}=185$ inches
$L_{2}=225$ inches
4. $L=185+225=410$ inches
5. $185 \times 20,850=3,857,250$
6. $410 \times 13,730=5,629,300$
7. $3,857,250+5,629,300=9,486,550$
8. $\mathbf{9 , 4 8 6 , 5 5 0}+\mathbf{4 4}, 160=214.8$

## CONC!USIONz

Cargo unit cencer of gravity is locased 214.8 inches aft of front axle.

```
(Example--Front)
```

VEHICLE WEIGHT AND DIMENSION CARD
FICHE DE DIMENSIONS ET DE POIDS DU VEHICULE

-     -         -             -                 -                     -                         -                             -                                 -                                     -                                         -                                             -                                                 -                                                     -                                                         -                                                             -                                                                 -                                                                     -                                                                         -                                                                             - (3d language/3ème langue)

State unit of measure used. Préciser l'unité de mesure utilisée. _ _ _ _ (3d language/3ème langue).

## WEIGHT

POIDS

> (3d language/3ème langue)

LENGTH
LONGUEUR
— _ _ _ (3d language/3ème langue)

## BREADTH

LARGEUR
_ _ _ (3d language/3ème langue)

HEIGHT
HAUTEUR
_ _ _ (3d language/3ème langue)

GROUND PRESSURE OR MAXIMUM AXLE LOAD
PRESSION UNITAIRE OU POIDS DE
L'ESSIEU LE PLUS CHARGE
_ _ _ (3d language/3ème langue)

Figure 3-30. Vehicle weight and dimension card.

# (Example--Back) <br> Directions for Use 

Mode d'emploi

1. This card is designed to display vehicle laden weight and dimensions to all concerned with loading it on any means of transport, e.g., to an aircraft, ship, etc.
2. Cette fiche est destinèe á indiquer le poids on charge et les dimensions d'un véhicule à tous ceux qui peuvent être responsables de son chargement sur n'importe quel mode de transport, par example: avion, navire, etc.
3. 

_ _ _ _ (3d language/3ème langue)
2. Accurate weight and dimensions will be printed in chalk by the unit or depot preparing a vehicle for movement. This card will then be fixed inside the windscreen on the passenger's side. On tanks or other vehicles without windscreens, this card will be fixed on a suitable surface on the opposite side of the vehicle from the driver's seat, where it can be easily seen. If possible, it should be protected from inclement weather.
2. Le poids et les dimensions exacts serent indiqués à la craie, en lettres majuscules, par l'unité ou le dépôt préparant le véhicule en vue de son transport. Cette fiche sers ensuite apposee à l'intérieur du pare-brise, du côté du passager. Dans le cas des chars ou autres véhicules sans pare-brise, la fiche sera apposée sur une surface appropriee sur le côté du véhicule opposé à celui du siège du conducteur et dans une position facilement visible. Si possible, le fiche doit être à l'abri des intempéries.
2.

3. This is a NATO form and whoever "chalks in" the weights and dimensions should use his country's normal system of weight and measurement.
3. Cette fiche est un formulaire OTAN et la personne chargee d'inscrire la craie le poids et les dimensions du véhicule doit utiliser le système normal de poids et mesures de son propre pays.
3. - - - -
(3d language/3ème langue)
Figure 3-30-Continued.


Figure 3-31. Motor pool parking space.

## $\star$ CHAPTER 4

## RAIL

## Section I. ORGANIZATION

## 4-1. General

a. The transportation railway service is the overall organization of rail units assigned or attached to the senior transportation organization, which is normally a transportation command, theater army support command (TASCOM). It is composed of railway supervisory, operating, and maintenance units as required to operate trains, to maintain rail lines of communication, and to perform organizational and direct support maintenance of locomotives and rolling stock. These units are discussed in detail in FM 55-20 and TM 55-206.
$b$. The operation of military railways may be accomplished in three phases:
(1) Phase 1. This phase is conducted exclusively by military railway personnel.
(2) Phase II. During this phase, railway lines are operated and maintained by military railway personnel augmented with and assisted by local civilian railway personnel. This phase is under direct military supervision.
(3) Phase III. This phase is initiated as soon as local conditions permit. Under this arrangement, local national civilian railway personnel operate and maintain railway lines under the direction and supervision of the highest military railway echelon in the theater, thus releasing railway unit personnel for other duties.

## ( 4-2. Organization of Transportation Railway Service (TRS) (Fig 4-1)

Headquarters and headquarters company, transportation railway group.

TOE
Headquarters and headquarters company, transportation railway brigade.
*55-225 To operate and maintain a railway division in a theater of operations.

Headquarters and headquarters company, transportation railway battalion.

55-226 To command, administer, and supervise the operation of railway and attached supporting units of the transportation railway battalion.

## Assignmen

To a theater support command, normally attached to a headquarters and headquarters company, transportation command.

To the transportation command, theater army support command (TASCOM): may be attached to the transportation railway brigade or operate directly under the transportation command, TASCOM.

To transportation railway group......

## Capability

Provides command and supervision of three or more transportation railway groups, TOE 55-202.

Provides command and supervision for from two to six transportation railway battalions and transportation railway maintenance units as required.
a. During phase I operations (complete military operation of the railway): operates 40 locomotives per day in road and yard service over approximately 90 to 150 miles of railroad;
b. Operates a railway classification yard for the formation of trains;
c. Adequate to inspect, condition, and make organizational and direct support maintenance on approximately 40 locomotives and 800 railroad cars; performs running inspections of approximately 2,000 railroad cars per day. Also repairs tools and mechanical equipment of all companies within the battalion;
d. Inspects and maintains approximately 90 to 150 miles of railway right-of-way (tracks); and available railway signals, electrical communications, structures, bridges and buildings located within a railway division; and
$e$. Inspects and repairs wire communications and signal appurtenances used for train movements.
a. Provides command, staff planning, administration, control, and supervision of operations of the transportation railway battalion and assigned and attached units;

Organic to the transportation railway battalion.

## Capabiluty

b. Dispatches all trains operated by the. battalion and supervises on-line operations; and operates railway stations and signal towers which are the responsibility of the battalion;
c. Provides messing facilities and organizational motor maintenance facilities for assigned units of the battalion.

Transportation railway engineering company.

Transportation railway equipment maintenance company.

Transportation train operating company.
*55-227 To maintain and repair railway track, bridges, buildings, and railway signals and communications within a railway division.

55-228 To inspect, service, and make running repairs to diesel-electric locomotives and rolling stock.

Organic to transportation railway battalion.

Organic to transportation railway battalion.

55-229 To provide road and yard personnel for the operation of railway locomotives and trains.

Organic to transportation railway battalion.

Performs maintenance and repair of track, railway signals, electrical communications, bridges, and structures of a railway division on a 24 hour basis.
a. Services and makes running repairs to approximately 40 diesel-electric locomotives and 800 railway cars on an around-the-clock basis;
b. Performs running inspection for 2,000 railway cars daily;
c. Performs light repairs to tools and limited repairs to special mechanical equipment within the battalion.
At full strength, provides 40 traincrews daily for road and/or terminal operation, including the performance of incidental switching service for 90 to 150 miles of railroad on an around-the- clock basis.
 headquarters and a transportation railway battalion as appropriate.

Transportation electric power transmission company.

55-217 To maintain and repair electric power transmission facilities for the transportation railway battalion.
**Diesel-electric locomotive repair company.

55-247 To perform general support maintenance of diesel-electric locomotives and railway cranes.

To the transportation command (TASCOM) and normally is attached to a transportation railway battalion where electric motive power is operated by an electrified catenary when required and authorized by Department of the Army.

To the maintenance battalion of a material command field depot. May be attached to a transportation railway group.

Maintains and repairs electric power transmission facilities, including substations and catenary for 200 miles of electrified railway, including sidetracks, passing tracks, and yard tracks.

Performs general support maintenance in support of 200 diesel-electric locomotive units and/or railway cranes with a maximum capability of 25 locomotives and/or cranes per month.

[^13]*Railway car repair company (General Support).

55-248 a. To perform general support maintenance on railway equipment;
b. To supply repair parts for organizational and direct support mainte nance of railway equipment when sources of supply are not otherwise assigned in an area of operation.

Team EA, ambulance train maintenance detachment (DS).
Team EI, railway yard operating detachment.

55-520 To perform running repairs on ambulance train railway cars.
55-520 To operate a railway yard $\qquad$
the senior transportation railway unit in a theater of operations.
To a transportation railway battalion or comparable unit.

Team EL, railway workshop mobile detachment (DS).

55-520 To perform direct support mainte nance of diesel-electric locomotives and rolling stock in areas where static facilities are inadequate or nonexistent.

To headquarters and headquarters company, transportation railway group or to a transportation railway battalion or comparable unit.

To the maintenance battalion of a material command field depot. May be attached to a transportation railway group.

[^14]Note. Additional teams EB, EC, ED, EE, EF, EG, EH, EJ, EK, EM, and EN authorized by TOE 55-520 for various maintenance and operating functions not discussed in detail herein.

*Assigned as required
Figure 4-1. Organization of the transportation railway service.

## Section II. EQUIPMENT

## 4-3. Whyte Classification System of Lócomorives

The locomotives described in this section are classified according to the Whyte system, which classifies locomotives according to the arrangement of their wheels. A series of numerals separated by hyphens are used to designate the total number of wheels on the axle of each type of locomotive truck-the front (leading) truck, driving wheel
group, and rear (trailing) truck, respectively. On steam locomotives, the figures always describe the locomotive's wheeis from front to rear ; the wheels of the locomotive tender are not counted. For example, the classification of 2-8-2 indicates the locomotive has one pair of leading wheels, four pairs of coupled driving wheels, and one pair of trailing wheels. The absence of leading and/or trailing wheels is always denoted by a zero; thus, a 2-8-0 locomotive has no trailing wheels. Diesel
locomotives are also classified by this system; figures such as $0-6-6-0$ indicate no leading or trailing wheels and two sets of three driving axles each, or a total of 12 driving wheels. The classification commonly used in Europe and other parts of the world, however, classifies a diesel or electric locomotive by letters and figures. A diesel $0-4-4-0$ is classified $B-B$; a $0-6-6-0$ is designated

C-C, etc. Idler wheels (those which exert no tractive effort) and leading and trailing wheels are designated with numbers. A single-unit locomotive with two six-wheel trucks where the center pair are idlers would be designated as A1A-A1A. An electric locomotive four-wheel leading and tratling trucks and six driving wheels would be designated $2-\mathrm{C} / \mathrm{C}-2$.

## 4-4. Characteristics of Railway Equipment

a. Locomotives, Diesel-Electric.

| Type | $\begin{aligned} & \text { Gage } \\ & \text { (in.) } \end{aligned}$ | $\underset{(\mathrm{lb})}{\text { Weight }^{\text {Prent }}}$ | Length overeouplers | $\underset{\text { Exidth }}{\text { Extreme }}$ | $\begin{gathered} \text { Extreme } \\ \text { height } \end{gathered}$ | Tractive force (lb) |  | Horsepower | Curvature min radius (ft) | $\underset{\substack{\text { Fupal } \\ \text { caparity } \\ \text { (gal.) }}}{\text { and }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Starting at 30 percent adhesion | Continuous |  |  |  |
| 131-ton, 0-6-6-0, domestic and foreign svc. FSN 2210-554-0786 | 561/2 | 262,900 | $55^{\prime}$ | $10^{\prime \prime} 0^{\prime \prime}$ | $14^{\prime} 0^{\prime \prime}$ | 75,700 | 37,850 at 10 mph | 1,000 | 231 | 1,600 |
| 127-ton, 0-6-6-0, domestic and foreign svc. <br> FSN 2210-270-1354 | 561/2 | 261,100 | $55^{\prime}$ | $10^{\prime \prime} 0^{\prime \prime}$ | $14^{\prime \prime}{ }^{\prime \prime}$ | 75,700 | $\begin{array}{r} 37,850 \mathrm{at} \\ \quad 10 \mathrm{mph} \end{array}$ | 1,000 | 231 | 1,600 |
| 120-ton, 0-6-6-0, domestic and foreign sve. | 561/2, 60 | 240,000 | 57'5" | $9^{\prime} 8^{\prime \prime}$ | 13'6" | 73,000 | $\begin{gathered} 37,000 \text { at } \\ \quad 10 \mathrm{mph} \end{gathered}$ | 1,600 | 193 | 1,600 |
| FSN 2210-814-5291, <br> FSN 2210-815-3521, wigenerator. - | 63, 66 | $\begin{array}{r} 245,000 \\ \text { w/steam } \\ \text { generator } \end{array}$ |  |  |  |  |  |  |  | 800 <br> w/steam generator 1,600 |
| 120-ton, 0-6-6-0, domestic and foreign svc. FSN 2210-819-4219 | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | $\begin{array}{r} 240,000 \\ 245,000 \\ \text { w/steam } \\ \text { generator } \end{array}$ | 56'9" | $9^{\prime \prime} 7^{\prime \prime}$ | 13'5" | 72,000 | $\begin{array}{r} 36,000 \mathrm{at} \\ 10 \mathrm{mph} \end{array}$ | 1,600 | 193 | $\begin{array}{r} 1,600 \\ \text { £00 } \\ \text { w'steam } \\ \text { generator } \end{array}$ |
| 120-ton, 0-4-4-0, demestic svc.-.-. FSN 2210-554-0785 | $561 / 2$ | 240,000 | 55'9" | $10^{\prime \prime}{ }^{\prime \prime}$ | 14'6" | 75,000 | $\begin{array}{r} 40,000 \mathrm{at} \\ 11 \mathrm{mph} \end{array}$ | 1, 500 | 150 | 800 |
| 120-ton, 0-4-4-0, domestic svc--.-. FSN 2210-262-0751 | $561 / 2$ | 246,000 | 48'10" | $10^{\prime \prime} 2^{\prime \prime}$ | 14'0゙" | 73,000 | $\begin{array}{r} 36,000 \mathrm{at} \\ 10 \mathrm{mph} \end{array}$ | 1,200 | 100 | 750 |
| 115-ton, 0-4-4-0, domestic svc. FSN 2210-112-8508 | $561 / 2$ | 230,000 | $45^{\prime} 6^{\prime \prime}$ | $10^{\prime \prime}{ }^{\prime \prime}$ | 14'6" | 69,000 | $\begin{array}{r} 34,000 \mathrm{at} \\ 15 \mathrm{mph} \end{array}$ | 1,000 | 50 | 635 635 |
| 100-ton, 0-4-4-0, domestic svc.....-. <br> FSN 2210-819-9320 | 561/2 | 199,000 | 44'6" | $10^{\prime \prime} 0^{\prime \prime}$ | 14'4" | 59,700 | $\begin{array}{r} 28,750 \mathrm{at} \\ 10 \mathrm{mph} \end{array}$ | 660 | 50 | 635 |
| 100 -ton, $0-4-4-0$, domestic sve. FSN 2210-371-7535 | $561 / 2$ | 200,000 | 44'5" | $10^{\prime \prime} 0^{\prime \prime}$ | $14^{\prime \prime} 7^{\prime \prime}$ | 69.700 | $\begin{array}{r} 35,0 \mathrm{CO} \text { at } \\ 10 \mathrm{moh} \end{array}$ | 「00 | 100 | 600 |
| 80-ton, 0-4-4-0, dcmestic svc-.--... FSN 2210-820-5451 | 561/2 | 161,000 | $36^{\prime} 10^{\prime \prime}$ | 9'6" | 13'7 ${ }^{\prime \prime}$ | 48,000 | $\begin{array}{\|r} 24,000 \mathrm{at} \\ 10 \mathrm{mph} \end{array}$ | 500 | 75 | 400 |
| 80-ton, 0-4-4-0, domestic svc....... <br> FSN 2210-E04-3614 | $561 / 2$ | : 61,000 | $36^{\prime} 10^{\prime \prime}$ | 9'6" | $13^{\prime \prime}{ }^{\prime \prime}$ | 48,000 | $\begin{array}{r} 24,000 \mathrm{at} \\ 10 \mathrm{mph} \end{array}$ | 470 | 75 75 | 400 400 |
| 80-ton, 0-4-4-0, domestic svc.----FSN 2210-804-3615 | $561 / 2$ | 161,600 | 41'0" | $9^{\prime} 6^{\prime \prime}$ | $13^{\prime \prime} 4^{\prime \prime}$ | 48,000 | $\begin{aligned} & 21,000 \mathrm{at} \\ & 5.2 \mathrm{mph} \end{aligned}$ | 550 | 75 | 400 |
| 65-ton, 0-4-4-0, domestic swc------FSN 2210-819-9314 | $561 / 2$ | 130,000 | $34^{\prime \prime}{ }^{\prime \prime}$ | $10^{\prime \prime} 1^{\prime \prime}$ | $13^{\prime \prime} 5^{\prime \prime}$ | 39,000 | $\begin{aligned} & 19,500 \mathrm{at} \\ & 10 \mathrm{mph} \end{aligned}$ | 400 500 | 75 75 | 250 500 |
| 60 -ton, 0-4-4-0, domestic and foreign sve. FSN 2210-819-9318 | $\begin{gathered} 561 / 2,60 \\ 63,66 \end{gathered}$ | 122,000 | $\begin{gathered} 38^{\prime} 11^{\prime \prime} \\ \text { (Type E) } \\ 39^{\prime} 3^{\prime \prime} \\ \text { (Willison) } \end{gathered}$ | $9^{\prime} 6^{\prime \prime}$ | $13^{\prime \prime}{ }^{\prime \prime}$ | 36,000 | $\begin{aligned} & 15,680 \mathrm{at} \\ & 7.78 \mathrm{mph} \end{aligned}$ | 500 | 75 | 500 |
| 45 -ton, $0-4-4-0$, domestic and foreign svc. <br> FSN 2210-529-9038 | 561/2 | 90,000 | 33'6" | $9^{\prime \prime} 7^{\prime \prime}$ | $12^{\prime \prime}{ }^{\prime \prime}$ | 27,000 | $\begin{gathered} 12,000 \mathrm{at} \\ 6 \mathrm{mph} \end{gathered}$ | 380 | 75 | 250 |


| Type | Gage(in.) | Weight (lb) | Length over couplers | Extreme width | Extreme height | Tractive force (lb) |  | Horsepower | Curvature $\min$ radius (ft) | Fuel capacity (gal.) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Starting at 30 percent adbesion | Continuous |  |  |  |
| 45-ton, 0-4-4-0, domestic svc (side rod drive). <br> FSN 2210-831-1135 | 561/2 | 90,000 | $28^{\prime \prime}{ }^{\prime \prime}$ | $9^{\prime} 6^{\circ}$ | $12^{\prime} 0^{\prime \prime}$ | 27,000 | $\begin{array}{\|c} 13,500 \mathrm{at} \\ 6.2 \mathrm{mph} \end{array}$ | 300 | 50 | 165 |
| 44-ton, 0-4-4-0, domestic svc.-. FSN 2210-804-3610 | $561 / 2$ | 91,270 | $33^{\prime} 10^{\prime \prime}$ | $9^{\prime} 4^{\prime \prime}$ | $13^{\prime \prime} 3^{\prime \prime}$ | 26,400 | $\begin{gathered} 11,000 \text { at } \\ 9 \mathrm{mph} \end{gathered}$ | 380 | 75 | 250 |
| 44-ton, 0-4-4-0, domestic sve. <br> FSN 2210-820-5602 | $561 / 2$ | 89,000 | $33^{\prime \prime} 5^{\prime \prime}$ | $10^{\prime} 1^{\prime \prime}$ | $13^{\prime \prime} 3^{\prime \prime}$ | 26,400 | $\begin{gathered} 13,000 \mathrm{at} \\ 7.1 \mathrm{mph} \end{gathered}$ | 380 | 50 | 250 |
| 25-ton, 0-4-0, domestic sve.-. <br> FSN 2210-834-3202 | $561 / 2$ | 50,000 | $16^{\prime \prime} 1^{\prime \prime}$ | $8^{\prime 7} 7^{\prime \prime}$ | $10^{\prime \prime} 4^{\prime \prime}$ | 15,000 | $\begin{aligned} & 6,200 \mathrm{at} \\ & \quad 6.2 \mathrm{mph} \end{aligned}$ | 150 | 50 | 75 |

## b. Locomotive Cranes.

| Type | $\underset{\text { (in.) }}{\substack{\text { Gage }}}$ | $\begin{aligned} & \text { Weight } \\ & \hline \end{aligned}$ | Length over couplers | Extreme height | Extreme width | Boom (ft) length | Reach radius and capacity |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  | Main hoist | Aux hoist |
| Locomotive, steam, wrecking, 75 -ton, broad gage, domestic and foreign svc. <br> FSN 2230-174-9138 | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | 191,000 | 30'10" | 17'10" | 10'4" | $\begin{gathered} 25-2 \text { piece } \\ \text { curved } \end{gathered}$ | $\begin{aligned} & 16^{\prime} 75 \text {-ton } \\ & 25^{\prime} 34 \text {-ton } \end{aligned}$ | $\begin{aligned} & 25^{\prime} 10 \text {-ton } \\ & 30^{\prime} 8 \text {-ton } \end{aligned}$ |
| Locomotive, crane, diesel, mechanical, 150 -ton, domestic svc. <br> FSN 2230-554-4545 | 561/2 | 291,700 | $31^{\prime \prime}{ }^{\prime \prime}$ | $15^{\prime \prime}{ }^{\prime \prime}$ | $10^{\prime \prime} 4^{\prime \prime}$ | 28-2 piece straight | 28' 67-ton |  |
| Locomotive, diesel, electrical, 40-ton, broad gage, domestic and foreign svc. FSN 2230-554-2728 | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | 221,500 | $36^{\prime \prime} 1^{\prime \prime}$ | 13'6" | 10'4" | 50-2 piece straight | $\begin{aligned} & 12^{\prime} 40 \text {-ton } \\ & 50^{\prime} 63 / 4 \text {-ton } \end{aligned}$ |  |
| Locomotive, diesel, electric, 40-ton, domestic svc.... FSN 2230-434-6649 | 561/2 | 220,000 | 29'4" | 15'1" | 10'6" | $\begin{aligned} & \text { 50-2 piece } \\ & \text { straight } \end{aligned}$ | $\begin{aligned} & 12^{\prime} 40 \text {-ton } \\ & 50^{\prime} 63 / 4 \text {-ton } \end{aligned}$ |  |
| Locomotive, diesel, mechanical, 25-ton, broad gage, domestic and foreign svc. <br> FSN 2230-174-9130 | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | 148,000 | $27^{\prime \prime} 7^{\prime \prime}$ | $13^{\prime \prime} 0^{\prime \prime}$ | $8^{\prime} 6^{\prime \prime}$ | 50-2 piece straight | $\begin{aligned} & 50^{\prime} 63 / 4 \text { ton } \\ & 12^{\prime} 25-\text { ton } \end{aligned}$ $50^{\prime} 4 \text {-ton }$ |  |
| Locomotive, diesel, mechanical, 25 -ton, narrow gage, foreign svc. <br> FSN 2230-202-2111 | $\begin{gathered} 36,393 / 8 \\ 42 \end{gathered}$ | 152,000 | $32^{\prime \prime} 6^{\prime \prime}$ | $12^{\prime \prime} 0^{\prime \prime}$ | $8^{\prime \prime}{ }^{\prime \prime}$ | 40-2 piece straight | $\begin{aligned} & 12^{\prime} 25 \text {-ton } \\ & 40^{\prime} 6 \text {-ton } \end{aligned}$ |  |
| Locomotive, diesel, mechanical, 25 -ton, domestic svc_ FSN 2230-809-9863 | $561 / 2$ | 155,000 | $30^{\prime \prime}{ }^{\prime \prime}$ | 15'2* | 10'8" | $\begin{aligned} & \text { 50-2 piece } \\ & \text { straight } \end{aligned}$ | $\begin{aligned} & 12^{\prime} 25 \text {-ton } \\ & 50^{\prime} 4 \text {-ton } \end{aligned}$ |  |
| Locomotive, diesel, mechanical, 35 -ton, domestic svc_ FSN 2230-803-8571 | $561 / 2$ | 167,000 | $30^{\prime \prime} 0^{\prime \prime}$ | $15^{\prime 7}$ | 10'4 | 50-2 piece straight | $\begin{aligned} & 12^{\prime} 35 \text {-ton } \\ & 50^{\prime} 5 \text {-ton } \end{aligned}$ |  |

c. Locomotive, Gasoline-Mechanical and Diesel-Mechanical.

| Type | $\underset{\text { (in.) }}{\text { Gage }}$ | Weight <br> (lh) | ( Horsepower | Curvature, min radius (ft) | $\underset{\substack{\text { Fuel } \\ \text { capacity } \\ \text { (gal.) }}}{ }$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 10-ton, single-engine, 0-4-0, domestic servic | 561/2 | 20,000 | 100 | 75 | 30 (diesel) |

## d. Railway Maintenance Motor Cars.

| Type | $\underset{\text { (in.) }}{\substack{\text { Gage }}}$ | Weight <br> (lh) | $\begin{gathered} \text { Length } \\ \text { (in.) } \end{gathered}$ | $\begin{aligned} & \text { Width } \\ & \text { (in.) } \end{aligned}$ | $\underset{\substack{\text { Height } \\ \text { (in.) }}}{\text { cen }}$ | Capacity | Horsepower | $\underset{\text { capacity }}{\text { cuel }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Gasoline mechanical, 4 wheels, solid drawbar couplers, closed cab with handbrake. <br> FSN 2230-230-2765 | $\cdot 561 / 2$ | 2,950 | 112 | 65 | 58 excluding cab | $8-\mathrm{man}$ | 62.6 | 8 gal |
| Gasoline mechanical, 4 wheels, solid drawbar couplers, open body with handbrake. <br> FSN 2230-926-1053 | 561/2 | 1,700 | 103 | 65 | 50 | 10-man | 62.6 | 8 gal |

## e. Boxcars.

| Type | (Gape) | Capacity |  | Inside dimension |  |  | Door dimensions | $\begin{gathered} \text { Light } \\ \text { weeight } \\ \text { (ston) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | (b) | (euf) | Length | Width | Height |  |  |
| 8W, domestic service | 561/2 | 100,000 | 3,975 | 50'6" | $9^{\prime \prime}{ }^{\prime \prime}$ | 10'6" | $10^{\prime}$ wide, clear opening $8^{\prime}$ high, clear opening | 23 |
| 8W, broad gage, foreign service | $56112,60,63,66$ | 80,000 | 2,520 | $40^{\prime \prime}{ }^{\prime \prime}$ | $8^{\prime 6}{ }^{\prime \prime}$ | 6'55/8' | $\begin{aligned} & 8^{\prime 3} 11^{\prime \prime} \text { high } \\ & 6^{\prime} 834^{\prime \prime} \text { wide } \end{aligned}$ | 18.5 |

## f. Open-Top Cars.

(1) Flatcars.

| Type |  |  | Normal <br> capacily <br> (lb) |
| :--- | :--- | :--- | :--- |

[^15](2) Gondolas.

| Type | Gage (in.) | (b) | (cu ft) | Inside dimensions |  |  | Light (ston) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Length | Width | Height |  |
| High side, 8W, narrow gage, foreign service | 36, $393 / 8,42$ | 60,000 | 940 | $34^{\prime \prime}{ }^{\prime \prime}$ | $6^{\prime} 101 / 2^{\prime \prime}$ | $4^{\prime}$ | 13 |
| Low side, 8 W , narrow gage, foreign service | 36, $393 / 8,42$ | 60,000 | 356 | $34^{\prime \prime} 6^{\prime \prime}$ | $6^{\prime} 101 / 2^{\prime \prime}$ | $1^{\prime} 6^{\prime \prime}$ | 12.1 |
| High side, 8W, broad gage, foreigr service | 561/2 | 80,000 | 1,680 | $40^{\prime}$ | $8{ }^{\prime} 33 / 4{ }^{\prime \prime}$ | $4^{\prime}$ | 18 |
| Low side, 8 W , broad gage, foreign service | 561/2, 60, 63, 66 | 80,000 | 500 | $40^{\prime} 4 \frac{1}{2 \prime \prime}$ | $8^{\prime} 31 /{ }^{\prime \prime}$ | $1^{\prime} 6^{\prime \prime}$ | 16 |
| Low side, 8 W , drop ends, domestic service. | $561 / 2$ | 100,000 | 1,184 | $41^{\prime \prime} 6^{\prime \prime}$ | $9^{\prime} 61 / 8^{\prime \prime}$ | $3^{\prime}$ | 23 |
| High side, std gage, domestic service | $561 / 2$ | 100,000 | 1,580 | 41'6" | $9^{\prime} 6^{\prime \prime}$ | $4^{\prime} 6^{\prime \prime}$ | 25 |

## (3) Hopper care.

| Type |  | $\underset{(\text { (in.) }}{(G)}$ | $\begin{gathered} \text { Normal } \\ \text { capacity } \\ \text { (lb) } \end{gathered}$ | Length | Widh | Height |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 8W, domestic service |  | $561 / 2$ | 100,000 | $33^{\prime}$ | $9^{\prime} 51 / 2^{\prime \prime}$ | $9^{\prime \prime} 7^{\prime \prime}$ |
| g. Tank Cars. ${ }^{\text {Type }}$ | Gage (in.) |  | $\begin{gathered} \text { Normal } \\ \substack{\text { capacity } \\ (\text { gal. })^{1}} \end{gathered}$ | Inside diameter (in.) |  | $\underset{\text { wcight }}{\text { Ligh }}$ ston |
|  |  | $\begin{gathered} \text { Length } \\ \text { over tank } \\ \text { heads } \end{gathered}$ |  |  |  |  |
|  |  |  |  | Tank ${ }^{2}$ | Dome |  |
| Nickel-clad, ICC-103-AW, 8 W domestic service | 561/2 | 31'11 ${ }^{\prime \prime}$ | 7,500 | 78, approx | 45 |  |
| ICC-103, ICC-103-W, 8W, domestic service---- | 561/2 | 34', approx | 10,000 | 87, approx | 593/r, approx |  |
| Caust'c soda, ICC-103-W, 8 W , domestic service. | 561/2 | 34', approx | 10,000 | 88, approx | 64 |  |
| Petroleum, 8W, narrow gage, foreign service | 36, $383 / 2,42$ | $38^{\prime} 47 / 8^{\prime \prime}$ | 6,000 | $621 / 2$ | 54 | 16 |
| Petroleum, 8W, broad gage, foreign service | $561 / 2,60,63,66$ | $38.53 / 8{ }^{\prime \prime}$ | 10,000 | $803 / 4$ | $661 / 2$ | 19 |
| Nitric acid, ICC-103-W, 8W, domestic service | $561 / 2$ | $33.71 / 2^{\prime \prime}$ | 7,800 | 78, approx | 353/8 |  |
| Phosphorus, ICC-103-W, 8W, domestic service | 561/2 | $34^{\prime} 81 / 4{ }^{\prime \prime}$ | 8,000 | 78, approx | 64 |  |
| Petroleum, std gage, domestic service | $561 / 2$ | ----------- | 10,000 |  |  | 23 |

## h. Refrigerator Cars.

| Type | Gage (in.) | Normal capacity <br> (tb) | Length inside end lining | Width inside side lining | Ice capacity (lb) | $\underset{\substack{\text { Dimension of } \\ \text { doors }}}{ }$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 8 W , disassembled, foreign service | 561/2 | 80,000 | 38'91/2" | $6^{\prime} 11^{\prime \prime}$ | 11,000 | $4^{\prime}$ wide |
|  |  |  |  |  |  | $7^{\prime}$ high |
| 8W, disassembled, broad gage, foreign service | $561 / 2,60,63,66$ | 80,000 | $32^{\prime} 1 / 2^{\prime \prime}$ | 7'8', approx | 11,000 | $4^{\prime}$ wide |
| 8 W , mechanical, foreign service |  |  |  |  |  | $7^{\prime}$ high |
|  | $5612,60,63,66$ | 80,000 | $40^{\prime} 9^{\prime \prime}$. equipment compartment | $7^{\prime} 6^{\prime \prime} \text {, approx }$ | None | $6^{\prime}$ wide |
|  |  |  |  |  |  | $7^{\prime}$ high |

[^16]
## i. Special-Purpose Cars.

| Type | Gage (in.) | Weight (b) |  | Ooer end sils |  | Height above rail | Remarts |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Light | Loaded | Lenpth | Widh |  |  |  |
| Car, amb unit, 8W, domestic service.--- | 561/2 | 157,000 | 167,300 | 78'11* | $10^{\prime}$ | $13^{\prime \prime} 6^{\prime \prime}$ | Capacity: 27 pa 1 nurse, 1 doc | ents, 6 corpsmen, or. |
| Car, guard, domestic service | 561/2 | 92,740 | 99,300 | 57 | $9^{\prime \prime} 1^{\prime \prime}$ | $14^{\prime} 21 / 2^{\prime \prime}$ | Airconditioned, kitchen. 2 sle ments. | hower, tollet, ing compart- |
| Car, kitcher, troop/amb train, 8W, domestic service. | 561/2 | 100,160 | ---- | - $54.21 / 2^{\prime \prime}$ | 9'58/4" | $13^{\prime} 6^{\prime \prime}$ | Width, side doo | ópenings: 6 ' |
| Car, kitchen, dining and storage, amb train, 8 W , foreign service. | $561 / 2,60,63,66$. | 111,400, avg | --- | 631/4" | $9^{\prime}$ | 13' | Seat capacity: |  |
| Car, ward, amb train. | 561/2, 60, 63, 66 | 111,400, avg |  | 63, $1 /{ }^{\prime \prime}$ | $9{ }^{\prime}$ | $13^{\prime}$ | Berth capacity |  |
| Car, personnel, amb train | $561 / 2,60,63,66$ | 111,400, avg | - | 631/4/ ${ }^{\text {a }}$ | $9^{\prime}$ | $13^{\prime}$ | Berth capacity: 2 nurses. | 5 EM, 4 doctors, |
| j. Cranes. |  |  |  |  |  |  |  |  |
| Type |  |  | Gage (in.) |  | ${ }_{\left(W_{(i)}(i) h t\right.}$ | Boom length | Boom height dowon | Reach radius (mair hoist) |
| Wrecking, steam, 75-ton, broad gage, domestic and foreign service |  |  | 561/2, 60, 63, 66 |  | 191,000 | $25^{\prime}$ (2-pc, curved) | ) $12^{\prime} 33 / 4^{\prime \prime}$ | 16'-75-ton |
| Locomotive, diesel-mechanical, 150-ton, domestic service...-. |  |  | 561/2 |  | 291,700 | 28' (2-pc, straight) | ) $13^{\prime} 6^{\prime \prime}$ max. | 28'-67-ton |
|  |  |  | 561/2 |  | 167,000 | $50^{\prime}$ (2-pc, straight) | ) $13^{\prime} 6^{\prime \prime}$ max. | 12'-35 ton |
| Locomotive, diesel-mechanical, 25 -ton, broad gage, domestic and fore:gn service ${ }_{\text {- }}$ |  |  | 561/2, 60, 63, 66 |  | 148,000 | $50^{\prime}$ (2-pc, straight) | ) $13^{\prime} 6^{\prime \prime}$ max | 12'-25-ton |
| Locomotive, diesel-electrical, 40-ton, broad gage, fore ${ }^{\text {gn }}$ service - --------------- |  |  | 56112, 60, 63, 66 |  | 221,000 | $50^{\prime}$ (2-pc, straight) | ) $13^{\prime} 6^{\prime \prime}$ max | 12'-40-ton |
|  |  |  |  |  |  |  | ) $10^{\prime} 10^{\prime \prime}$ | 12'-25-ton |

## 4-5. Dimensions, Weight, and Capacities of Typical US Freight Cars

There are no standard dimensions for commercial cars. The figures given are for types in common use. The 40 -ton stock car comes in many lengths, varying from $35^{\prime} 7^{\prime \prime}$ to $41^{\prime} 10^{\prime \prime}$. All types have similar variations in capacity and dimensions.



## - Yee eapacity, 4 tons. <br> Ice capacity, 5 tons. <br> ${ }_{8}^{8} 8,000$ gallons. <br> ${ }^{\circ} 10.000$ gallo

4-6. Dimensions, Weight, and Capacities of Predominant Types of West German Freight Cars

| Type of cas |  | $\begin{gathered} \text { Tare } \\ \begin{array}{c} \text { weight } \\ (\text { ston } \end{array} \end{gathered}$ | Capacity |  | Inside dimensions |  | Heioht |  | Door dimensions | Height of floor ahove top of rail |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Number } \\ \text { of } \\ \text { axles } \end{gathered}$ |  | $\begin{aligned} & \text { Cubic } \\ & \text { feeel } \\ & \text { leol- } \\ & \text { full } \end{aligned}$ | $\begin{aligned} & \text { Short } \\ & \text { lons } \end{aligned}$ | Length | Width |  | Width | Height |  |
| Boxcar, G_ | 2 | 11.4 | 1,500 | 16.5 | 25'113/4" | $8^{\prime}$ | 7'49/6 | $4^{\prime} 111_{6}{ }^{\prime \prime}$ | 6'611/6" | /6 ${ }^{7}$ |
| Boxcar, GLMHS-50...- | 2 | 13.4 | 2,500 | 23.1 | 36,95/6" | 8'111/16" | $9^{15} / 8^{\prime \prime}$ | $66^{\prime 1} / 16^{\prime \prime}$ | $6^{\prime} 6^{11 / 66^{\prime \prime}}$ | 4'9/6" |
| Boxcar, GM-30 | 2 | 12.7 | 1,700 | 23.1 | 24'10" | $8^{\prime} 10^{\prime \prime}$ | 31'4* | $5^{\prime} 6^{\prime \prime}$ | $6^{\prime}$ | Not available |
| Boxcar, GMS-54- | 2 | 12.6 | 2,100 | 23.1 | $30^{\prime} 511 / 1{ }^{\prime \prime}$ | $8{ }^{\prime} 811 /{ }^{\prime \prime}$ | 8'91/2* | $5^{\prime} 10^{18} 96$ | $6^{\prime \prime} 11^{\prime \prime}$ | 4,1/6" |
| Boxcar, KMMKS-51.-- | 2 | 12.5 | 1,420 | 30.8 | 28'813/16 ${ }^{\prime \prime}$ | . $9^{\prime 5} / 8^{\prime \prime}$ | 5'61/8" | $5^{1} 10{ }^{13} / 16^{\prime \prime}$ | $4^{\prime} 105 / 8^{\prime \prime}$ | $4^{\prime} 1^{7}$ /6" |
| Boxcar; KMM8KS-58. | 2 | 14.3 | 1,800 | 29.7 | 28'89/16" | $8^{\prime} 111 / 16^{\prime \prime}$ | 715/16" | $12^{\prime} 83^{\prime \prime}{ }^{\circ}$ | $6^{\prime} 6^{11 / 16{ }^{\prime \prime}}$ | $4^{\prime} 11 / 16^{\circ}$ |
| Gondola, X-05 (low side). | 2 | Not available | 320 | 23.1 | $25^{\prime \prime} 7$ | $8^{\prime \prime} 7^{\prime \prime}$ | $1^{\prime \prime}{ }^{\prime \prime}$ |  |  | Not available |
| Gondola, XLM-57 (low side). | 2 | 8.4 | 330 | 23.1 | 29'7" | $8^{\prime \prime}{ }^{\prime \prime}$ | 1'4* | -------- | ---- | $4^{\prime}$ |
| Gondola, 0MM-37 (high side). | 2 | 9.7 | 1,210 | 24.6 | 2777 | $9^{\prime}$ | 4'10" |  | - | $4^{\prime}$ |
| Gondola, OMM-52 (high side). | 2 | 11.0 | 1;200 | 28.6 | $28^{\prime}$ | $8^{\prime}$ | $4^{\prime} 10^{\prime \prime}$ |  |  | $4^{\prime}$ |
| Gondola, OMM-55 (high side). | 2 | 11:0 | 1,200 | 27.5 | 28'89/6" | $93 / 8{ }^{\prime \prime}$ | $4^{\prime} 111 / 16^{\prime \prime}$ | $5^{\prime} 101 / 2{ }^{\prime \prime}$ |  | $4^{\prime} 7 / 8^{\prime \prime}$ |
| Gondola, OMM-53 (high side). | 2 | 12.1 | 1,200 | 27.5 | $28^{\prime}$ | $8^{\prime \prime} 9^{\prime \prime}$ | $4^{\prime} 10^{\prime \prime}$ |  |  | $4^{\prime}$ |
| Gondola, OMM-33 (high side). | 2 | 11.5 | 1,260 | 27.0 | $28^{\prime} 73 / 16^{\prime \prime}$ | 9'7/6" | 5'1" | $4^{\prime} 111^{1 / 16}{ }^{\prime \prime}$ | ------ | $4^{\prime} / 5 / 8$ |
| Flatcar, R-102-.------ | 2 | 10.6 |  | 16.5 | $33^{\prime} 25 / 16^{\prime \prime}$ | $8^{\prime \prime} 9^{\prime \prime}$ |  |  |  |  |
| Flatcar, RM-31a-.----- | 2 | 14.3 |  | 22.1 | 34'119 ${ }^{\text {/ }}$ " | 8'65/6" ${ }^{\prime \prime}$ | --------- |  |  | $4^{\prime} 11 / 8^{\prime \prime}$ |
| Flatcar, RMM-33as, ${ }^{\text {a }}$----- | 2 | 11.4 |  | 27.0 | $34^{\prime} 83 / 8^{\prime \prime}$ $40^{\prime}$ | 9'21/4" ${ }^{\prime \prime}{ }^{\prime \prime}{ }^{\prime \prime}$ |  |  |  | $4^{\prime} 114^{\prime \prime}$ |
| Flatcar, SM-142 ${ }^{\text {a }}$-------- | 2 | 11.9 |  | 25.3 | $41^{\prime \prime} 6^{\prime \prime}$ | 8'9" |  |  |  | ${ }^{4}$ Not available |
| Flatcar, SS-15 | 4 | 21.5 |  | 40.2 | 48'2" | 8'9" |  |  |  | Not available |
| Flatcar, SSLMA-44---- | 4 | 22.7 |  | 44.1 | 59, $2^{7} / 16^{\prime \prime}$ | $9^{\prime} 1 /{ }^{\prime \prime}$ |  |  |  | $4^{\prime} 53 / 4{ }^{\prime \prime}$ |
| Flatcar, SSLMAS-53. .- |  | 26.3 |  | 61.6 | 60, ${ }^{5} / \%^{\prime \prime}$ | $8^{\prime} 111^{13} / 6^{\prime \prime}$ |  |  |  | $4^{\prime} 61 / 8{ }^{\prime \prime}$ |


| Flatcar, SSKM-49 | 4 | 17.1 |  | 55.1 | 40.83/4" | 8'515/6" |  | 4'39/6" |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Flatcar, USA-owned. | 4 | 16.7 |  | 50.0 | 40'9" | 8'53/4" |  | 4'39/6" |
| Tank car | 2 | 14.0 | (b) |  | 21'2" |  | Not available | $5^{\prime}$ |
| Tank car | 4 | 26.4 | (c) |  | $33^{1 / 2}{ }^{\prime \prime}$ |  | Not available | $5^{\prime}$ |

a Height of flatcar is determined by height of stanchion.
Height of flatcar
b 4,356 US gallons.
$-14,266$ US gallons.

4-7. Dimensions, Weight, and Capacities of Predominant Types of Vietnam Freight Cars

| Type of ear | $\begin{aligned} & \text { Number } \\ & \text { of axles } \end{aligned}$ | $\begin{gathered} \text { Light weight } \\ (\text { (ston) } \end{gathered}$ | Capacity |  | Inside dimensions ( m |  |  | Door dimensions (melers) |  | $\begin{aligned} & \text { Height of } \\ & \text { foor above } \\ & \text { top of rail } \\ & \text { (meters) } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\overline{\text { Cubic meters }}$ | Pounds | Length | Width | Height | Widih | Height |  |
| Boxcar, G_ | 2 | 6.0 | 22.95 | 22,045.8 | 5.414 | 2.120 | 2.0 | 1.45 | 1.9 | 1.0 |
| Boxcar, GG | 4 | 19.5 | 66.35 | 55,144.5 | 13.118 | 2.529 | 2.0 | 1.829 | 1.8 | 1.1 |
| Flatcar, M | 2 | 4.9 |  | 22,045.8 |  |  |  |  |  | 1.0 |
| Flatcar, MM | 4 | 13.0 |  | 55,144.5 |  |  |  |  |  | 1.0 |
| Gondola, H | 2 | 5.2 | 12.1 | 22,045.8 | 5.47 | 2.2 | 1.03 | 1.45 | 1.03 | 1.0 |
| Gondola, HH. | 4 | 13.65 | 29.98 | 55,114.5 | 11.0 | 2.5 | 1.09 | 1.45 | 1.09 | 1.0 |
| Gondola, USA-owned | 4 | 16.5 | 26.88 | 60,000.0 | 10.6 | 2.39 |  |  |  | 1.0 |
| Tank car, MR. | 2 | 5.6 | 10.0 | 22,045.8 |  |  |  |  |  | 1.0 |
| Tank car, MMR | 4 | 18.5 | 30.0 | 45,908.0 |  |  |  | --- | ------ | 1.08 |

## 4-8. Dimensions, Weight, and Capacities of Predominant Types of Korean Freight Cars

| Type of car | $\begin{aligned} & \text { Number } \\ & \text { of axles } \end{aligned}$ | $\begin{gathered} \text { Light } \\ \begin{array}{c} \text { weight } \\ (\text { (sion }) \end{array} \end{gathered}$ | Capacity |  | Inside dimensions (melers) |  |  | Door dimensions (melers) |  | Height of floor above iop of rail (meters) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Cubic meters | Pounds | Lenoth | Width | Height | Width | Height |  |
| Boxcar | 4 | 18.8 | 58.0 | 66,000 | 10.202 | 2.67 | 2.10 | 1.52 | a 1.8 | Not available |
| Flatcar | 4 | 17.0 |  | 99,000 | 10.5 | 3.05 |  |  |  | 1.2 |
| Gondolas. | 4 | 12.7 | 46.64 | 66,000 | 10.084 | 2.643 | 1.75 |  |  | Not available |
| Tank cars, Juna | 4 | 20.5 | (b) | 71,962 | 11.8 | 2.050 | Not available |  |  | Not available |
| Refrigerator, mechanical, USA- | 4 | 29.5 |  | 100,000 | 9.95 | 2.641 | 2,082 | 2.39 | 2.44 | Not available |

## wned.

- Estimates.
- Estimates.

| 4-9. Capacity of Standard US Passenger Cars |  |  |  |
| :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Day } \\ \text { coach 1 } \end{gathered}$ | Tourist sleeper | Standard sleeper ${ }^{9}$ |
| Length in feet | 65-75 | 65-75 | 65-80 |
| Number of sections | None | 13-16 | 12-16 |
| 2 men to each double seat $\qquad$ | 60-70 | 52-64 | 53-64 |
| 3 men to each 2 double seats $\qquad$ | 45-52 | 39-48 | 40-48 |

## Section III. OPERATIONS

## 4-10. Planning Requirements

In planning for the most effective use of a railway system, detailed information about items a through $z$ is essential. FM 55-8 provides additional information on evaluating existing facilities.
$a$. Length of line.
b. Condition of roadbed and track.
c. Gage of track.
d. Single, double, or multiple track.
$e$. Weight of rail.
$f$. Type of ballast and depth.
$g$. Type of ties (if wood, treated or untreated).
$h$. Tie spacing.
i. Axle-load limitations (track and bridge).
$j$. Profile of line showing location and length of ruling grade.
$k$. Alinement of lines showing location and length of minimum-radius curves.
$l$. Location and description of bridges and tunnels.
$m$. Location and length of passing tracks.
$n$. Location, type, and quantity of fuel supply.
o. Location, quantity, and quality of water supply.
$p$. Location and capacity of yards.
q. Location and capacity of car repair shops and enginehouses.
$r$. Type and availability of motive power (weight in working order, expected working tractive effort, drawbar pull, and age).
s. Type and availability of rolling stock (capacity, dimensions, and age).

|  | $\begin{gathered} \text { Day } \\ \text { coacht } \end{gathered}$ | Touriat sleeper | Standard sleeptr ${ }^{\text {8 }}$ |
| :---: | :---: | :---: | :---: |
| Sleeping capacity: -bleper sleeper |  |  |  |
| 2 men per berth |  |  |  |
| (maximum) | None | 52-64 | 53-64 |
| 3 men per section | None | 39-48 | 36-48 |
| 1 man per berth | None | 26-32 | 27-32 |
| ${ }^{1}$ Limited number of steel coaches, 70 feet long or over, available. |  |  |  |
| no drawing room. |  |  |  |

$t$. Climatic and prevailing weather conditions.
$u$. Diagrams showing minimum structure, maximum unrestricted loading, and equipment gages.
$v$. Signal system (wire or radio requirements and coordinating responsibilities).
$w$. Dispatching facilities.
$x$. Route junctions.
$y$. Availability of new equipment and repair parts.
z. Local labor resources.

## 4-11. Outline of Standing Operating Procedure for Rail Movements

a. General. Policies and factors involved in selecting and accomplishing movements via rail.
b. Supply Movements.
(1) Releases. When required, methods of obtaining, formats, dissemination, action required.
(2) Routing. Responsibilities and procedures for determination, coordination, and accomplishment.
(3) Diversions and reconsignments. Authority and initiating procedures for; method of execution.
(4) Records and reports. Responsibilities and methods for the maintenance of specific records; appropriate references to reports to be submitted.

## c. Personnel Movements-Troops.

(1) Military authorization identification numbers (MAIN). Purposes, composition, methods, and procedures for assignment and use; marking on and eradicating from trains.
(2) Halts. Types; policies, procedures, and responsibilities for establishment and conduct.
(3) Travel warrants. Types, forms, authority, and responsibilities for issue, distribution, and usage.
(4) Troop-train commanders. Appointment, responsibilities, and functions; relationship with transportation personnel; instructions to be furnished (TM 55-204).
(5) Rations and water. Responsibilities and procedures for securing, furnishing en route, and disposition at destination.
(6) Discipline of troops. Responsibilities and command policies, police of rail equipment, sanitation.
(7) Diversions. Authority for ordering, responsibilities and procedures for effecting, reference to reporting.
(8) Records and reports. Responsibilities and methods for the maintenance of specific records and appropriate references to reports to be submitted.

## 4-12. Outline of Standing Operating Procedure for Transportation Railway Service

a. General. Policies and procedures for-
(1) Integration of rail transportation in the theater transportation net.
(2) Operational control.
(3) Coordination with adjacent commands for use of rail capacity and support of operating units.
(4) Coordination of the theater rail plan for selection, rehabilitation, and operation of rail lines in support of theater strategic plans.
b. Mission. Rail net and fac̣ilities operated; terminals, installations, and commands supported.
c. Organization. Operating units available, location, and operating limits.
d. Functions. Responsibilities for operation and maintenance of military railways, equipment, and freight, passenger, and special trains.

## e. Planning.

(1) Long-range planning responsibility and procedures; selection of rail primary and alternate routes; determination of line capacity, troop equipment, and supply requirements; rehabilitation and project requirements; communications and security requirements; demolition plans.
(2) Current operational plans: current rail line capacity and requirements; phases of operation; selection and rehabilitation of new or additional railheads, yards, and installation facilities.
f. Operations. Procedures for dissemination and implementation of movement programs; coordina-
tion with transportation movements officer; priorities for and utilization of rail equipment; responsibilities for preparation and compilation of operational and situation reports; procedures for ordering and documentation of cars; responsibilities for scheduling special trains; construction and use of railcar spanners, responsibility and methods of loading, blocking, bracing, and inspecting loaded cars.
g. Maintenance. Responsibility, procedures, inspections, reports, and standards for maintenance of military and utility railway facilities and equipment, including organizational, field, and depot maintenance.
h. Supply. Responsibility and procedures for requisitioning, stocking, distributing, maintaining levels of, disposing of excess, and accounting for railway operating and maintenance supplies; requirements and priorities for major items, including locomotives and rolling stock.
i. Intelligence and Reconnaissance. Responsibility and procedures for collecting, processing, disseminating, and using intelligence.
j. Security. Procedures, responsibility, coordination, and requirements for security of supplies en route by rail and security of trains and rail line-of-communication facilities; defense and demolition plans.
k. Records and Reports. Responsibility and procedures for reports; railway operation, situation, personnel status, equipment maintenance and inspection, equipment status, and project.
l. Training. Responsibility for conducting unit and technical training.

## 4-13. Maximum Bulk Loading of Typical US Freight Cars

The rated weight capacity of a car does not mean that the car can carry the rated tonnage of all items. For many types of cargo, the cubic capacity of the car is reached ahead of the rated capacity. When this occurs, the tonnage that the car can carry represents its actual capacity.
a. High Density Items. Freight cars loaded with high density items can nearly always be loaded to their rated capacity. Examples of high density items are ammunition, barbed wire, cement, flour, gravel, corrugated iron, rails, rifles in chests, sand, stone, sugar, telephone wire, and engineer tools.
b. Lighter Bulk Items. Some items for which the cubic capacity of the car is reached at the time of or before the rated tonnage has been loaded are listed below.

|  |  | apac30 | sh |  |
| :---: | :---: | :---: | :---: | :---: |
| Rated |  |  | 40 |  |
| Actual, by items: |  |  |  |  |
| Blankets, baled |  | 27 | 32 | 40 |
| Bread |  | 19 | 24 | 30 |
| Canned goods in boxes |  | 30 | 36 | 45 |
| Clothing, baled |  | 27 | 32 | 40 |
| Meat |  | 15 | 24 | 35 |
| Motor vehicle parts |  | 24 | 28 | 40 |
| Sandbags |  | 21 | 24 | 30 |
| Tentage |  | 15 | 20 | 30 |
| Ties, railroad |  | 19 | 26 | 32 |

## 4-14. Clearances-General

Overhead clearances and platform heights are measured from top of rail, side clearances from centerline of track. Clearances below those specified are dangerous, and protection must be provided by appropriate warning signs or devices. For example, telltales must be used for overhead clearances ranging between 18 to 22 feet. Unless local conditions require greater clearances, the
standard minimum clearances are as follows:
a. Overhead.
$\left.\begin{array}{llr} & & \begin{array}{c}F e e t \\ \text { and }\end{array} \\ \text { Mires: } & \\ \text { Meters } & \text { inches }\end{array}\right\}$


Figure 4-2. Standard single-track bridge and tunnel clearances.

| Gapes | 23\%/8 | 2 | 201/2 | so | 35 | 36 | s7 | 37\%/8 | 371/6 | :993/8 | 40 | 411/4 | 411/2 | 41\%/4 | 42 | 563/2 | 68\% | 60 | 63 | 68 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| a. Africa. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | X | - | - | - | X | - | X | - | - | - | - |
|  | - | - | - | - | - | - | - | - | - | x | - | - | - | - |  |  |  |  |  |  |
| Central African Republic---------------------------- | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | X | - | - | - | - | - | X |  |  |  |  |  |
| Congo, Republic of (Brazzaville) .-----------------1 | - |  | - | - | - | - | - | - | - | x | - | - | - | - | x |  |  |  |  |  |
|  | x | X | - | - | - | - | - | - | - | X | - | - | - | - | X |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x | - | - | - | - |  |  |  |  |  |  |
|  | - | - | x | - | - | - | - | - | - | X | - | - | - | - | - | x |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x | - | - | - | - | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |
|  | - | - | - | - |  |  |  |  |  | X |  |  |  |  |  | X |  |  |  |  |
|  | - | - | - |  | - | - | - | - | - | X | - | - | - | - |  |  |  |  |  |  |
| Kenya | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |
| Libya | - | - | - | - | - | - |  | - | x | - |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x | - | - | - | - | - |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - |  | - | - | - | - | - | x |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |
|  | - | - | - | - | - | - | - | - | x | - | - | - | - | - | - | X |  |  |  |  |
| Nigeria | - | - | - | x | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |
| Portuguese East Africa (Mozambique)-------------1 | - | - | x |  | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |
| Portuguese West Africa (Angole) | x |  | - | - | - | - | - | - | - |  | - | - | - | - | x |  |  |  |  |  |
| Republic of South Africa | - | X | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |  |  |  |  |  |
| Rhodesia- | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |



| Gages | 25\%/ | 24 | 291/2 | so | 35 | $s 6$ | 37 | 375/8 | 37\% | 395/8 | 40 | 411/2 | 411/2 | 41\% | 48 | 563/2 | 66\% |  | 60 | 63 | 66 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | - | - | - | X | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | x |
|  | - | - | - | X | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | X |
|  | - | - | - | - | - | - | - | - | - | - | - | X | - | - | - | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | x | - | - | - | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |  |  |  |  |  |  |
| Turkey ------------------------------------------1. | - | - | X | - | - | - | - | - | - | x | - | - | x | - | - | X | - | - | x |  |  |
|  | - | - | - | - | - | - | - | - | - | x | - | - | - | - | - | - | - | - | x |  |  |
| Vietnam $\qquad$ c. Europe. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - |  | - | - | - | - | - | x |  |  |  |  |  |
|  | - | - | - | x | - | - | - | - | - | x | - | - | - | - | - | x |  |  |  |  |  |
|  | - | $\cdot-$ | - | - | -- | - | - | - | - | X | - | - | - | - | - | x |  |  |  |  |  |
|  | x | - | X | x | - | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x | - | - | - | - | - | x |  |  | x |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |
|  | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |  |  |
| France---------------------------------------- | - | - | - | - | - | - | - | - | - | x | - | - | - | - | - | X |  |  |  |  |  |
|  | x | - | x |  | - | - | - | - | - | x | - | - | - | - | - | X |  |  |  |  |  |
|  | - | - | X | - | - | - | - | - | - | x | - | - | - | - | - | x |  |  |  |  |  |
|  | - | - | - | x | - | - | - | - | - | - | - | - | - | - | - | X |  |  | x |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |  |
|  | - | - | - | - | - | - | - | x | - | - | - | - | - | - | - | x |  |  |  |  |  |
|  | x | - | x | - | - | 二 | - | - | - | - | - | - | - | - | - | x | - | - | X |  |  |
|  | x | - | x | - | - | - | - | - | - | - | - | - | - | - | - | X | - | - | x |  |  |
|  | - | - | - | - | - | - | - | - | - |  | - | - | - | - | - | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x | - | - | - | - | x | X |  |  |  |  |  |
|  | - | - | x | - | - | - | - | - | - | - | - | - | - | - | - | x | - | - | x |  |  |

c. Europe.

|  | - | - | - | - | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | x |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | x |  |  |  |  | x |
|  | x | - | - | - | - | x | - | - | - | X | - | - | - | - | - | - | - | - | - | - | x |
|  | - | - | - | - | x | - | - | - | - | - | - | - | - | - | X | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | x | - | - | - | - | - | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |
|  | x | - | - | - | - | - | - | - | - | X | - | - | - | - | X | x | - | - | X |  |  |
|  | X | x | - | x | - | - | - | - | - | - | - | - | - | - | x | x | - | - | - |  |  |
|  | x | - | - | X | - | - | - | - | - | X | - | - | - | - | - | x |  |  |  |  |  |
| d. Central America and West Indies. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |  |
|  | - | - | - | - | - | x | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |
| Dominican Republic.------ | - | - | - | X | - | - | - | - | - | - |  |  |  |  | X |  | x |  |  |  |  |
|  | - | - | - | - | - | X | - | - | - | - |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | x | - | - | - | - |  |  |  |  |  |  |  |  |  |  |  |
| Haiti | - | - | - | x | - | - | - | - | - | - |  |  |  |  | x |  |  |  |  |  |  |
|  | - | - | - | - | - | x | - | - | - | - | - | - | - | 二 | X |  |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |  |
|  | - | - | - | - | - | x | - | 二 | - | - | - | - | - | - | - | - | - | - | X |  |  |
| Puerto Rico....................................... | - | - | - | - | - | - | - | - |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | - | -. | - | - | - | - | - | - | - | - | x |  |  |  |  |  |
| e: North America. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Canada-........................................ | - | - | - | - | - | X | - | - | - | - | - | - | - | - | x | x |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |  |
| Mexico_.-.-.-..................................... | - | - | - | - | - | x | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |
|  |  | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |
| Alaska |  | - | - |  | - |  | - | - | - | - | - | - | - | - | - | x |  |  |  |  |  |
|  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |


| Gages | 231/8 | 24 | 291/2 | so | 35 | 36 | 37 | 375/8 | s77/10 | 393/8 | 40 | 411/4 | 411/2 | \$1916 | 42 | 661/2 | 56\% |  | 60 | 69 | 66 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| f. South America. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Argentina----------------------------------------- | - | - | X | - | - | - | - | - | - | X | - | - | - | - | - | X | - | - | - | - | X |
| Bolivia.------------------------------------------- | - | - | - | X | - | - | - | - | - | X |  |  |  |  |  |  |  |  |  |  |  |
| Brazil--------------------------------------------- | - |  | - | X | - | - | - | - | - | X | - | - | - | - | - | X | - | - | - | X |  |
| British Guiana | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |
| Chile----------------------------------------------- | X |  | - | X | - | - | - | - | - | X | - | - | - | - | X | X | - | - | - | - | X |
|  | - | - | - | - | - | X | - | - | - |  |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | X | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |  |
|  | - | X | X | X | - | - | - | - | - | X | - | - | - | - | - | X |  |  |  |  |  |
|  | X | - | - | - | - | X | - | - | - |  | - | - | - | - | - | X |  |  |  |  |  |
| Surinam (Dutch Guiana).-------------------------- | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | $\bigcirc$ | - | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |
|  | - | X | - | X | - |  | - | - | - | X | - | - | - | - | X | X |  |  |  |  |  |
| g. Pacific Ocean. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | X | - | - | - | - | - | - | - | - | - | - | X | X | - | - | - | X |  |
|  | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - |  |  |  |  |  |  |
|  | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |  |  |  |  |  |  |
|  | - | - | - | - | - | 一 | - | - | - | - | - | - | - | - | X |  |  |  |  |  |  |
| Philippines | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |  |
|  | - | - | - | - | -- | - | - | - | - | - | - | - | - | - | X |  |  |  |  |  |  |

## 4-16. Clearances and Gages

The sample clearance diagrams shown in figures 4-3 and 4-4 refer to the distance that equipment or cargo may project to the side at various heights above track level. They are composites incorporating the smallest dimensions of all similar dimensions of the countries having the gages shown (para 4-5) ; therefore, not all the limiting clearances shown in the composites will exist si$\dot{\text { multaneously on any particular rail line. A clear- }}$ ance diagram for the rail line(s) over which operations are to be conducted must be obtained or made. Horizontal distances shown in the diagrams
should not be confused with the track gage. The composite clearances in figure 4-3 show minimum clearances for the standard-gage ( $561 / 2$-inch), and for the broad-gage track indicated. Figure 4-4 shows clearances for three sizes of narrow-gage track. Examples of the use of the diagrams are given below.
a. In figure 4-3, a vertical clearance of 3 feet 8 inches can be depended upon for a width clearance which is at least 9 feet 8 inches. In the same figure, a vertical clearance of $93 / 4$ inches can be depended upon if the width clearance is not less than 8 feet $11 / 2$ inches.


Figure 4-s. A composite clearance diagram: $561 / 2-60-, 68-$, and 66 -inch gages.


Note1: $2^{\prime}-8 \frac{3}{4}{ }^{\prime \prime}$ for 36 -inch track gage $3^{\prime}$ for $39 \frac{3}{8}$ - and 42-inch track gage

Notez: 4' for 36 - and $39 \frac{3}{6}$-inch track gage 4'-5" for 42-inch track gage

Figure 4-4. A composite clearance diagram: $36-, 39 \%$-, and 42-inch gages.
b. In figure 4-4, a vertical clearance between $133 / 4$ inches and 3 feet 4 inches can be depended upon when the width clearance is not less than 8 feet.

## 4-17. Bridge Capacity

a. Cooper's E Rating. This figure indicates, in thousands of pounds, the weight a bridge can support for each driving axle of a locomotive. Mili-
tary railroad bridges are normally designed for Cooper's E-45 but may be built for lighter or heavier loadings as required. For example, the following method is used to determine the rating a bridge must have if it is to be crossed safely by a 2-8-0 (steam) locomotive weighing 140,000 pounds on drivers:

A 2-8-0 locomotive has four driving axles.

140,000 pounds (weight of locomotive) divided by 4 (number of driving axles) equals 35,000 pounds (weight per driving axle).
Therefore, any bridge which has a rating of E-35 or above can be crossed safely by this locomotive.
b. Steel ।-Beam Bridge (Fig. 4-5). The chart below refers to bridges already constructed with two, four, six or more steel stringers or girders of equal dimensions. To estimate the capacity of a railway bridge with this type of construction, the
width and thickness of the lower flange of one stringer are measured at the center of the span length; the depth and length of the stringer are also measured. Using the chart below, the steel stringer that is nearest to these dimensions is selected, and the corresponding E-rating of the bridge is read. The rating is reduced according to the age and condition of the bridge. The quantity of reduction must be determined by qualified personnel, normally from the Corps of Engineers. For additional information concerning bridge capacities, refer to TM 5-312.


Figure 4-5. Measuring a steel stringer.
f (This chart presents data for determination of order of magnitude of stringers. One stringer per rail is assumed. Qualified personnel from N Corps of Engineers should he consulted for bridge capacity.)

## Stringer dimenoic

| Thickness | Width | Stringer depth | 10 | 11 | 12 | 13 | 14 | $S_{\text {pan }}^{\text {lingeth (1) }}$ | 16 | 17 | 18 | 19 | ${ }^{2}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $3 / 8$ | 83/8 | 18 | E-42 | E-41 | E-41 | E-41 |  |  |  |  |  |  |  |
| 8/8 | 103/8 | 24 |  | E-59 | E-48 | E-40 | E-35 | E-31 | E-27 |  |  |  |  |
| 1/2 | 103/8 | 30 |  |  |  | E-61 | E-59 | E-51 | E-46 | E-41 | E-37 | E-33 | E-30 |
| 1/2 | 121/2 | 30 |  |  |  |  |  | E-62 | E-56 | E-50 | E-45 | E-41. | E-37 |
| 1 | 14 | 36 |  |  |  |  |  |  |  | E-60 | E-58 | E-55 | E-54 |
| 1/2 | 123/8 | 42 |  |  |  |  |  |  |  |  |  | E-60 | E-54 |
| 11/2 | 14 | 42 | - |  |  | - |  | ----- |  |  |  |  | E-63 |
| 11/8 | 16 | 42 |  |  |  |  |  |  |  |  |  |  |  |
| 1/2 | 16 | 48 |  |  |  |  |  |  |  |  |  |  |  |
| 1 | 16 | 48 | (1) |  |  |  |  |  |  |  |  |  |  |
| 15/8 | 14 | 54 |  |  |  |  |  |  |  |  |  |  |  |
| $13 / 4$ | 14 | 60 |  |  |  |  |  |  |  |  |  |  |  |
| 11/2 | 14 | 60 |  |  |  |  |  |  |  |  |  |  |  |
| 21/8 | 15 | 66 |  |  |  |  |  |  |  |  |  |  |  |
| 2 | 14 | 66 |  |  |  |  |  |  |  |  |  |  |  |
| 2 | 14 | 72 |  |  |  |  |  |  |  |  |  |  |  |
| $21 / 2$ | 151/2 | 72 |  |  |  |  |  |  |  |  |  |  |  |
| 21/8 | 14 | 78 |  |  |  |  |  |  |  |  |  |  |  |
| $21 / 2$ 2116 | 16 20 | 84 96 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

(This chart presents data for determination of order of magnitude of stringers. One stringer per rail is assumed. Qualified personnel from Corps of Engineers should be consulted for bridge capacity.)

| Stringer dimenotomu (im.) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Louper flange |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Thickness | Widh | Stringer depth | 22 | 24 | 26 | 28 | so | 36 | 40 |  | $\mathrm{sm}_{50} \text { lenth }$ | (a) $84$ | 60 | 64 | 70 | 74 | 80 | 84 | 90 |
| 1/2 | 103/8 | 30 | E-27 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1/2 | 121/2 | 30 | E-31 | E-26 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 | 1.4 | 36 | E-51 | E-48 | E-43 | E-39 | E-34 | E-26 |  |  |  |  |  |  |  |  |  |  |  |
| 1/2 | 123/8 | 42 | E-45 | E-39 | E-34 | E-30 | E-26 |  |  |  |  |  |  |  |  |  |  |  |  |
| $11 / 8$ | 14 | 42 | E-60 | E-57 | E-54 | E-51 | E-45 |  |  |  |  |  |  |  |  |  |  |  |  |
| 11/8 | 16 | 42 |  | - |  | E-60 | E-54 | E-42 | E-32 |  |  |  |  |  |  |  |  |  |  |
| 11/2 | 15 | 48 | ----- | - |  |  | E-59 | E-52 | E-47 | E-43 | E-33 |  |  |  |  |  |  |  |  |
| 1 | 16 | 48 |  |  |  | E-66 | E-57 | E-45 | E-35 | E-30 |  |  |  |  |  |  |  |  |  |
| 15/8 | 14 | 54 | --- | - |  |  |  | E-54 | E-43 | E-36 | E-28 |  |  |  |  |  |  |  |  |
| 13/4 | 1.4 | 60 | --- | - |  |  |  |  | E-60 | E-54 | E-43 | E-37 | E-30 | E-27 |  |  |  |  |  |
| 11/2 | 14 | 60 |  |  |  |  |  |  | E-57 | E-48 | E-38 | E-33 | E-27 |  |  |  |  |  |  |
| 21/8 | 15 | 66 | --- |  |  |  |  |  |  |  | E-57 | E-54 | E-46 | E-41 | E-34 | E-31 | E-26 |  |  |
| 2 | 1.4 | 66 |  |  |  |  |  |  |  |  | E-56 | E-48 | E-40 | E-35 | E-30 | E-26 |  |  |  |
| 2 | 14 | 72 |  |  |  |  |  |  |  | --- | E-62 | E-54 | E-44 | E-39 | E-32 | E-29 | E-25 |  |  |
| $21 / 2$ | 151/2 | 72 | - |  |  |  |  |  |  |  |  |  | E-55 | E-51 | E-43 | E-38 | E-33 | E-29 |  |
| 21/8 | 14 | 78 |  |  |  |  |  |  |  |  | -- | E-64 | E-52 | E-46 | E-39 | E-35 | E-30 |  |  |
| 21/2 | 16 | 84 |  |  |  |  |  |  |  |  |  |  |  | E-64 | E-54 | E-49 | E-41 | E-38 | E-30 |
| 21116 | 20) | 96 |  |  |  | - | --- | - | -- | -- | --- | - |  |  |  |  |  | E-59 | E-51 |



Figure 4-6. Measuring a wooden stringer.
c. Wooden Bridge (Fig 4-6). For a bridge with wooden stringers, the width of each stringer is measured under one track at the center of the longest span and added to obtain total stringer width. In figure 4-6, the total stringer width is 2 x W . The depth and length of one stringer are also measured. The following table is used with the same procedures as the table in $b$ above.

| Stringer dimensions (in.) |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Span length (ft) |  |  |  |  |
| Widt | Dept | th 10 | 12 | 14 | 16 | 18 | 20 | 28 |
| 18 | 12 | E-16 | E-12 |  |  |  |  |  |
| 18 | 14 | E-22 | E-18 | E-10 |  |  |  |  |
| 18 | 16 | E-28 | E-20 | E-15 | E-10 |  |  |  |
| 18 | 18 | E-38 | E-26 | E-18 | E-14 | E-12 |  |  |
| 20 | 12 | E-18 | E-12 |  |  |  |  |  |
| 20 | 14 | E-25 | E-17 | E-12 |  |  |  |  |
| 20 | 16 | E-33 | E-23 | E-16 | E-12 | E-10 |  |  |
| 20 | 18 | E-43 | E-29 | E-21 | E-16 | E-13 | E-10 |  |
| 24 | 12 | E-22 | E-15 | E-11 |  |  |  |  |
| 24 | 14 | E-30 | E-21 | E-14 | E-11 |  |  |  |
| 24 | 16 | E-40 | E-28 | E-20 | E-15 | E-12 |  |  |
| 24 | 18 | E-52 | E-36 | E-25 | E-19 | E-15 | E-12 | E-10 |
| 36 | 12 | E-34 | E-23 | E-17 | E-12 | E-10 |  |  |
| 36 | 14. | E-47 | E-32 | E-23 | E-17 | E-14 | E-11 |  |
| 36 | 16 | E-62 | E-43 | E-30 | E-23 | E-19 | E-15 |  |
| 36 | 18 | E-78 | E-53 | E-30 | E-30 | E-24 | E-20 | E-16 |
| 40 | 12 | E-38 | E-26 | E-19 | E-14 | E-11 |  |  |
| 40 | 14 | E-52 | .E-36 | E-26 | E-20 | E-16 | E-12 |  |
| 40 | 16 | E-69 | E-47 | E-35 | E-26 | E-21 | E-17 | E-17 |
| 40 | 18 | E-87 | E-60 | E-44 | E-34 | E-27 | E-22 | E-18 |
| 48 | 12 | E-46 | E-31 | E-23 | E-17 | E-13 |  |  |
| 48 | 14 | E-63 | E-43 | E-31 | E-24 | E-19 | E-15 |  |
| 48 | 16 | E-83 | E-57 | E-41 | E-32 | E-26 | E-21 |  |
| 48 | 18 | E-105 | E-73 | E-53 | E-41 | E-33 | E-27 | E-22 |
| 54 | 12 | E-52 | E-35 | E-27 | E-19 | E-15 |  |  |
| 54 | 14 | E-72 | E-49 | E-35 | E-22 | E-18 |  |  |
| 54 | 16 | E-94 | E-65 | E-46 | E-36 | E-29 | E-24 |  |
| 54 | 18 | E-119 | E-82 | E-60 | E-46 | E-38 | E-30 | E-25 |
| 60 | 12 | E-58 | E-40 | E-30 | E-22 | E-17 |  |  |
| 60 | 14 | E-79 | E-55 | E-39 | E-30 | E-35 | E-20 |  |
| 60 | 16 | E-104 | E-72 | E-52 | E-40 | E-33 | E-27 |  |
| 60 | 18 | E-132 | E-92 | E-67 | E-52 | E-42 | E-34 | E-28 |

## 4-18. Loading Open-Top Cars

Military equipment loaded on Department of De-fense-owned cars traveling over the lines of common carriers and on cars belonging to common carriers within the continental United States must meet the loading standards of the individual railroad and those of the Association of American Railroads (AAR). Cars loaded on railroads of foreign countries must meet the blocking and lashing standards of the country involved. Standardization Agreements (STANAG) govern the loading of military equipment on rail lines of the NATO nations in Europe. The standards for and methods of blocking, nailing, and bracing for some typical military loadings are given in this paragraph. Association of American Railroads' regulations, Rules Governing the Loading of Department of Defense Material on Open-Top Cars, on file at all ITO in CONUS (see also para 4-20) should be followed. The following examples apply only to the loading of flatcars and composite gondolas with wooden floors with the equipment listed in $a$ through $d$ below and illustrated in figures 4-7 through 4-11. The letters in the item column refer to the letters shown in the illustrations. In all examples, brake wheels have the clearances shown in figure 4-12. The various wooden blocks, cut to specific patterns and numbered, are illustrated in figure 4-13. Additional details are contained in TM 55-601.
A. Six-Wheel truck (Fig 4-7).

| Item | No. of pieces |
| :---: | :---: |
| A |  |
| B | '8 or 12 as |
|  | required |

Brake-wheel clearance. See figure 4-12.
Block, pattern 16. Locate $45^{\circ}$ portion of block against front and rear of front wheels, in front of inside and outside in-

D $\quad 4$ or 6 as
C 1 each item D

$$
\begin{gathered}
\text { D } \quad 4 \text { or } 6 \text { as } \\
\text { required }
\end{gathered}
$$

Description
termediate wheels and in back of inside and outside rear wheels. Nail heel of the block to the car floor with three 40 d nails and toenail that portion of the block under the tire to the car floor with two 40d nails before items C and D are applied.
Suitable protective material, such as waterproof paper or burlap, etc. Locate bottom portion under item $D$, the top portion to extend 2 inches above item D.
Each to consist of one piece of 2 - by 6 - by 36 -inch lumber and three pieces of 2-by 4 - by 36 -inch lumber. Nail one edge of the 2 - by 6 - by 36 -inch piece with five 12 d nails. Then place against the tire and nail to the car floor through the 2- by 4 -inch piece with four 20d nails. Nail the other two pieces of 2 - by 4 - by 36 -inch to the one below in the same manner (sketch 1, fig. 4-7).
Six strands of No. 8-gage wire. Attach to the shackles located at each end of the unit and to

## Item No. of pieces

F 8 or 12 as required

## Description

stake-pockets on the same side of the car. When load exceeds 22,000 pounds, 8 strands of No. 8-gage wire is used. Metal fillers sufficient to provide a suitable radius must be used to protect the wire at stakepockets and applied so as to prevent dislodgement. Twist wires taut with a rod, bolt, or suitable length of 2 - by 2 inch lumber and secure to prevent unwinding (sketch 2, fig 4-7). Substitute, if desired, $1 / 2$-inch IWRC steel cable in a complete loop and secure with four $1 / 2$-inch cable clips. Thimble must be used at the stake-pocket (sketch 3, fig. 4-7), to protect the cable and be secured to the cable with one cable clip.
Each to consist of six strands of No. 8-gage black-annealed wire. Pass through the spokes or holes in the front and rear wheels and through the car stake-pockets so that they form an $X$ across the face of the wheel. Twist taut with a rod, bolt, or suitable length


Figure 4-7. Loading a six-wheel truck on an open-top car.

Description
of 2- by 2-inch lumber and secure to prevent unwinding. When load exceeds $22,000 \mathrm{lb}$., use additional $F$ applied to the intermediate rear wheels.

1. All handbrakes are to be set with the hand levers wired or blocked. Gear shift levers for automatic or conventional transmissions must be placed and wire-tied in neutral position. Clutch pedal is to be secured in depressed position by wiring to floor board plate or by wiring a wood block to the pedal shaft beneath the floor board.
2. When No. 8-gage wire is used for tiedown purposes, the wire is to be threaded in a continuous length until all the required number of strands are formed (one complete loop consists of two strands).
3. Tires are to be inflated to 10 psi above highway operating pressures.
b. Lighter, Amphibious, 5-Ton (LARC-V) (Fig 4-8).

| Item | No. of pieces | Description |  |
| :---: | :---: | :---: | :---: |
| A | -------- | Brake-wheel clearance (fig 4-12). |  |
| B | 16 | Blocks, pattern 15 (fig 4-13). |  | Blocks, pattern 15 (fig 4-13). Locate two in front and two in rear of each of the four wheels, and secure to floor with two 60d nails in the heel of block and two 40d nails in each side of block.

C 4
Rub-rail assemblies, see sketch A (fig 4-8). Nail 2- by 8- by 36-inch vertical member to the lower piece of 2 - by 4 - by 36 -inch lumber with five 12 d nails. Position this assembly with 2 - by 8 -inch lumber against tire and secure to floor of car through 2- by 4inch piece with five 20 d nails. Secure second 2-by 4- by 36inch piece of lumber to the lower 2 - by 4 -inch piece with five 20 d nails.
D 2

E $\quad 4$

F 4

Each to consist of two pieces of 2- by 4 -inch lumber, length equal to distance between items C. Secure lower piece to floor with 20 d nails spaced 8 inches apart. Nail top piece to lower piece in like manner.
Two pieces of 2 - by 4 - by 24 inch lumber. Nail to items C and D, using eight 20d nails to each piece.
Suitable protective material between tires and rub-rail assemblies. \%/8-inch diameter ca-

| Item | No. of pieces | Description |
| :---: | :---: | :---: |
| G | 6 |  |
|  |  | ble, 6 by 19 IWRC. Form complete loop with 14 -inch overlap. See sketch B. |
| H | 4 | Same as item G, except with 26inch overlap. See sketch C (fig 4-8) for fittings. |
| ${ }^{\mathbf{J}}$ | 3 | Shackles. For vehicles having a $11 / 16$-inch hole in the towing bracket, use a 1 -inch diameter pin with a $7 / 8$-inch steel galvanized coated anchor shackle. For vehicles having a larger hole in the towing bracket use an appropriate size pin and shackle. Attach the shackle to the towing bracket and secure the pin with a cotter key. |
| K | 4 | 2- by 4- by $141 / 2$-inch wood protective spacer between cable and side of vehicle. Secure to cable with staples. |
| L | 4 | Rubber hose protective spacer, 15 inches long. See sketch C. |
| M | 64 | 5/-inch cable clamp, U-type only. |
| N 0 | 6 10 | \%/8-inch closed thimble at load end of bow and stern cables. | - 10 or

Same as item G, except with 26inch overlap. See sketch C (fig 4-8) for fittings.
hackles. For vehicles having a bracket use a 1 -inch meter pin with a $7 / 8$-inch steel galvanized coated anchor hackle. For vehicles having a brack use an appropriste size pin and shackle. Attach the shackle to the towing with a cotter key.

- by 4- by $141 / 2$-inch wood proand $\mathbf{x}$ sp cable with staples.
Rubber hose protective spacer,
15 inches long. See sketch C.
only. end of bow and stern cables. 5/8-inch open thimble.
c. Mounted Gun or Howitzer (fig 4-9). 1,2

| Item | No. of pieces | Description |
| :---: | :---: | :---: |
| A |  | Brake-wheel clearance (fig 4-12). |
| B | 4 | Blocks, pattern 16 (fig 4-13). Locate $45^{\circ}$ portion of block at front and rear wheels. Secure heel of block to floor with three 40 d nails and toenail that portion under tire to floor with two 40d nails before items $C$ are applied. |
| C | 2 | Each consisting of two pieces of lumber 2 - by 4 - by 36 -inches. Secure lower piece to floor with three 40 d nails and top piece to one below in like manner. |
| D | 2 | Support, pattern 62 (fig 4-18), length $1 / 4$-inch longer than the distance between point of support on gun carriage to partially relieve weight on tires. Secure each to floor with six 40d nails. |
| E | 2 | Four strands of No. 8-gage, black annealed wire. Pass through holes in wheels and secure to stake-pockets. |
| F | 2 for single spade, 4 for double spade | 6 - by 8 - by 24 -inches, cut to fit contour of spade. Locate in front and rear of spade. Toenail to floor with five 40d nails. |

Each consisting of two pieces of而 2 - by 4- by 36 -inches. Sech low pith the 40 d nell in manner
port 14 ith 62 (fg 4 distance boin port on gun carriage to partially relieve weight on tires. Secure each to floor with six

Four strands of No. 8-gage, black annealed wire. Pass through holes in wheels and secure to stake-pockets.
be by 24 inche, tot to front of spade. Locate in nails.


SKETCH "A"


Figure 4-8. Blocking and tiedown details.


TIE DOWN SEQUENCE - SIDE CABLES 'H" TO 日E APPLIED AFTER ALL uínén ċables have been tightened. the proper degree of taut. NESS FOR CABLE "H" is ogtaned gy Positioning spacen " $X^{\prime \prime}$ as SHOWH IN SKETCH C AND TIGHTENING CABLE UNTIL FIRM CONTACT ls made throuohout the lemgth of spacer. apply spacer stapies after cable puller is removed.

Blocking and tiedown details, side view
Figure 4-8-Continued.

| Item | No. of pieces <br> $\mathbf{G}$ each item <br> $\mathbf{F}$ |
| :---: | :--- |
| H | 2 |
| J | 1 pair |
|  |  |
| K | 1 |

## Description

Each consisting of two pieces of lumber 2 by 4 by 12 inches. Secure lower piece to floor, against item $F$, with three 40d nails and top piece to one below in like manner.
2 by 4 by 12 inches. Locate against each side of spade and secure to floor with three 40d nails.
Stakes or green saplings. Locate one-third of distance from end of gun trail to center of wheels.
Six strands, No. 8-gage, black annealed wire. Loop around and over top of rear end of gun trail and secure to opposite stake-pockets. Substitute, if desired, 2- by .05inch high-tension bands or $1 / 2$-inch steel cables.
d. Tanks and Similar Units, From 60,000 to 100,000 Pounds (Fig 4-10).1,2,3,4

| Item | No. of pieces |
| :---: | :---: |
| A |  |
| B | 2 |
| C | 2 |
| D | 2 each items B and C |
| E | $\begin{aligned} & 2 \text { each items } \\ & \text { B and C } \end{aligned}$ |
| F | 2 each unit |

Deacription
Brake-wheel clearance (fig 4-12).
Blocks, pattern 31 (fig 4-13). Locate one against each rear crawler tread.
Blocks, pattern 30 (fig 4-13). Locate one against each front crawler tread.
2 by 4 by 20 inches. Locate one on inside of items B and C and secure to floor with six 20d nails.
Each consisting of two pieces of lumber 2 by 4 by 12 inches. Locate against ends of items $B$ and $C$. Secure lower piece to floor with four 20d nails and top piece to one below in like manner.
Each consisting of 2 pieces of lumber 2 in . by 4 in . by 14 feet. Locate on floor against inside of each crawler tread,

1. a See notes at end of $d$ below.

Hand brakes must be set and levers wired or blocked.
See General Rules for further details.


Figure 4-9. Loading a 37 mm to 105 mm mounted gun or howitzer on an open-top car.

N $\quad 2$ each unit $\quad$ /8-inch steel cable, $6 \quad \mathbf{x} \quad 19$
Item No. of pieces
G 3 each unit

H 6

J $\quad 6$

K 6

L $\quad 12$

M
4

Description
and secure lower piece to floor with twelve 30d nails and top piece to one below in like manner.
Each consisting of two pieces of lumber 2 by 4 inches, long enough to fill space between item F. Locate one near center and one near each end of items F. Secure lower piece to floor with four 30 d nails and top piece to one below in like manner.
Each consisting of two pieces of lumber 6 by 6 inches, length to suit, cut to fit contour of bogie wheels. Locate one piece between inside and outside wheels of each bogie assembly.
Each consisting to two pieces of lumber 4 by 4 inches, length to suit. Locate against bogie wheels on top of item H .
Each consisting of two pieces of lumber 4 by 4 inches, long enough to fill space between items $H$ with two $20 d$ nails.
Each consisting of two strands No. 8-gage, black annealed wire. Pass under crawler tread and around items H and J. Substitute, if desired, at each location, one $3 / 4$ - by .035inch high-tension band. Use staples or nails bent over to retain bands or wires in position.
$11 / 4$-inch-diameted rods. Attach to lifting lugs and pass through stake-pockets and $1 / 2-$ by 4 - by 10 -inch plates underneath stake-pockets on opposite sides of car. Substitute, if desired, $5 / 8$ inch steel cable, doubled. IWRC. Apply two $3 / 8$-inch cables in a complete loop securing gun barrel to unit at each side. Not required when unit is equipped with external built-in gun brace; however, if external gun brace is inoperative, cable may be used. 'Substitution of wire or banding is not authorized.

When necessary to extend floor to provide bearing for wheels or for the application of items $D$ on units loaded on floor of car, apply one piece of blacking on top of stake-pockets, long enough to extend beyond wheel chock blocks and high
enough to be level with top of floor. Use 1- by 4by 18 -inch lumber at each end of blocking, nail each to floor with three 20d nails and to blocking with two 20d nails. This method is illustrated in figure 1-C, section I, AAR Loading Rules. Figure 4-10, when applicable, may be used for the loading of vehicles being shipped under the provisions of DOT Special Permit No. 3498 during a National Emergency providing the gross weight per vehicle does not exceed 100,000 pounds each, use figure 4-11.

[^17]| ${ }_{\text {Item }}^{\text {A }}$ | No. of pieces |  |
| :---: | :---: | :---: |
| B | 2 | Brake-wheel clearance (fig 4-12). 10 inches by 18 inches by 24 |
|  |  | feet. Locate, as shown along each side of car. Secure each to car with at least five bolts 1 inch in diameter passed through items $\mathbf{B}$ and $\mathbf{C}$, wood filler in stake-pocket, and $1 / 2$ by 4 - by 10 -inch plate underneath stake-pocket. Not required for units loaded on floor of car. |
| C | As required | Metal filler, length, width, and thickness to suit. Locate between items $B$ and top of stake-pockets. Not required when units are loaded on floor of car. |

D 4 Each to consist of two pieces of lumber 2 by 6 by 18 inches. Locate against item $B$, as shown. Secure lower piece to floor with four 30d nails and top piece to one below in like manner. Not required for units loaded on floor of car.
E 2 Blocks, pattern 30. Locate one against each front crawler tread.
F 2 Blocks, pattern 31. Locate one against each rear crawler tread.
2 by 3 by 20 inches. Locate as shown against each side of items $\mathbf{E}$ and $\mathbf{F}$ and secure to floor or item B with four 20d nails in each.
H 4

Each to consist of two nieces of lumber 2 by 12 by 18 inches. Locate one against each item $\mathbf{E}$ and $F$. Secure lower piece


Figure 4-10. Loading a tank or similar unit, 60,000 to 100,000 pounds, on an open-top car.

K 3

L 2

## Description

to floor or item B with five 30d nails and top piece to one below in like manner. Substitute, if desired, pattern 81 (fig 4-13).
2 by 8 by 13 inches. Locate as shown against items $B$ and crawler, one near each end of unit and one at center. Secure each to item B with four 30d nails, and to item $K$ with three 30d nails. Not required for units loaded on floor of car or when pattern 80 (fig $4-13$ ) is used.
.4 by 6 inches, length equal to distance between items J. Not required for units loaded on floor of car. Substitute, if desired, pattern 80.
Each to consist of two pieces of lumber 2 inches by 4 inches by 14 feet. Locate against inside of crawler treads. Secure

## Description

lower piece to floor with 30d nails spaced about 12 inches apart and top piece to one below in like manner. Required only when units are loaded on floor of car.
Each to consist of two pieces of lumber 2 by 4 inches, length to suit, suitably spaced between items L. Secure lower piece to floor with 30d nails and spaced about 12 inches apart and top piece to one below in like manner. Required only when units are loaded on floor of car.
Each to consist of two pieces of lumber 6 by 6 inches, length to suit, cut to fit contour of bogie wheels. Locate one piece between inside and outside wheels of each bogie assembly.

| rtem | No. of pieces | Deesoription |
| :---: | :---: | :---: |
| 0 | 1 each item N | 2 by 4 inches, length to suit. Locate on top of item N , as shown, and secure with four 20d nails. |
| $\mathbf{P}$ | 8 | Rods $11 / 4$ inches in diameter. Attach to lifting lugs and pass through stake-pockets and $1 / 2$ - by 4 - by 10 -inch plates underneath stake-pockets, as shown. Substitute, if desired, $6 \times 19$ IWRC wire rope, doubled. |
| Q | 2 | \$/8-inch steel cable, doubled. Locate, as shown, between gun turret and crawler structure. |
| R | 2 each unit | \%/inch steel cable, $6 \times 19$ IWRC. Apply two \%-inch cables in a complete loop securing gun barrel to unit at each side. Not required when unit is equipped with external builtin gun brace; however, if external gun brace is inoperative, cable will be used. Substitution of wire or band ing is not authorized. |

When necessary to extend floor to provide bearing for wheels or for the application of Items $G$ on units loaded on floor of car, apply one piece of blacking on top of stake-pockets, long enough to extend beyond wheel chock blocks and high enough to be level with top of floor. Use 1- by 4-

[^18]by 18-inch lumber at each end of blocking, nail each to floor with three 20d nails and to blocking with two 20d nails.

## 4-19. High and/or Wide Loads

a. Cars with high and/or wide loads may create an operating hazard: Both the cargo and the personnel working on the line can be endangered. Every possible effort must be made to reduce such hazards.
b. The transportation officer initiating a high and/or wide load is responsible for coordinating the shipment with the shipping agency to effect the maximum reductions possible; for example, the removal of spotlights and toolkits, the lowering of booms, and the depressing of gun barrels. Shipping configurations of major items of Army equipment are contained in TB 55-46-1.
c. When the movement of a high and/or wide load must be made, a scale drawing should be given the serving carrier to determine rail transportability and, if transportable, to make necessary routing instructions.
d. It is essential that the dimensions provided the carrier be accurate and that they reflect the absolute minimum that can be achieved by the shipping agency. (The consignee's ability to reassemble dismantled equipment must be considered.)
e. Whenever possible, an item of equipment should actually be measured to determine its shipping cube. Dimensions from supply manuals, TM,


Figure 4-11. Loading tanks and similar units over 100,000 pounds on flatcars.


Figure 4-12. Brake-wheel clearance.


Figure 4-1s. Chocks with dimensions and pattern numbers of the Association of Amorican Railroade.


Figure 1-18-Continued.


Figure 4-18-Continued.

FM, etc., should not be used without verification. Incorrect dimensions can be very dangerous and costly.
$f$. When moving outsize (high or wide) loads through areas of close clearances, such às low bridges or tunnels, building platforms close to the track, etc., trains should be operated at slow or reduced speeds; everyone concerned should be alerted to the movement.

## Q-20. Looding Explosives amed Orher Hazarcous Alaierials

$a$. The authority and responsibilities of the DOT are established by Federal Law in Section 831-835, Title 18 of the US Code for the requirements governing the handling and transport of hazardous materials. These regulations are published in 49 CFR parts 170-179 and R. M. Graziano's Tariff Number 25 entitled "Hazardous Materials Regulations of the DOT." The DOT is responsible for the regulation of shipment and/or movement of all hazardous materials in interstate commerce by rail, air, highway and water through its major operating agencies. These regulations give requirements for classification, compatibility, packaging, marking, labeling, storage, and placarding of containers and vehicles for hazardous materials. Requirements for carriers of rail freight for loading, unloading, storage, marking, placarding, compatibility, and handling packages in cars are given in 49 CFR 174. These regulations cover minimum transportation requirements only. DOD and DA may supplement DOT requirements when deemed necessary. The transportation of military explosives and hazardous materials by either military carriers or commercial carriers within CONUS is governed by AR 55-355. AR 55-355 requires compliance with all regulations, reporting of accidents in accordance with AR 385-40, maintenance of records, tracing of shipments and completion of DD Form 6 and SF 361 when required, and insuring that security is maintained. AR $55-355$ gives a list of AAR loading rules applicable to safe transportation. Approved military drawings for out-loading procedure will be complied with by the shipper. The use of placarding of containers and vehicles is given in AR 55-355. The marking of packages will be in accordance with MIL STD 129. The DOT regulations 49 CFR 173-56(C) and (C) (1) require approval of the Bureau of Explosives (Association of American Railroads) of all loading, blocking and bracing methods used for rail shipment of unboxed explosive projectiles, explosive torpedoes,
explosive mines or explosive bombs, exceeding 90 pounds in weight and explosive projectiles of not less than $41 / 2$-inches in diameter. Explosive projectile less than $41 / 2$-inches in diameter may be shipped without being boxed, when palletized, only for the military.
$b$. The transportation of explosives must conform to certain safety standards given by DOD and DOT. TM 9-1300-206 provides information on the care, handling, preservation, and destruction of ammunition. Quantity-distance standards for manufacture, handling, storage, compatibility, and transport of mass-detonating ammunition, explosives and ammunition are covered. Also, quan-tity-distance classes and tables for all classes of ammunition and explosives are given.
c. The Bureau of Explosives (AAR) pamphlet 6 illustrates methods for loading and bracing carload and less-than-carload shipments of explosives and other dangerous articles. Bureau of Explosives (AAR) pamphlet 6A illustrates methods for loading and bracing carload and less-than-carload shipments of loaded projectiles, loaded bombs, etc. $B$ of $E$ (AAR) pamphlet 6 C illustrates methods for loading and bracing trailers and less than trailer shipments of explosives and other dangerous articles via trailer-on-flatcar (TOFC) or con-tainer-on-flatcar (COFC). Methods of bracing or blocking other than those given in the above pamphlets will be submitted to the Bureau of Explosives for approval.
d. Information to implement DOT regulations has been published in various AR and TM 55-602. The USAMC has published a number of outloading drawings for ammunition, missile systems, special weapons and other hazardous materials.
Basic precautions to be observed are as follows:
$e$. Lost space in loading packages in a car should be avoided by pressing each package firmly toward the end of the car as it is loaded.
$f$. High pressures on small areas must be avoided. The largest possible area of a package must be used to resist pressures. Beveledged boards must be nailed to the car floor to cover defects in the floor or projecting pieces of metal or nails. Cars with corrugated or pressed metal ends, not lined, and cars with bowed ends must be boarded up at the inside of the ends to the height of the load.
g. Placing a large shipment in one end of a car must be avoided. A shipment in excess of 12,000 pounds must not be loaded in one end of a car
unless other freight is to be loaded in the other end to balance it. Failure to observe this precaution may cause the car to leave the track.
$h$. Bracing and blocking must be made with sound lumber, free from cross grain, knots, knotholes, checks, or splits which impair the strength of the material or interfere with proper nailing.
i. Nails should be used plentifully and in the proper places.
(1) Balanced nailing is important. All nails should be of such length as to have the necessary holding power and ample penetration into car walls, floors, or other bracing and blocking. To obtain the greatest holding power, nails must be long enough to nearly penetrate but not protrude through the timber holding the point of the nail. Nails must not be large enough to cause splitting; they should not be placed along one grain of the wood. Whenever possible, nails should be driven straight-not toenailed. Brass or copper hammers should be used to nail braces around packages of explosives.
(2) The lining of cars is only three-quarters or seven-eights of an inch thick and has little holding power for large nails. Therefore, nails holding sidewall blocking should be driven into the heavy uprights supporting the lining.
$j$. Noncompatible chemicals or explosives must not be loaded or stowed together.
$k$. The following must not be used:
(1) Cars with end doors.
(2) Cars with aútomobile loading devices unless the loading device is attached to the roof of the car so that it cannot fall (applicable to the shipment of class A explosives only).
(3) Refrigerator cars, except when-
(a) Authorized by the carrier or owner,
(b) Ice bunkers are protected by solid bracing, and
(c) Unfixed floor racks are removed.
$l$. When heavy loads are handled in and out of cars on lift trucks, a temporary steel plate or other floor protection of suitable size must be used to prevent the truck from breaking through the floor.
$m$. When loading in closed cars, the following safety rules must be followed:
(1) Lading must be so secured that it will not come in contact with side doors, or roll or shift in transit.
(2) Adequate stripping must be placed across
each door opening to prevent lading from falling, rolling out of a doorway, or coming in contact with a door while in transit.
(3) Load must be so placed in the car that there is not more weight on one side than on the other. One truck must not carry more than onehalf the load limit stenciled on the car. Cars should be loaded as heavily as possible up to, but not exceeding, the load limit stenciled on the car. Loads should be placed in cars as shown in figure $4-14$. The distances shown in the figure represent lengths of different loads. Relative position on the car of each load is also shown.
(4) Material loaded between truck centers and ends of car must not exceed 30 percent of the stenciled load limit ( 15 percent each end) when both ends are loaded and 10 percent when only one end is loaded. The percentage of stenciled load limits shown in figure 4-14 must not be exceeded for loads located between truck centers, measured lengthwise of car, except when car owner designates otherwise.
$n$. The following instructions apply in loading and blocking ammunition. (Less-than-carload shipments may be loaded and braced in the same manner.) All space between sides of car and rows of containers must be tightly wedged in place at time of loading. Bulkhead braces for partial layers must be long enough to permit nailing to upright braces behind car lining. Length will vary, depending on weight of lading supported. The filler strips nailed to the sides of the car must be extended across the doorway. No other doorway protection is required.

## 4-21. Marking Dangerous-Cargo Cars

a. Loaded Cars. Labels and placards required for containers and railcars used for transporting explosives and other hazardous materials are described in 49 CFR parts 172, 173 and 174. Explosives Class A placards must be rectangular in shape, measuring 11 by 14 inches and printed in red and black ink. Closed cars and tank cars containing dangerous ladings are marked with placards giving the contents. These cards, usually 10 to 14 inches square and printed with large red and black lettering, indicate the contents of the car and give special handling instructions. The placards usually are tacked to placard boards bolted to the outside of the car-one at each end and one on each door on each side of the car. Cars of all-steel construction often have a framed card pocket, one each in the four locations, enumerated, into which the printed placards are slipped.

af Not more than $15 \%$ load limit between truck centers and ends of car
Figure 4-14. Load limits for explosives.
b. Empty Cars. Empty tank cars and boxcars are often placarded with notices that warn of lingering gases and fumes. These warning cards on cars stress that care must be used in switching the cars as well as in unloading their contents.
c. Examples. Typical car placards used on commercial and military railroads in the United States are shown in figures 4-15 through 4-18 and four-language placards for use by the Army in Europe are shown in figure 4-18.

## 4-22. Cargo Security

a. At Origin.
(1) The shipper is responsible for the security of carload freight until the car is coupled to a locomotive or train for movement. The shipper must be fully aware of this responsibility.
(2) Before loading, the shipper should inspect the car thoroughly to insure that it meets security requirements. Cars with holes or dam aged places in floors, roofs, or sides, or insecure doors must be repaired before they are used.
(3) The shipper is responsible for properly
loading and bracing the load and for closing and sealing the car. Improperly stowed or braced loads may be damaged in movement and invite pilfering (TM 55-601).
(4) Loading should conform to the standards necessary for safe movement under existing operating conditions. In sealing closed cars, the best protection is provided by tightly twisting a 10 inch length of heavy-gage wire through the locking eyes and snubbing off the wire ends closely. Usually No. 8- or 10 -gage wire is used. Zero-gage may be necessary when the pilferage or sabotage threat is acute. The door hasps of closed doors are always sealed with a thin, metallic seal on which a serial number is stamped. This seal is broken easily and provides little protection against pilferage; however, the absence or breakage of a seal indicates tampering. Shipments in open cars should be covered with securely fastened tarpaulins if required by nature of shipment. Small items shipped on flatcars should be fastened securely to the car floor.
(5) The shipper prepares an accurate list of



Figure 4-15. Dangerous radioactive material placard, railcars.


Figure 4-16. Explosives placard, railcars.
contents, prepares the waybills, and affixes placards to the cars. After a car is loaded, sealed, and documented, it should be moved as quickly as possible.
(6) At military installations the originating transportation officer and railway personnel must inspect all open-top cars before movement to insure that they are loaded properly and meet clearance requirements.

## b. In Transit.

(1) In CONUS the appropriate commercial railroad and in oversea theaters the transportation railway service is responsible for the security of all carload freight in transit from the time the car is moved from its loading point until it is placed at the designate unloading point. In CONUS the originating rail carrier and in oversea theaters the transportation railway service prepares all car records, train documents, and other records required to insure prompt movement and to prevent loss of cars en route. When operating conditions permit, cars containing freight subject to pilferage are grouped to permit economy in the use of guards. Special handling is given to mail or high-priority traffic of a classified nature.
(2) Train guards are provided by appropriate Army headquarters in CONUS. In oversea
theaters, train guards are provided by military police or other units assigned or attached to the transportation railway service for security duties. These units also guard cars and trains during movement in railroad yards. Sensitive supplies may be guarded by personnel assigned to the car by the loading agency. The yardmaster advises the dispatcher on receipt of cars with special guards. He also notes the receipt on the train consist that is transmitted to yards and terminals. This insures that all railway personnel avoid delays in transit and expedites placement at the destination.
(3) Guard crews check car seals and inspect trains for cars that are not secure. They prepare a record, by car number, of all guarded cars in trains, noting any deficiencies or incidents en route. When a relief guard takes over, the crews make a joint inspection and sign this record.
(4) When a bad-order car containing supplies subject to pilferage is set out, a member of the guard crew should remain with the car until he is properly relieved. Guard crews must be alert at all times, particularly when the train has stopped, and when it is passing through tunnels, cuts, and villages at slow speed.

## c. At Destination.

(1) The consignee becomes responsible for


Figure 4-17. Radioactive material labels.
carload freight when it is placed at the depot, siding, or track he designates. Cars should be unloaded as quickly as possible to lessen chances for pilferage.
(2) In removing wire seals from closed cars, care must be taken to avoid breaking latches on the car door. Wire cutters are recommended for this purpose.

## 4-23. Troop Movements

a. Space Requirements. For planning purposes, the following capacity data may be used when loading troops on US equipment (other details contained in para 4-8 through 4-10, TM 55-604).
(1) Sleeping cars (average). Thirty-two troops with individual equipment.
(a) Officers and warrant officers are moved in standard pullmans, two per section, and are listed by number of sections; for example, 14 officers are shown as seven sections. Officers and
warrant officers of all units in one train will be grouped in one or more pullman cars as required.
(b) Enlisted men move in tourist pullmans, usually two per section. NCOs of the first five grades are entitled to separate berths. Space must be provided for personnel attached from medical units and men detached as guards on freight cars.
(2) Coaches (average). Fifty-five troops with individual equipment.
(3) Passenger trains (long-distance moves, average). Eleven sleeping cars, two kitchen cars, one or two baggage cars; 350 troops per train is typical.
(4) Freight trains. For troop-unit moves, including such heavy equipment as tanks, artillery, and engineer equipment, trains seldom exceed 65 cars ( 650 short tons) for infantry divisions; 55 cars ( 1,200 short tons) for armored divisions.
(5) Mixed trains. Desirable from a tactical


Figure 4-18. Railway car placards, US Army, Europe.
and organizational standpoint, since they carry all personnel with their vehicles, artillery, and equipment. Not economical when passenger equipment is in short supply because they move at freight train speed. In mixed trains, boxcars should be substituted for baggage cars.
(6) Kitchen-baggage cars. Furnished on the basis of one per 250 men or fraction thereof. Requirements per train depend upon how transportation is grouped. For tentative estimates, allow one per unit.
(7) Flatcars. Number required is computed on the basis of maximum utilization of each car, regardless of length. Computation is not restricted to cars of one length. Twelve inches if left clear at one end of each car for brake-wheel clearance.

## b. Organizational Equipment.

(1) Amount of headquarters, kitchen, and maintenance equipment varies somewhat in all units. For planning, allow 20 short tons per company or equivalent unit.
(2) Organizational equipment is usually loaded in unit transportation; loading it separately requires more boxcars. Checkable baggage up to 150 pounds is carried free; generally, this is loaded in a baggage car or boxcar. When transportation groupings permit, checkable baggage for two companies or similar units may be loaded in one boxcar
c. Foreign Railways.
(1) Few foreign railways are capable of moving complete troop units by rail at the same time the rail net is supplying a major force. Accordingly, tracked vehicles and foot troops may move by rail while wheeled vehicles with their normal towed loads move on highways.
(2) For planning, the following capacities may be assumed:
(a) Freight cars.

Well flatcars $\qquad$ 50 short tons
Medium flatcars 25 short tons
Small flatcars 12 short tons
Boxcars $\qquad$ 10 short tons or 25 troops (b) Passenger cars.

Coaches 40 troops
Sleeping cars 32 troops

## 4-24. Troop-Train Commanders

## a. Assignment.

(1) An officer in charge of troops (train) is appointed or detailed for all troop trains. He is usually senior officer commanding troops. Duties are discussed in TM 55-604.
(a) If only one unit is involved, he may be detailed by headquarters of unit ordered to move.
(b) If more than one unit is moving, he may be appointed by transportation movements officer at entrainment station unless an officer has been appointed by higher hểadquarters.
(2) If the troops are of mixed nationalities, the senior officer commanding troops, regardless of nationality, is troop-train commander; in cases of equal senior rank, the commander of largest number of troops served will be the troop-train commander.
(3) He serves until journey is completed, regardless of officers boarding train en route.

## b. Duties.

(1) Administration. The troop train com-mander-
(a) May appoint one or more officers as assistants. When troops of other nationalities are traveling on same train, officers of the nationalities concerned are appointed as assistants.
(b) Complies with instructions received en route from the responsible transportation movements officer.
(c) Ascertains details of loading baggage, vehicles (if any), and personnel from transportation movements officer, stationmaster, or port commander if moving from a port.
(d) Submits troop-movement order to transportation movements officer.
(e) Makes location of troop-train commander's headquarters on train known to all troops.
( $f$ ) Gives order of entrainment; directs entrainment, noting location of various units and their baggage.
(2) Discipline. The troop-train commander-
(a) Is responsible for the protection, discipline, and conduct of all troops aboard the train.
(b) Directs that separate accommodations be provided for all females traveling; details an officer to any car in which separate compartments are occupied by male and female personnel to insure observance of proprieties.
(c) Issues orders that prohibit-

1. Discussing the move with unauthorized persons.
2. Detraining without orders.
3. Throwing rubbish out of windows.
4. Leaning out of windows.
5. Damaging railway property.
6. Marking or writing on side of cars.
7. Violating blackout.
8. Wasting water in lavatories.
9. Riding on trains except where author-
ized.
10. Using intoxicants.
11. Using train latrines while in stations.
(3) Sanitation. The troop-train commander is advised by train crew of-
(a) Approximate time and duration of rest stops to be made during a long journey.
(b) Whistle signal to be used for notification of such stops.
(4) Air defense. The troop-train commander will-
(a) Interrupt movement program only if assault is specifically directed against the destination station.
(b) Be prepared to assist local anti-aircraft after consultation with transportation movements officer.
(c) Enforce blackout.
(5) Defense against ground attack. This will depend upon the area involved, type and degree of attack, and the forces available to the troop-train commander. He should follow instructions and/or SOP provided by the local commander.

## 4-25. Estimating Railway Capacity

Since the direction of military supply movements is primarily forward, military rail line capacity estimates generally are based on net tonnage moved in one direction. However, total capacity is based on train density and the movements of trains in both directions must be considered. When the railway net under consideration is composed of several divisions and branch lines, separate estimates should be made for each division and branch line. In estimating railway line capacity in terms of payload hauled, the limiting factors are the power of the locomotive and resistance offered by the grade, the curve, the locomotive, the cars, the lading, and the weather. The formulas and factors presented in the following paragraphs are listed in the order in which they must be considered.

## 4-26. Weight on Drivers

a. General. The weight on drivers of a locomotive is expressed in short tons. It is that weight which is supported by the coupled driving wheels when they rest on a straight and level track. It does not include any of the remaining portion of the locomotive's weight. Different types and classes of locomotives differ in weight. All locomotives are constructed to specifications issued by the purchaser, the using railroad, or the manufacturer.
b. Army Locomotives. The weights on drivers of some common types of diesel-electric locomo-
tives used by the Department of the Army are included herein for ready reference. A complete table of Army locomotive characteristics is contained in table C-1, FM 55-20.

| Type | Weight on Drivers (ston) | Horsepower |
| :---: | :---: | :---: |
| 0-6-6-0, standard-gage | 131 | 1600 |
| 0-6-6-0, multigage | 127 | 1600 |
| 0-4-4-0, standard-gage | 120 | 1200 |
| 0-4-4-0, standard-gage | 120 | 1500 |
| 0-4-4-0, standard-gage | 80 | 1000 |

## 4-27. Tractive Effort (TE)

a. General. Tractive effort is a measure of the potential power of a locomotive expressed in pounds; it is the horizontal force which a locomotive can exert if the wheels do not slip. A locomotive's tractive effort is included in the data supplied by the manufacturer. The tractive effort of some locomotives used by the Department of the Army may be found in table C-1, FM 55-20. When such data are not available, tractive effort can be computed using the formulas in $c$ below. Due consideration must be given to the locomotive's age and condition.
b. Starting and Continuous Tractive Effort. Starting tractive effort is the power that a locomotive has available to move itself and the load it is hauling from a stopped position. Continuous tractive effort is the effort required to keep a train rolling after it has been started. As the train increases in momentum, the tractive effort needed diminishes rapidly. In steam locomotives no differentiation is made between starting and continuous tractive effort. A steam locomotive can generally continue to pull what it can start. However, a diesel-electric locomotive cannot continue to exert the same force achieved in starting without damaging its power unit. The continuous tractive effort of a diesel-electric locomotive is approximately 50 percent of its starting tractive effort.

## c. Rule-of-Thumb Method of Determining Trac-

 tive Effort.(1) Starting tractive effort is closely correlated to the adhesion which the driving wheels maintain at the rails. If the tractive effort expended exceeds this adhesion element, the drivers will slip. Normally, the adhesion element when the rails are dry is 30 percent of the weight on drivers; when the rails are wet, 20 percent. Therefore, 25 percent is taken as the average.
(2) Thus, for a locomotive weighing 80 tons
or 160,000 pounds on drivers, the approximate starting tractive effort would be $\frac{160,000}{4}$ or 40,000 pounds.
(3) If it were a steam locomotive, the continuous tractive effort of the above locomotive would also be 40,000 pounds. If it were a diesel-electric locomotive the continuous tractive effort would be approximately $\frac{40,000}{2}$ or 20,000 pounds.

## 4-28. Drawbar Pull

a. General. Drawbar pull is the actual pulling ability of a locomotive, less the effort necessary to move the locomotive. Actual tests have indicated that 16 to 20 pounds of pull per ton are required to start the average locomotive or freight car on straight, level track under favorable weather and temperature conditions. A locomotive or car equipped with roller bearings will start with somewhat less effort. For railway planning, 20 pounds per ton should be used. This resistance drops after equipment starts rolling; but to establish pulling ability (drawbar pull) available for starting and pulling a train, 20 pounds per ton of locomotive weight should be subtracted from the continuous tractive effort of the locomotive. Thus, a diesel-electric locomotive weighing 80 tons on drivers and having a continuous tractive effort of 20,000 pounds has a drawbar pull of 18,400 pounds ( 20,000 pounds minus 1,600 pounds).
b. Speed Factors. Maximum drawbar pull can be exerted only at lowest speeds-up to approximately 10 miles per hour-after which it drops off sharply. Drawbar pull at given speeds can be obtained by applying a speed factor to the maximum drawbar pull. However, speeds are different for different types of locomotives. In one type of steam locomotive, drawbar pull was found to diminish in inverse ratio to speed. For example, drawbar pull is 80 percent at 20 miles per hour, 50 percent at 50 miles per hour, and 20 percent at 80 miles per hour. This may be used as a rule-ofthumb for estimating drawbar pull of steam locomotives at various speeds. The drawbar pull of diesel-electric locomotives diminishes more rapidly at the higher speeds.

## 4-29. Rolling Resistance

The force components acting upon a train in a direction parallel with the track which tend to hold or retard the train's movement constitute rolling resistance. The components of rolling re-
sistance are friction between the railheads and the treads and flanges of the wheels, resistance due to undulation of track under a moving train, internal friction of rolling stock, and resistance in still air. An absolute figure to be used as rolling resistance is unknown. Experience indicates that a safe average value to use in the theater of operations for rolling resistance is as shown below :

| .Pounds per ton of train | Track condition |
| :---: | :---: |
| 5 | Excellent |
| 6 | Good to fair |
| 7 | Fair to poor |
| 8 | Poor |
| 9-10 | Very poor |

## 4-30. Grade Resistance

As determined by the following formula, grade resistance is equal to 20 pounds per ton of train times the rate percent of grade.

$$
\mathrm{RG}=\frac{\mathrm{WR}}{\mathrm{~B}}
$$

Where $\mathrm{Rg}=$ grade resistance
$\mathrm{W}=1$ ton ( 2,000 pounds)
$\mathrm{R} \quad=$ rate percent of grade
$\mathrm{B} \quad=$ one station ( 100 feet)
Thus, Rg in pounds per ton may be expressed
$2,000 \times$ percent of grade
$\mathrm{Rg}=$
100

## 4-31. Curve Resistance

No entirely satisfactory theoretical discussion of curve resistance has been published; however, engineers in the United States usually allow from 0.8 to 1 pound per degree of curve. In military railway planning, the factor 0.8 pound per ton of train per degree of curve is used. The continual passing of trains around a curve eventually moves the track, which disturbs alinement and distorts the curve. The track should be restored to its correct curvature after determining whether any distortion exists. This should be done by TRS maintenance-of-way personnel. A field expedient for determining the curvature of a track is the string method (para 4-45).

## 4-32. Weather Factor

a. The weather factor is another expression of train resistance. It reflects, by percentage, the effects of adverse cold and wet weather upon actual hauling power of a locomotive. Experience and tests have proved that whenever the temperature drops below $32^{\circ} \mathrm{F}$., the hauling power of the locomotive is decreased. Table C-3, FM 55-20, shows
the weather factor (percent) for different degrees of temperature.
b. Ordinarily, wet weather is regarded as local and temporary and is disregarded in normal planning. However, in countries of extended wet seasons the loss of tractive effort due to slippery rail may prove serious if sanding facilities are inadequate. The applicable reduction is a matter of judgment but, in general, tractive effort will not be less than 20 percent of weight on drivers.

## 4-33. Gross Trailing Load (GTL)

Gross trailing load is the maximum tonnage that a locomotive can move under given conditions, i.e., curvature, grade, and weather. It is determined by combining all of the factors discussed in the preceding paragraphs. When double-heading with steam locomotives or using pushers, the GTL is equal to the sum or the GTL of the two locomotives (or 100 percent of the total GTL for dieselelectric locomotives). The formula for gross trailing load is as follows:

$$
\mathrm{GTL}=\frac{\mathrm{DBP} \times \mathrm{W}}{\mathrm{RR}+\mathrm{GR}+\mathrm{CR}}
$$

Where GTL $=$ gross trailing load
DBP $=$ drawbar pull
$\mathrm{w}=$ weather resistance
$\mathrm{RR}=$ rolling resistance
GR $=$ grade resistance
$\mathrm{CR}=$ curve resistance

## 4-34. Net Trainload (NTL)

Net trainload is the payload carried by the train. The total weight of cars under load is gross weight. The light weight, or weight of cars empty, is tare. The difference between these two is the net load or payload of the train. In military railway. planning, the net trainload is taken as 50 percent of the gross trailing load.

## 4-35. Train Density (TD)

## a. General.

(1) The term train density is used to denote the number of trains that may be operated safely over a division in each direction during a 24 -hour period. Work trains are not included in computing train density. However, their presence on divisions, and the amount of time they block the main track, can reduce the density of a rail division. Train density may vary greatly over various divisions due to the condition and length of the main line, number and location of passing tracks, yard and terminal facilities, train movement control
facilities and procedures, availability of train crews, motive power, and rolling stock.
(2) On a single-track line, passing tracks are normally 6 to 8 miles apart. When multiple tracks (three or more) are encountered, they are generally considered as double track since it is frequently necessary to remove a portion of the third and fourth tracks in order to maintain the double track line.
(3) The capacity or operating turnover of cars and trains in and out of terminal yards must be considered, either from definite experience and intelligence factors or by inference from other related information.
(4) The following rule-of-thumb and formula are primarily designed to determine freight train density; however, they will be reasonably accurate on lines having 20 percent passenger trains included.
b. Rule-of-Thumb for Determining Train Density. In the absence of sufficient intelligence upon which to evaluate the potential train density of a rail line, a train density of 10 for single track and 15 for double track should be used as planning factors.
c. Formula for Determining Single-Track Train Density. When sufficient operational intelligence is available, the following formula and factors may be used in determining train density for a specified railway division. In determining the number of passing tracks, those less than 5 miles apart should not be included. Passing tracks selected should be uniformly spaced throughout the division.

$$
\mathrm{TD}=\frac{\mathrm{NT}+1}{2} \times \frac{24 \times \mathrm{S}}{\mathrm{LD}}
$$

Where TD $=$ train density
NT $=$ number of passing tracks
$1=$ constant (number of trains that could be run if there were no passing tracks)
$2=$ constant to convert to one direction
$24=$ constant (number of hours per day)
$\mathrm{S}=$ average speed (table C-4, FM $55-20$ )
$\mathrm{LD}=$ length of division
d. Formula for Determining Double-Track Train Density. In determining the train density for double-track operations, fluidity and flexibility must be maintained. Thus, the number of trains operated should not exceed that number which can be cleared off either main track in case of emergency at any given time. Using the factors in $c$, above, train density for double track may be computed as follows:

$$
\mathrm{TD}_{2}=(\mathrm{NT}+1) \times \frac{24 \times \mathrm{S}}{\mathrm{LD}}
$$

## 4-36. Net Division Tonnage (NDT)

a. Net division tonnage is the tonnage in short tons, or payload which can be moved over a railway division ( $90-150$ miles) each day. It includes railway operating supplies which must be programed for movement the same as the supplies of any other service.
b. Net division tonnage is determined by multiplying the net trainload (NTL) by the train density (TD) of the particular division. Net division tonnage is computed separately for each division.
c. When calculating net division tonnage, certain other factors must be taken into consideration. For example, troop, passenger, or hospital trains will replace an equal number of tonnage freight trains. When the operation of such trains is anticipated, allowance in net division tonnage estimates is made by adjusting the train densities of the divisions concerned.

## 4-37. End Delivery Tonnage

In military operations, the end delivery tonnage measured in short tons which is delivered at the end of the railway line (railhead) each day. In all all-rail movement, the end delivery tonnage is the same as the net division tonnage of the more restrictive division.

## 4-38. Miscellaneous Operational Values

a. Effect of Temperature on Hauling Power of Locomotives.

| Temperature ( ${ }^{\circ} \mathrm{F}$ ) | Loss in hauling power (percent) |
| :---: | :---: |
| Above +32 | 0 |
| +31 to +16 | 5 |
| +15 to 0 | 10 |
| -1 to -10 | 15 |
| -11 to -20 | 20 |
| -21 to -25 | 25 |
| -26 to -30 | 30 |
| -31 to -35 | 35 |
| -36 to -40 | 40 |
| -41 to -45 | 45 |
| -46 to -50 | 50 |
| -21 to -25 | 25 |
| -26 to -30 | 30 |
| -31 to -35 | 35 |
| -36 to -40 | 40 |
| -41 to -45 | 45 |
| -46 to -50 | 50 |

## b. Average Rolling Resistance Values.

| Condition of truck | Pound per ton of train |
| :---: | :---: |
| Exceptionally good | -.- 5 |
| Good to fair | --- 6 |
| Fair to poor | 7 |
| Poor | 8 |
| Very poor | 9 to 10 |
| c. Terminal Times. |  |
| Type of locomotive | Hours |
| Steam | 8 |
| Diesel-electric | 3 |
| d. Rolling Stock. <br> (1) Freight. |  |

(a) Requirements are computed separately for operations between major supply installations or areas on each line of communication as follows:


Type of locomotive Hours
Steam 8
Diesel-electric 3
d. Rolling Stock.
(1) Freight.
(a) Requirements are computed separately for operations between major supply installations or areas on each line of communication as follows:

$$
\frac{\text { Daily tonnage }}{\substack{\text { Average tons } \\ \text { per car }}} \times \text { turnaround time }=\text { number of cars }
$$

Turnaround time is the total estimated number of days required for a car from the time it is placed for loading at its point of origin, moved to its destination, unloaded, and returned to its point of origin. Such time may be computed as follows: Allow 2 days at origin, 1 day at destination, and 2 days' transit time for each division, or major portion thereof, which the cars must traverse. This method, rather than an actual hour basis, is used to incorporate delays due to terminal and way-station switching as well as intransit rehandling of trains.

| Rolling stock |  |
| :---: | :---: |
| Location or type of operation | Days' dispatch required |
| At base of operation | 2 |
| Forward traffic | 1 per division |
| Return traffic | 1 per division |
| At railhead | 1 |

(b) Computations should be increased by 10 percent to meet operational peaks, commitments for certain classes of cars, and bad order cars.
(c) An average planning factor for net load per car may be assumed as follows:

(d) Tank car requirements are computed separately based on the bulk POL requirement and the computed turnaround time.
(2) Passenger.
(a) Passenger car requirements will vary, depending on troop movement policies, evacuation policies, and rest and recuperation policies.
(b) Theater passenger car requirements are fulfilled by acquisition of local equipment with the exception of hospital cars and trains.
e. Road Locomotives. The number of road locomotives required for operation over a given railway division may be determined by the following formula:

Road
locomotives required:
$T D \times(R T+T T) \times 2 \times 1.20$
24
Where $T D=$ train density
$R T=$ running time (length of division divided by average speed)
$T T=$ terminal time (time for servicing and turning locomotive)
$24=$ number of hours per day
$2=$ constant for two-way traffic
$1.20=$ constant allowing 20 percent reserve
Note. The expression RT +TT is the percent of time during a 24 -hour period in which a road locomotive is in use and is called the locomotive factor. The expression provides for the pooled use of motive power which may make one or more trips per day over a short division.

## f. Switch Engines.

(1) The number of switch engines required at a terminal is based on the number of cars dispatched and received, or passing through the terminal per day. When the number of cars has been computed, that figure is applied to the table in (2) below to determine the number of switch engines required at each terminal.
(2) When the total number of switch engines required for the railway line has been computed, add 20 percent as a reserve to allow for maintenance, operational peaks, etc.

Port, railhead, loading, unloading
Division

## g. Fuel Requirements.

Estimated average rate of fuel consumption

|  | Estimated average rate of fuel consumption |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type of locomotive | Type of operation |  | Oil (gal) | Coal (b) | Per hour Oil (b) | Oil (gal) |
| Steam (coal-burning) |  |  |  |  |  |  |
| 2-8-0, 82-ton, standard gage. | Road. | 90 |  | 700 |  |  |
| 2-8-0, $90-$ ton, standard gage |  | 115 |  | 950 |  |  |
| 2-8-2, 60-ton, narrow gage. | Road | 100 |  | 750 |  |  |
| Steam (oil-burning) |  |  |  |  |  |  |
| 2-8-0, 82-ton, standard gage. | Road | 55 |  |  | 450 |  |
| 2-8-2, 60-ton, narrow gage. | Road | 60 |  | ------ | 500 |  |
| Diesel-electric |  |  |  |  |  |  |
| 0-6-6-0, 120-ton, standard gage. | Road switcher. |  | 2.5 |  | - | 11.5 |
| 0-4-4-0, 60-ton, standard gage | Road switcher |  | 0.9 |  |  | 8.0 - |
| 0-6-6-0, 80-ton, narrow gage | Road switcher |  | 1.5 |  |  | 10.0 |
| 0-4-4-0, 48-ton, narrow gage | Road switcher |  | 0.9 |  |  | 8.0 . |

Road swithe -
Road switcher
0.9
h. Determining Average Speed Values. For planning purposes, average speed values can be estimated by using the table below. To determine speed, select the most restrictive factor of the eight factors shown. If the restrictive factor (s) is not known, use an average speed value of 8 mph ( 13 kmph ) for a single track and 10 mph ( 16 kmph ) for double track. If the most restrictive factor affects only a comparatively short distance ( 10 percent or less) of the division, use the next higher average speed. If the average speed falls below 6 mph ( 10 kmph ) because of the gradient,
reduce tonnage to increase speed. (A 2-percent reduction in gross tonnage increases speed 1 mile per hour.) If the ruling grade materially affects the tonnage, consider using helper service.

| Restrictive factors |  | Average speed |  |  |  |
| :--- | :--- | ---: | ---: | ---: | ---: |
| Condition of track | Percent of <br> grade | Single track <br> mph | kmph | Double track <br> $m p h$ <br> kmph |  |
| Exceptionally good | 1 or less | 12 | 19.3 | 14 | 22.5 |
| Good to fair ---- | 1 to 1.5 | 10 | 16.1 | 12 | 19.3 |
| Fair to poor $-\cdots$ | 1.5 to 2.5 | 8 | 12.9 | 10 | 16.1 |
| Poor | 2.5 to 3 | 6 | 9.6 | 8 | 12.9 |

## Section IV. CONSTRUCTION, MAINTENANCE, AND SUPPLY

## 4-39. Construction Requirements

a. New Construction.
(1) New construction is an engineer responsibility, discussed in detail in TM 5-370. For planning purposes, a railroad division includes 100 principal-route miles of main line, single- or dou-ble-track, with its terminal operating and maintenance facilities, fueling and watering facilities, and the signaling equipment or interlocking facilities necessary for safe operation. Passing sidings on single-track lines, crossovers on double-track lines, and stations are located at intervals as re-
quired by traffic. Normally, at least one spur or siding is provided at each station. The engineer service in the theater of operations is responsible for new rail construction and large-scale rehabilitation. Transportation railway service mainte-nance-of-way personnel, however, may be required to assist engineer personnel in the latter work.
(2) The following table shows the materials and net effective man-hours required for new construction of 1 mile of standard-gage ( $561 / 2$-inch), single-track railroad.

b. Rehabilitation. The following chart reflects the rehabilitation requirements that can be anticipated for a $100-\mathrm{mile}$ ( $161-\mathrm{km}$ ) standardgage, single-track division extending inland from a port, using average percentage of demolition over the entire division. For further information, see FM 55-20 and FM 5-35.

|  | Item | $\begin{gathered} P_{i e f} 100 \text { miles }(161 \mathrm{~km}) \end{gathered}$ | Percent of demolition | Construction material ${ }^{\text {a }}$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $\begin{gathered} \text { Rehabilitation } \\ (q u a n t u ̈ y) \end{gathered}$ | Short tons | $\begin{aligned} & \text { Measurement } \\ & \text { tons } \end{aligned}$ | Man-hours (thousands) |
| Main line trackage |  | 100 mi | 10 | 7.0 mi | 2,708 | 1,033 | 36.4 |
| Port trackage ${ }^{2}$ |  |  | 100 | 3 mi | 1,368 | 1,092 | 14.4 |
| Passing siding ${ }^{2}$ |  | 2.4 mi | 80 | 2.4 mi | 1,049 | 874 | 11.5 |
| Station sidings ${ }^{2}$ |  | 1.6 mi | 80 | 1.6 mi | 730 | 582 | 7.7 |
| Railway terminal ${ }^{\text {9. }} 8$ |  | 1 ea | 75 | 0.75 ea | 8,025 | 4,875 | 160 |
| Water stations. |  | 3 ea | 100 | 3 ea | 135 | 210 | 9 |
| Fuel stations. |  | 1 ea | 100 | 1 ea | 19 | 16 | . 9 |
| Bridging ( 70 ft per mile) |  | 7,000 | 55 | $\begin{aligned} & 2,700 \text { linear } \\ & \text { feet } \end{aligned}$ | 2,700 | 2,672 | 70 |
| Culverts.. |  | $\begin{aligned} & 28,000 \text { linear } \\ & \text { feet } \end{aligned}$ | 15 | $\begin{aligned} & 4,200(74 \mathrm{ea}) \\ & \text { linear feet } \end{aligned}$ | 63 | 63 | 13.7 |
| Grading and ballast. |  |  |  |  |  |  | 40.5 |

[^19]
## 4-40. Maintenance Responsibilities

a. After railways are constructed and turned over to the transportation railway service for operation, minor railway maintenance in the communications zone and in the combat zone to the forward limit of traffic is the responsibility of the transportation railway service. This is discussed in TM 55-204.
b. The transportation railway service is responsible for the maintenance of the railway communications circuits that are used exclusively for the operation and administration of the railways. This responsibility becomes effective when all the circuits on the line have been turned over to the transportation railway service for administration and operation. The transportation railway service is responsible for the operation and for the organizational and direct support of railway block signals, of interlocking plants, and of centralized traffic control devices. It is also responsible for the installation, maintenance, and operation of internal communications.
c. The transportation railway system is normally divided into a number of divisions for maintenance and operation. Each division is assigned a railway battalion; each battalion includes personnel from the railway engineering company to perform necessary maintenance of tracks and structures.
$d$. The battalion commander has overall responsibility for railway maintenance, including maintenance work, instructions, and procedures. The company commander of the railway engineering company is maintenance-of-way superintendent and is directly responsible for the maintenance of tracks and structures, for the proper supervision of all maintenance work and procedures, and for the necessary inspection of track and structures on the division. Platoon and section leaders are charged with the proper supervision of assigned maintenance operations.

## 4-41. Maintenance Categories

a. General. Army maintenance is divided into four categories: organizational, direct support, general support, and depot.

## b. Locomotives.

(1) Organizational maintenance consists of during-operation maintenance, inspection of visible moving parts, lubrication, and repair or replacement of parts whose condition might interfere with the efficient operation of the equipment.

During-operation maintenance is performed by the railway operating company, the balance is performed by the railway equipment maintenance company.
(2) Direct support maintenance is performed by the mobile railway workshop in the forward area and by the railway equipment maintenance company in the rear areas. When the repairs are not too extensive, the locomotive is repaired and put back into service. If the repairs are beyond the capabilities of the railway workshop, only those repairs will be made that are necessary to move the locomotive to a fixed installation for repair.
(3) General support maintenance and limited depot maintenance are performed by the dieselelectric locomotive repair company.
(4) There are no units provided in the transportation railway service for the performance of full depot maintenance. This category of maintenance beyond the capabilities of the railway car repair company and diesel-electric locomotive repair company will normally require evacuation to CONUS or to an appropriate base or facility.

## c. Rolling. Stock.

(1) Normally the railway battalion's train maintenance sections and crews perform organizational and direct support maintenance; this includes running repairs and inspection of rolling stock. The railway repair car companies are responsible for general support and limited depot maintenance.
(2) Organizational maintenance is performed at the originating point of the train and at inspection points en route by military car inspectors or civilian railroad personnel. It consists of making running repairs required for the safe operation of the train.
(3) Direct support maintenance is performed by maintenance personnel, either military or civilian, at the home terminals of the cars or at a prescribed location. It consists of running and emergency repairs that necessitate taking the car out of service for a short time (TM 55-203).
(4) Repair track installations (rip tracks) normally are set up at main terminals. Usually they are also necessary at other points on the division, such as function points or heavy loading centers, to take care of repairs that cannot be made at the loading installation and to avoid moving the cars into the main terminal. The master mechanic (railway equpment company commander) is responsible for the operation of the repair-track installation.

## 4-42. Inspection and Maintenance of Locomotives

a. Basic Principles.
(1) Suitable inspection pits and facilities must be provided for inspection, repair, and adjustment of parts.
(2) The engineman is responsible for the equipment he operates.
(3) The fireman is responsible for maintaining the proper water level and steam pressure on steam locomotives. He receives instructions from the engineman, has immediate superior.
(4) Each locomotive must be inspected daily, or at the end of each trip, and DA Form 55-226 must be completed for steam locomotives; DD Form 862 F or diesel-electric locomotives.
(5) Each locomotive must be inspected every 30 days and DA Form 55-227 completed for steam locomotives; DD Form 1336 for diesel-electric locomotives.
(6) In addition to the daily and 30-day inspections, each locomotive must be inspected semiannually and annually. Maintenance documentation will be in accordance with TM-series rail maintenance manuals.
b. Enginehouses. The two general types of enginehouses are turnaround and maintenance. The turnaround enginehouse is small and is only equipped with facilities for performing minor repairs and services. Work done in this enginehouse usually requires only $11 / 2$ to 3 hours. The maintenance enginehouse has facilities for making major as well as minor repairs; here the division locomotives are maintained in good operating condition and kept at maximum availability. TM 55-201 (steam locomotives) and TM 55-202 (die-sel-electric locomotives) are general references covering maintenance procedures at enginehouses.

## 4-43. Maintenance of Way

a. Roadway. Roadway maintenance is the care taken and work performed to keep that part of the right-of-way on which the track is constructed in good condition. Right-of-way includes excavations, embankments, slopes, shoulders, ditches, and diversions of roads and streams. Maintenance is discussed in detail in TM 55-204.
b. Track. In a theater of operations, the track must be maintained in operable condition at all times. The four primary considerations in track maintenance are gage, surface, alignment, and dress. The roadbed and track must be inspected
frequently to avoid delays in operation resulting from damage caused by sabotage, direct enemy action, or weather.
c. Structures. In a theater of operations, the structures essential to the railway operation must be maintained in accordance with the standard maintenance prescribed. Structures include bridges, culverts, tunnels, and fueling and watering facilities. When repairing structures, minimum clearances must be observed at all times.
d. Distortion. The continual passing of trains around a curve eventually moves the track, which disturbs alinement and distorts the curve. The track should be restored to its correct curvature after determining if any distortion exists. This should be done by TRS maintenance-of-way personnel. A field expedient for determining the curvature of a track is the string method (para 4-45).

## 4-44. Degree of Curvature and Curve Radius

The table below shows relationships between degree of curvature and radius of curvature for simple curves. Degree of curvature means the degrees of central angle subtended by a 100 -foot ( 30.48 -meter) chord. Radius of curvature is the distance from the apex of the central angle out to the curve. The degree of curvature and radius of curvature form the sector of a circle; the area of this sector may be expressed in either of the following ways-

$$
\begin{aligned}
\text { Area } & =\frac{R \times \text { arc }}{2} \\
& =\frac{3.1416 \times R^{2} \times D}{360}
\end{aligned}
$$

Equating the two expressions above, $\mathrm{R}=$

$$
\begin{aligned}
& \frac{\operatorname{arc} \times 360}{2 \times 3.1416 \times \mathrm{D}} \\
& =\frac{\operatorname{arc} \times 57.3}{\mathrm{D}}
\end{aligned}
$$

Where
$R=$ radius of curvature in feet
$D=$ degree of curvature in degrees
For a $1^{\circ}$ curve, the arc and chord are almost the same. Therefore, for practical purposes the arc in the formula for $R$ above can be called a 100 -foot chord for a $C$ value of $1^{\circ}$. $R$ then equals 5,730 for a $1^{\circ}$ curve, and $\frac{5,730}{D}$ for a D -degree curve.

| $D$ | $R$ | $D$ | $R$ | $D$ | $\boldsymbol{R}$ |
| :--- | :---: | :---: | :---: | :---: | :---: |
| 1 | 5730 | 8 | 716 | 15 | 382 |
| 2 | 2865 | 9 | 637 | 16 | 358 |
| 3 | 1910 | 10 | 573 | 17 | $\mathbf{8 3 7}$ |

## $\quad D$ 4 5 6 7 <br> $R$ 1433 1146 955 819 <br> ${ }^{D}{ }^{D}$ 12 13 14 <br> $R$ 621 478 441 409 <br> $D$ 18 <br> 4-45. Determining Curvature by String Method (Fig 4-19)

$R$
818

If a surveying instrument is not available, the degree of simple curvature (arc of a circle) of a track may be computed by the string method. Although this method is not exact because of the uncertainty of how much the string has stretched, the degree of error is insignificant. To determine the degree of curvature of a track by the string method-
a. Select a portion of track well within the main body of the curve.
b. Measure a chord distance of 62 feet ( 18.897 meters) along the inside (five-eighths of an inch down from the top) of the high rail (A to B, fig 4-19).
c. Stretch a string or strong cord very tightly between points A and B , and measure the distance M at the midpoint of the cord. The distance in inches is approximately equal to the degree of curvature. In the example shown in figure 4-19, if $M$ is 5 inches, the degree of curvature is $5^{\circ}$. (As a curve gets sharper, the distance $M$ increases.)

## 4-46. Railway Supply

a. Railway supplies, as distinguished from organizational supplies, are expendable supplies required for the operation and maintenance of railway divisions.
b. Whenever possible, local sources of supply should be used to ease transportation requirements. In a theater of operations, supplies may be procured from military stocks, manufacturers that are in or near the theater, foreign railways, captured enemy material and equipment, parts and assemblies manufactured or repaired by the railway battalion, and transfers from other railway operation units.
c. All operating units must submit reports of supplies on hand at the beginning of operations to facilitate supply control.
d. The battalion supply officer serves as fuel agent for the railway transportation battalion; he is responsible for the operating agencies of the transportation railway service receiving sufficient locomotive fuel-regardless of source. Requisi-
tions for fuel and lubricants are made through normal supply channels.
$e$. Tables of allowances and supplies are prepared by the supply officer of the highest transportation railway echelon for all units within the command. A workable stock level allowance must be determined for each unit to insure uninterrupted operation at all times. Normally, stock levels for the railway division are determined from past requirements.
$f$. An estimate of repair parts requirements may be made by using the factor of 1.5 short tons per month for each train per day moving in either direction. Beginning with the first railway division, select the train density established for the division, and multiply by 2 (for two-way travel); then multiply this result by 1.5 , which equals the total amount in short tons of spare parts required per month for this specific division. Continue this process for each successive division to determine the grand total of short tons required per month for the entire railway. This is an estimate only. Revisions are necessary based on operation conditions.

## 4-47. Supply Request Procedure

a. The normal procedure for requesting a Transportation Corps item of supply is as follows. The company commander submits a request to the battalion supply officer. The battalion supply officer consolidates requests, makes lateral transfers of transportation supplies when necessary, prepares a formal request, and forwards it to the railway group supply officer. The supply officer of the railway group determines if the item or items requested are available in one of the other units assigned to the railway group. The item or items are transferred if they are available, if they are not available, the request is processed and forwarded to the Assistant Chief of Staff, Services and Maintenance, of the Transportation Railway Brigade: He may then direct the transfer of the requested item or items from one railway group to another. If the items cannot be obtained from another railway group, he passes the request to the transportation depot company for issue.
$b$. When the railway group is the highest echelon of the transportation railway service in the theater, the group supply officer discharges supply responsibilities. When the railway battalion is not operating as a part of a railway group, the battalion supply officer is authorized to handle supply matters directly with supply agencies. The highest transportation railway service headquarters in


Figure 4-19. Determination of degree of curvature, using the string method.
the theater may authorize the battalion supply officer to request certain transportation items of routine supply directly from the appropriate supply depot without the approval of the next higher echelon. Items in short supply may be controlled as necessary, depending on the stock level in the depot. The battalion supply officer may be permitted, by the same headquarters, to request routine items from the depots of the other technical services.
c. To obtain supplies from outside sources-industry, railway, stocks, and railway supply chan-nels-the battalion supply officer prepares purchase orders or requests in accordance with the policy established in the particular theater. Normally, purchase orders or requisitions are for-
warded to the railway group supply officer for further action; however, the railway battalion commander may be delegated the authority to approve purchase orders and requisitions for specified quantities of particular supplies. In such cases, the battalion procures the supplies locally and sends information copies of the transaction to the railway group supply officer. When the company commander is authorized to make local purchases, information copies of each transaction must be sent to the battalion supply officer. It is essential that accurate records be maintained of all transactions in order to protect the US Government from fraudulent claims.
d. All captured enemy material and equipment must be recorded and accounted for.

## TERMINAL AND WATER TRANSPORT

## Section I. TERMINAL ORGANIZATION

| 5-1. Terminal Units: Capabilifies and Assignments (Condensed) |  |  |  |
| :---: | :---: | :---: | :---: |
| Unit | toe | Mission | Assignment |
| Headquarters and headquarters company, transportation terminal command A. | 55-131 | To command assigned and attached units engaged in the transfer of cargo and personnel in established terminal operations, logistics-over-theshore (LOTS) operations, and in support of amphibious operations. | To a logistical command. |


| Headquarters and head- | 55-121 |
| :--- | :--- |
| quarters company, trans- | (Tentative) |
| portation terminal |  |
| command $B$. |  |

[^20]a. To command assigned and attached units engaged in the transfer of cargo and personnel in established terminals, LOTS operations, and in the support of amphibious operations.
b. When augmented by appropriate TD, the terminal command may also be designated as an area command.
a. To command assigned and attached units engaged in the transfer of cargo and personnel in established terminal operations, LOTS

To a theater of operations. Normally attached to a logistical command or other appropriate headquarters.

To command assigned and units engaged transfer of cargo and personnel in estabtiod terminal logistics-over-the and in support of amphibious operations.

Mission
operations, and in support of amphibious operations.
$b$. When augmented by appropriate TD, the terminal command may also be designated as an area command.
To provide command, administration, and super-
vision of assigned and attached transportation terminal type units engaged in:
a. Operation of LOTS sites;
b. Transfer of personnel and cargo from one mode of transportation to another at established water terminals;
c. Operation of inland
terminal transfer points;
d. Support of Army and
joint tactical operations.
To load, unload, or transship from one to another means of transportation (water, rail, air, highway) at terminals and over-the-shore facilities.

Assignment
Capability
headquarters with assigned and attached units and appropriate separate administrative and logistical support units as required.

To a field army, separate corps force, or logistical command. Normally attached to a transportation terminal command.

Commands and controls from three to eight (depending on conditions) transportation terminal service companies, transportation, boat companies, transportation amphibian companies, transportation terminal transfer companies, transportation staging area companies, transportation truck companies, or any combination thereof.

Headquarters and headquarters detachment, ransportation terminal battalion.

Transportation terminal service company.

55-117
5

To theater of operations. May be attached to transportation terminal command; headquarters and headquarters detachment, transportation terminal battalion, TOE 55-116; or may operate separately under the supervision of appropriate staff transportation officer.

At full strength, operating on a 24 hour basis at two locations at established terminals or over beaches, can provide the following capabilities:
a. Discharge 1,200 short tons of general cargo or 1,800 tons of vehicles, or 1,350 short tons of mixed cargo per day.
b. Load 600 short tons of general cargo or 1,800 tons of vehicles, or 675 short tons of mixed cargo per day.
c. The following figures can be used for long-range planning:
(1) Discharge on standard firehatch ship at the average rate of 720 short tons of general cargo daily or load one standard fire-hatch ship at
Transportation terminal $\quad 55-118$
transfer company.


To transship cargo at Army air, rail, motor, and inland barge terminals.

To a field army support command, corps support brigade, or a logistical command. Normally assigned to a headquarters and headquarters company, transportation brigade, TOE 55-62. May be attached to the motor transport and/or aviation groups as required. May be assigned or attached to a logistical command.

To provide and operate landing craft for the movement of personnel terminal operations and to augment, when required, naval craft in joint amphibious operations.
the average rate of 500 short tons of general cargo daily.
(2) Sort cargo by technical service and load the cargo on an initial means of transportation at the pier or at the waterline in a beach operation.
(3) Prepare transportation documents for all cargo handled by the unit.
(4) Account for the cargo handled.
a. At full strength, this unit is capable of:
(1) Transshipping 900 short tons of cargo daily.
(2) As required, redocumenting transshipped cargo.
(3) Operating at three separate terminals on an around-the-clock basis.
b. At reduced strength, this unit is capable of:
(1) Transshipping 600 short tons of cargo daily.
(2) As required, redocumenting transshipped cargo.
(3) Operating at two separate terminals on around-the-clock basis.

At full strength, this unit is capable of:
a. Transporting an average of 720 short tons of general cargo based on an average load of 30 short tons per each of 12 landing craft making two trips daily.
b. Transporting, in a one-time maximum lift, 960 short tons of general cargo based on 16 landing craft.
c. Transporting, in a one-time maximum lift, 3,200 combat-equipped troops based on 16 landing craft.

Transportation heavy boat 55-129 company.

## Mission

To provide and operate landing craft for transporting personnel and heavy cargo in offshore discharge operations and for augmenting lighterage service in a port or harbor in inland or coastal waters, or on the open sea including lighterage service required in joint amphibious or other waterborne tactical operations.

To a communications zone logistical command, or other appropriate command in a theater of operations. May be attached to a transportation terminal command headquarters, an engineer amphibious support command, or may operate separately under appropriate staff transportation officer.

Transportation light am- 55-138
phibian company.

To provide lighterage for movement of cargo and personnel between ship and shore, or from shore to shore, in an amphibious or logistical operation.

## Capability

a. Transports an average of 16,000 troops with individual equipment, 2,160 short tons of vehicles, or 6,000 short tons of tanks, based on 10 landing craft making four trips daily.
b. Transports an average of 1,440 short tons of general cargo based on 10 landing craft making one trip daily.
c. Transports, in a one-time maximum lift, 1,800 short tons of cargo or 4,080 troops with individual equipment, based on use of 12 landing craft.
d. Maximum load, per vessel: 150 short tons of cargo or 400 troops with individual equipment for a trip not exceeding 2 hours, 350 troops for trips of from 2 to 3 hours, and not more than 300 troops for trips of over 3 hours.
e. Range of 1,200 nautical miles at 7 knots.
f. Using tug, tows disabled craft, retrieves beached craft, or augments the lift of the company when barges are available.
At full strength, this unit has the following capabilities:
a. Operating two 10 -hour shifts, transports daily an average of 1,080 short tons of general cargo, assuming availability of 27 lighters, each lighter carrying 4.5 tons per trip and averaging approximately nine trips per day.
b. Operating two 10 -hour shifts, transports daily approximately 7,800 combat-equipped troops, based on an availability of 27 lighters, each making 12 round trips with an average load of 25 men.
c. Transporting in a one-time lift, 170 short tons of general cargo, based

Assigned to a logistical command. May be attached to a transportation terminal command, a transportation terminal battalion, or may operate separately under the supervision of the appropriate staff transportation officer.

Transportation medium amphibian company.

To provide lighterage for the movement of cargo and personnel from ships lying offshore to transfer/segregation points beyond the beach line in LOTS operations and in support of amphibious operations.

Assigned to a logistical command. May be attached to a transportation terminal command, a transportation terminal battalion, or may operate separately under the appropriate staff transportation officer.

Transportation heavy am- 55-140 phibian company.

To provide lighterage for movement of personnel, wheeled and tracked vehicles, and general cargo from ships lying offshore to transfer/segregation areas beyond the beach line in LOTS operations and in support of amphibious operations.

Assigned to a logistical command. May be attached to a transportation terminal command, transportation terminal battalion, or may operate separately under the supervision of the appropriate staff transportation officer.
on 34 lighters carrying 5 tons each or 816 combat-equipped troops based on 34 lighters carrying 24 men each.

At full strength, this unit is capable of the following:
$a$. Transporting daily, operating two 10 -hour shifts, an average of 1,080 short tons of general cargo per day assuming availability of 19 lighters, each lighter carrying approximately 10.2 tons per trip and averaging five to six trips per day.
b. Transporting daily, operating two 10 -hour shifts, 9,500 combatequipped troops, based on an availability of 19 lighters, each making 10 round trips with an average load of 50 men.
c. Transporting a maximum onetime lift of 360 short tons of general cargo, based on 24 LARCs carrying 15 short tons each or 1,200 combatequipped troops, based on 24 LARCs carrying 50 men each. At reduced strength, operating only one 10 -hour shift and with 19 lighters operational, this unit can transport approximately 540 short tons or 4,050 combatequipped troops daily. The reduced strength column adapts this table of organization and equipment to the lesser requirements for personnel and equipment during prolonged noncombat periods and for a limited period of combat.
At full strength, this unit is capable of:
a. Transporting daily, operating two 10 -hour shifts, an average of 1,800 short tons of cargo (vehicles and other heavy or outsized equipment) or 7,200 combat-equipped troops, based on 12 lighters making five round trips with an average load of 30 tons or 120 men .
b. Transporting in a maximum onetime lift, with 15 lighters available, 900 short tons ( 60 tons per LARCLX) of general cargo or 3,000 (200 troops per LARC-LX) combatequipped troops. The reduced strength column adapts this table of organization and equipment to the lesser requirements for personnel consistent with operating only one 10 -hour shift and with 12 lighters operational, transports an average of 900 short tons of cargo (vehicles and other heavy or outsized equipment) or 3,600 personnel daily.
a. Provides depot maintenance on a 24-hour basis for approximately 100 self-propelled craft ( 70 on a oneshift basis at reduced strength), plus all nonpropelled craft associated therewith.
b. In order to accomplish its mission, a drydock and/or barge crane must be provided for use by this unit. If these items of equipment are not available locally, they must be furnished with crews from appropriate teams from TOE 55-500R.
a. Provides direct support and general support maintenance for 1,000 amphibian equivalents ( 3.8 equivalents for the LARC-V, 6 for LARCXV, and 10 for the LARC-LX).
b. Receives, stores, and issues all items of supply required for maintenance support of 1,000 amphibian equivalents.
c. Repairs unserviceable assemblies and returns them to supply channels.
d. Provides technical assistance service to supported units when required.
e. Provides direct support and general support maintenance for rolling

Transportation floating
craft depot maintenance company.

To provide depot maintenance for Army floating craft including landing craft of transportation boat companies.

To a transportation floating craft maintenance battalion or to a transportation terminal command.
a. To provide general support maintenance (third and fourth echelon) for amphibians in a theater of operations.
b. To receive, store, and issue all items of supply required for maintenance support of amphibians within its maintenance capability.

To logistical command. May be attached to transportation terminal command; headquarters and headquarters detachment, transportation terminal battalion, TOE 55-116D; or may operate separately under the supervision of appropriate staff transportation officer.
liquid transporters when augmented by teams from TOE 29-500D.

| Transportation service or- |
| :---: |
| ganization. | | 55-500 |
| :---: |
| (Tentative) |


| Transportation special |
| :---: |
| services organization. |
| 55- 510 |
| (Tentative) |

To provide personnel and equipment for the following purposes:
a. To supplement Transportation Corps TOE units where additional trained personnel are required in numbers less than TOE organization strength.
b. To perform Transportation Corps functions as part of a larger organization where the need for such activity is less than a similar TOE unit.
c. To form an organization where no TOE unit is provided or where a number of small cells of diversely trained personnel are required for the proper functioning of an organization.
To perform transportation specialized service functions to increase the productive capacity of fixed-site units where increments of less than company size are needed.

Teams may be attached or assigned as required to higher echelon units or may be organized into service units to perform the functions required by existing conditions.
ransportation special
services organization.

## 5-2. Assigned or Attached Units

Terminal commands may have any commination of these units assigned or attached as required to perform their mission.

## TOE

Unit
55-16
Headquarters and Headquarters Detach-, ment, Transportation Motor Transport Battalion.
55-17G
55-18G
55-19
55-28G
55-116
ment, Transportation Terminal Battalion.
55-118 Transportation Terminal Service Company.
55-118 Transportation Terminal Transfer Company.
55-128
55-129
55-138
55-139
65-140
Transportation Medium Boat Company. Transportation Heavy Boat Company. Transportation Light Amphibian Company. Transportation Medium Amphibian Company.
Transportation Heavy Amphibian Company.

55-157

55-158

55-500
(Tenta-
tive)
55-510 Transportation Special Services Organization.
b. Oth3r Units.
toe
5-129.
5-500
8-500
9-500
10-500
11-500
12-605
14-500 Finance Service Organization.
19-55 Military Police Battalion.
19-57 Military Police Company.

## Section II. VESSEL AND AMPHIBIAN

## 5-3. Transportation Floating Craft

| Nomenclature | Designation | Classification | $\begin{aligned} & \text { Length } \\ & \text { (overall } \end{aligned}$ | $\begin{gathered} \text { Beam } \\ \text { (molded) } \end{gathered}$ | $\begin{gathered} \text { Maximum } \\ \text { draft } \end{gathered}$ | Displacement (LTON) |  | Capacity (oal.) Water |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Light | Loaded | Potable | Nonpotable | nel |
| Vessel, liquid cargo, diesel, steel, 6,500 bbl, 182', design 294A. | $\mathbf{Y}$ | STD-B | 182'6" | $30^{\prime \prime} 0^{\prime \prime}$ | 11/21/4" | 476 | 1,458 | 3,000 | 10,480 | 9,980 |
| Vessel, supply, diesel, steel 176' design 381. | FS | STD-B | 176 ${ }^{\prime \prime}$ | 32'0" | $10^{\prime \prime} 0^{\prime \prime}$ | 465 | 935 | 2,042 | 11,624 | 21,000 |
| Vessel, special purpose, diesel, steel, 179', design 427. | FS | STD-B | 179'10" | 32'5" | 11'3" | 684.77 | 899 | 1,502 | 14,449 | 33,992 |
| Vessel, dry cargo, diesel, steel, 1,000 ton, 210', design 7013. | FS | STD-B | 222,9 \% ${ }^{\prime \prime}$ | $38^{\prime \prime} 0^{\prime \prime}$ | $14^{\prime \prime}{ }^{\prime \prime}$ | 892 | 2,150 | 10,000 | 15,940 | 54,100 |
| Vessel, liquid cargo, diesel, steel, $11,500 \mathrm{bbl}, 210$, design 7014 (fig. 5.1). | $\mathbf{Y}$ | STD-A | 222, 9 \% $4^{\prime \prime}$ | 38'0" | $17^{\prime \prime}{ }^{\prime \prime}$ | 797 | 2,500 | 10,000 | 15,940 | 58,670 |
| Vessel, refrigerator, diesel, steel, 54,102 cu ft capacity 210', design 7015. | FSR | STD-B | 222,9 3/4" | 38'0" | $15^{\prime \prime} 0^{\prime \prime}$ | 975 | 2,388 | 10,000 | 15,940 | 62,000 |

## 5-4. Boats

| Nomenclature | Desionation | Classification | Length(overall) | $\begin{gathered} \text { Beam } \\ \text { (molded) } \end{gathered}$ | $\begin{gathered} \text { Depth } \\ \text { moded } \\ \text { amidehipe } \end{gathered}$ | Dioplaosment (LTON) |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Light | Looded |
| Boat, utility, diesel, plastic $\mathbf{2 6}^{\prime} \mathbf{6}^{\prime \prime}$, design 6009. | J | STD-B | 26'6" | $8^{\prime} 1^{\prime \prime}$ | 4'97/8" | 3.04 | 4.02 |
| Boat, picket, diesel, wood, $36^{\prime} 6^{\prime \prime}$, design 243-B. | J | STD-B | 36'6" | 10'7" | $5^{\prime \prime} 0^{\prime \prime}$ | 6.7 | --- |
| Boat, picket, diesel, steel, 46'41/2", design 4003 (fig. 5-2). | J | STD-A | 46.41/2" | 123"' | 6'37/8 | 10 | 12 |
| Boat, picket, diesel, wood, 64'11", design 4002 (fig. 5-3). | Q | STD-A | 64'11" | 15'11" | 8'3" | 31 | 34.5 |
| Boat, passenger and cargo, diesel, steel, 65’6", design 2001 (fig. 5-4). | T | STD-A | 65'63/4" | 17'8" | 8'97/8' | 66 | 95 |

## CHARACTERISTICS AND DATA

| Speed | Range （nauti－ | Cargo capacity |  |  | Cargo space |  | $\begin{gathered} \text { Lift } \\ \text { capacity } \\ \text { (LTON) } \end{gathered}$ |  | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | miles） | （ cu ft） | （cu ft） | （ta－gal． | Hatches | Tanks | Std | Heavy |  |
| 8 | 2，560 | 2，400 |  | 6，711．3 | 1 | 6 | －－－－ | －ーーー | 1 Dry cargo hatch $2,400 \mathrm{cu}$ ft 6 Liquid cargo tanks． |
| 12 | 4，500 | 21，462 |  |  | 2 | 0 | 5 | 15 |  |
| 12 | 5，320 | －－－－－ | －－－－－－－ | －－－－－－ | 1 | 0 | 5 | 10 | Designed as an aircraft repair vessel and not as a cargo carrier．Hatch size $6^{\prime} \times 16^{\prime}$ ． |
| 13.37 | 6，750 | $\begin{aligned} & 56,400 \\ & \quad \text { plus } \\ & 3,400 \\ & \text { special } \end{aligned}$ | －－－－－－－ | －－－－－－ | 3 | 0 | 5 | －－－－ | Equipped with two level luffing cranes． |
| 12.7 | 7，700 | $\begin{aligned} & \text { 3,382 } \\ & \text { special } \end{aligned}$ | －－－－－－－ | 11，079．8 | 1 | 9 | 2，000 | －－－－ | 1 Dry cargo hatch 3,382 cu ft． 9 Liquid cargo tanks．Equipped with two 800 gpm cargo pumps． |
| 12 | 7，500 | －－－－－ | 40，920 | －－－－－－－ | 3 | 0 | 5 | －－－－ |  |


| Maximum draft （aft） | $\begin{aligned} & \text { Fuel } \\ & \text { capacity } \\ & \text { (sal.) } \end{aligned}$ | Fuel con－ aumption （gals．perhour） | Fresh vater （gat） | $\underset{(k n o e d)}{\text { Sped }}$ | $\begin{gathered} \text { Cruising } \\ \text { raneqe } \\ \text { (nautical } \\ \text { miles } \end{gathered}$ | Capacity |  | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | $\begin{gathered} \text { Cargo } \\ \text { (LTON) } \end{gathered}$ | Presenger |  |
| 3＇6＂ | 80 | 4 | －－－ | 10 | 200 | 1 | 12－15 | Transported on cradle． |
| 3＇3＂ | 300 | 11.38 | －－－ | 15 | 355 | －－－ | 6－8 | （1）Transported on cradle． <br> （2）Bow reinforced for beaching． |
| 2＇9＂ | 370 | 19 | 50 | 14 | 245 | 1.33 | 25 | （1）Transported on cradle． <br> （2）Replaces 243－B． |
| 5＇10＂ | 900 | 24.2 | 400 | 14 | 468 | 4 | 5 | Transported on cradle． |
| $6^{\prime \prime}{ }^{\prime \prime}$ | 1，150 | 18 | 400 | 7 | 397 | 24 | 24 | （1）Normally deckloaded． <br> （2）Limited ocean sailing under good conditions． |

## 5-5. Tugs

| Nomenclature | Designation | $\underset{\text { fication }}{\text { Clasi- }}$ | Length (overall) | $\begin{gathered} \text { Beam } \\ \text { (molded) } \end{gathered}$ | Depth molded amidships |  | cment <br> ( <br> Loaded | Maximum draft (aft) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Tug, harbor, diesel, 200 HP , steel, 45', design 320. | ST | STD-A | 45'21/4" | 12,93/4 | 74\% \% ${ }^{\text {\% }}$ | 25 | 29 | $6^{\prime}$ |
| Tug, harbor, diesel, 600 HP , steel, 65', design 3004. | ST | STD-A | 70'111/2" | 19'6' | 9'7\%" | 100 | 122 | 8'2\%/" |


| Tug, harbor, diesel, 650 HP, |
| :--- |
| steel, $85^{\prime}$, design 327-DS. |


| Tug, harbor, diesel, $1,200 \mathrm{HP}$, steel, 100', design: 3006. | LT | STD-A | 107'0" | 26'6" | 14'10" | 295 | 390 | 12'2' |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Tug, oceangoing, dieselelectric, $1,530 \mathrm{HP}$, steel, 143', design 377A. | LT | STD-B | 143'5" | $33^{\prime \prime}{ }^{\prime \prime}$ | 17'4' | 566 | 807 | $14^{\prime}$ |

[^21]| $\begin{gathered} \text { Fuel } \\ \text { cappacity } \\ \text { (pah) } \end{gathered}$ | Fuel rate (gal. per hour) |  | $\begin{aligned} & \text { oater } \\ & \text { onpotable } \end{aligned}$ | $\begin{aligned} & \text { Speed } \\ & \text { (honots) } \end{aligned}$ | Range ${ }^{\circ}$ (nautical miles) | $\begin{gathered} \text { Bollard } \\ \text { (poundels) } \\ \text { (pound } \end{gathered}$ | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 900 | 10.25 | 55 | -- | 10 | 790 | 4,400 | Deckloaded for overseas shipment. |
| 5,844 | 36.1 | 900 | -- | 12 | 1,700 <br> light <br> (142 <br> hours <br> w/tow) | 17,500 | Normally transported overseas on a larger vessel. |
| 11,252 | 37.5 | 500 | 4,100 | 9.5 | 2,686 | ----- | (1) Normally transported overseas on a larger vessel. <br> (2) Tow rope pull: |
| 21,146 | 68 | 2,756 | ---- | 12 | $\begin{aligned} & 3,700 \\ & (294 \\ & \text { hours } \\ & \text { w/tow }) \end{aligned}$ | 27,500 | Ocean sailing capability. |
| 58,131 | 130 | 400 | 6,810 | 11.5 | 5,100 | ----- | (1) Ocean sailing capability. <br> (2) Tow rope pull: |

## 5-6. Floating Cranes




Figure 5-1. Vessel, liquid cargo, diesel, steel, 11,500 barrels, 210 feet, design 7014.

## 5-7. Barges

| Nomenclature | Designation | Classification | Length (over all) | $\underset{\substack{\text { Beam } \\ \text { (mold }}}{ }$ <br> (mold- <br> ed | Depth (molded) | $\underset{\text { Light }}{\substack{\text { Digplo } \\ \text { ( }}}$ | lacement TON) Looded | $\begin{gathered} \text { Maxi } \\ \operatorname{Might}^{2 i g h} \end{gathered}$ | imum raft Loaded | Liquid | Cargo ${ }_{\text {Dry }}$ | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Barge, deck cargo, nonpropelled, steel, 475 tons, $110^{\prime}$, design 299. | BC | STD-B | $110^{\prime}$ | $30^{\prime}$ | 7'4" | 116.8 | 591.8 | 1'5" | 7' | Liquia | 475 LTON | (1) Deck bin size: $78^{\prime} \times 24^{\prime} \times$ $5^{\prime}$ with loading gates on four sides. |
| Barge, deck cargo nonpropelled, steel, 570 tons, $110^{\prime}$, design 7005 (fig. 5-7). | BC | STD-A | $110^{\prime}$ | 32' | $9^{\prime \prime} 0^{\prime \prime}$ | 120 | 690 | 1'8" | 7'8" | ---- | 570 LTON | (2) Can be towed overseas. <br> (1) Conversion kit, barge deck enclosure, design 7006, is adaptable to this item. |
| Barge, deck cargo, nonpropelled, steel, 585 tons, 120', design 231A (fig. 5-8). | BC | STD-A | $120^{\prime}$ | $33^{\prime}$ | $10^{\prime \prime} 6^{\prime \prime}$ | 175 | 760 | 2'4" | $8^{\prime \prime} 0^{\prime \prime}$ | ---- | 585 LTON | (2) Can be towed overseas. <br> (1) Can be towed overseas. <br> (2) Hull designed for relatively high-speed towing. |
| Barge, deck or liquid cargo, nonpropelled, steel, 578 tons or $4,160 \mathrm{bbl}$, 120', design 231B (fig. 5-9). | BG | STD-A | $120^{\prime}$ | $33^{\prime}$ | 10'6" | 175 | 753 | 2'4" | $8^{\prime \prime} 6^{\prime \prime}$ | $\begin{gathered} 4,160 \\ \text { bbl } \end{gathered}$ | 578 LTON on deck | Can be towed overseas with full load, provided maximum draft does not exceed $8^{4}$. |
| Barge, refrigerator, nonpropelled, steel, $14,200 \mathrm{cu} \mathrm{ft}$, 120', design 7010. | BR | STD-B | $120^{\prime}$ | $33^{\prime}$ | $10^{\prime \prime}{ }^{\prime \prime}$ | 225 | 546 | $\mathbf{3}^{\prime \prime} \mathbf{0}^{\prime \prime}$ | 5'10" | ---- | 14,200 cu ft | Can be towed overseas. |
| Repair shop, floating, marine equipment nonpropelled, steel, 210', design 7011. | FMS | STD-A | 210'5" | $40^{\circ}$ | $15^{\prime \prime} 0^{\prime \prime}$ | 1,160 | 1,525 | $6^{\prime \prime} 1^{\prime \prime}$ | 7'9' | N/A | N/A | (1) Can be towed overseas. <br> (2) Repair shops include electrical, carpentry, engine repair, battery, fuel injection, blacksmith, machine, refrigeration, sheet metal, welding, pipe fitting, paint, and ship fitting. |
| liquid cargo, nonpropelled, steel, 21 tons or | BK | STD-B | $45^{\prime}$ | $18^{\prime}$ | $3^{\prime \prime} 0^{\prime \prime}$ | 13 | 33 | 8' | 1'8' | $\begin{gathered} 225 \\ \text { bbl } \end{gathered}$ | 20.98 <br> LTON <br> on deck | (1) Can be sectionalized for deckloading and rail movement. <br> (2) Transports limited quan- |

225 bbl, 45', knockdown, design 218E.

Barge, deck cargo, nonpropelled, steel, 130 tons, 81', sectionalized, nesting, design 7001 (fig. 5-10).
Pier, barge type, self-elevating, nonpropelled, steel, $250^{\prime}$ long, $60^{\prime}$ wide, $10^{\prime}$ deep, design 7024.

Pier, barge type, self-elevating, nonpropelled, steel, 427 long, $90^{\prime}$ wide, ${ }^{15}{ }^{\prime}$ deep, design 7025.
tities of liquid or dry cargo on inland waters.
(3) Barge is divided into two sections, each $9^{\prime \prime} 2^{\prime \prime}$ x $45^{\prime \prime} 5^{\prime \prime} \times 3^{\prime} 0^{\prime \prime}$.
(1) Can be sectionalized and nested for shipment.
(2) Lacks stability.
dry)

362 LTON
(1) Can be towed overseas.
(2) Used to construct piers and sea island terminals. Fitted with one compressor for air jacks, 12 each $100^{\prime} \times 6$ caissons.
(1) Can be towed overseas.
(2) Same as design 7024.

Fitted with three compressors for air jacks, 38 each $100^{\circ} \times 6^{\prime}$ caissons.

## 5-8. Landing Ships

| Nomenclature | Designation | Length (overall) | $\begin{gathered} \text { Beam } \\ \text { (overall) } \end{gathered}$ | Lightdiaphacemont(LTON | Draft loaded |  | $\begin{gathered} \text { Spoed } \\ \text { (knots) } \end{gathered}$ | Operatingranpe(nautical(miles) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | Fwod | Aft |  |  |
| Dock, landing ship, LSD-1 class (U.S. Navy). ${ }^{\text {a }}$ | LSD | 457'9" | 72'1\%" | 4,428 | $\begin{gathered} 18^{\prime} \text { dry; } \\ 30^{\circ} 48_{4}^{\prime \prime} \end{gathered}$ flooded. | $\begin{gathered} 18^{\prime} \text { dry; } \\ 30^{\prime} 44^{\prime \prime \prime} \\ \text { flooded. } \end{gathered}$ | 15 | 10,000 |
| Dock, landing ship, LSD28 class (U.S. Navy). | LSD | 510'11/2" | 84'2' | 6,143 | $\begin{aligned} & 19^{\prime} \text { dry; } 322^{\prime} \\ & 6^{\prime \prime} \text { flooded. } \end{aligned}$ | $\begin{gathered} 19^{\prime} \text { dry } \\ 34^{\prime} 1^{\prime \prime} \end{gathered}$ flooded. | 16.5 | 9,500 |


| Tank, landing ship, LST542 class (U.S. Nayy). | LST | $328^{\prime}$ | $50^{\prime}$ | 1,589 | Normal beaching 4'4"; maximum beaching 5’3"; full load cannot beach $7^{\prime 2} \mathbf{2}^{\prime \prime}$ | Normal beaching 9'3"; maximum beaching 10'2"; full load cannot beach $13^{\prime \prime} 0^{\prime \prime}$. | 8.5 | 17,800 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Tank, landing ship, LST1153 class (U.S. Navy). | LST | 382 | 54 | 2,009 | Normal beaching $3^{\prime \prime} 4^{\prime \prime}$; maximum beaching 3'11"; full load cannot beach $9^{\prime} 6^{\prime \prime}$. | Normal beaching 11'3"; maximum beaching 11'11"; full load cannot beach $16^{\prime} 3^{\prime \prime}$. | 10.4 | 7,706 |
| Tank, landing ship, LST1156. class (U.S. Navy). | LST | 384' | 65'7" | 2,635 | Normal beaching 4.2"; maximum beaching 4'11"; full load cannot beach $8^{\prime \prime} 3^{\prime \prime}$. | Normal beaching 9'11"; maximum beaching 10'8"; full load cannot beach 14'8". | 12 | 6,000 |
| Tank, landing ship, LST1171 class (U.S. Navy). | LST | $442^{\prime}$ | $62^{\prime \prime}{ }^{\prime \prime}$ | 4,150 | Normal beaching 4'0"; maximum beaching 5'8"; full load cannot beach $9^{\prime \prime} 9^{\prime \prime}$. | Normal beaching $13^{\prime} 0^{\prime \prime}$; maximum beaching 13'11"; full load cannot beach | 14 | 6,048 |
| Lighter, beach discharge, deck cargo, diesel, steel, 338 ft , design 5002 (U.S. Army) (fig. 5-11). | BDL | 338' | 65' | 1,548.8 | $\begin{gathered} \text { Beaching } \\ 4^{\prime} 0^{\prime \prime} ; \\ \text { ocean } \\ 7^{\prime} 8^{\prime \prime} . \end{gathered}$ | $\begin{gathered} 16^{\prime} 0^{\prime \prime} . \\ \text { Beaching } \\ 10^{\prime} 0^{\prime \prime} ; \\ \text { ocean } \\ 13^{\prime} 8^{\prime \prime} . \end{gathered}$ | 8.5 | 5,500 |

[^22]
## 5-18

| Capacitiea |  |  | Caroo planning ${ }^{\text {a }}$ |  |  |  |  |  | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Deck dimensions |  |  |  | Weight limit |  |  |
| $\begin{gathered} \text { Cargo } \\ (L T O N) \end{gathered}$ | Troops |  |  |  |  |  | Per aq ft | Total |  |
|  | OFF. | EM | Deek | Lenoth | Width | ${ }_{\text {sq ft }}{ }^{\text {c }}$ | (b) | (STON) |  |
| 1,233 combat. | 16 | 250 | Well; | 394'; | 42'10"; | 16,776; |  |  | Maximum water depth on |
|  |  |  | half; | 125'; | 42'; | 5,250; | 86 lb | 200 | well deck: $10^{\prime}$ fwd; $10^{\prime}$ aft. |
|  |  |  | super. | 141'6" | 44'10" | 6,353 | 100 lb | 275 |  |
| 2,400 combat. | 25 | 322 | Well; | 396'; | $\begin{aligned} & 48^{\prime} 9^{\prime \prime} \\ & \text { to } 24^{\prime} \text {; } \end{aligned}$ | 18,400 ${ }^{\prime}$ | 1,075 lb; | 9,390 | Maximum water depth on well deck: $\mathbf{1 0}^{\prime} \mathrm{fwd} ; \mathbf{1 0}^{\prime}$ aft. |
|  |  |  | mezza' <br> nine; | 144'; | $\begin{aligned} & 48^{\prime \prime} 7^{\prime \prime} \\ & \text { to } 30^{\prime} \end{aligned}$ | 6,500; | 150 lb ; | 475 |  |
|  |  |  | cargo; | 71'2'; | 48'6 ${ }^{\prime \prime}$; | 3,143; | 150 lb ; |  |  |
|  |  |  | helicopter. | 71' | $43^{\prime \prime} 5^{\prime \prime}$ | 3,100 | 150 lb ; | 232 |  |
| Normal beaching 500; maximum beaching 900 ; full load 1,358 . | 10 | 127 | Tank | 222'6" | $24^{\prime \prime} 0^{\prime \prime}$ | 4,556 |  | ---- | Bow ramp- |
|  |  |  | Main | 100'0" | $45^{\prime} 0^{\prime \prime}$ | 4,432 | 300 lb | 400 | Capacity: 100 T (supported). <br> Capacity: 50 T (unsup- |
|  |  |  |  |  |  |  |  |  | ported). |
|  |  |  |  |  |  |  |  |  | Inside width: $12^{\prime} 6^{\prime \prime}$. |
|  |  |  |  |  |  |  |  |  | Overhead clearance: $13^{\prime \prime} 9^{\prime \prime}$. |



## 5-9. Landing Craft

| Nomenclature | $\begin{aligned} & \text { Desig- } \\ & \text { nation } \end{aligned}$ | $\begin{aligned} & \text { Classi- } \\ & \text { fication } \\ & \text { (U.S. } \\ & \text { Army } \end{aligned}$ | Length (overall) | $\underset{(\text { molded })}{\text { Beam }}$ | Depth amidships | Light displacement (LTON) | Fwd | Draft ${ }^{\text {aft }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Landing craft, utility, diesel, steel, 115', Navy design LCU | LCU | STD-B | $119^{\prime}$ | $32^{\prime}$ | 5'6" | 143 | Loaded $3^{\prime} 4^{\prime \prime}$ | Loaded $4^{\prime} 0^{\prime \prime}$ | 501 class.


| Landing craft, utility, diesel, steel, 115', Navy design LCU 1466 class (fig. 5-12). | LCU | STD-A | 115 ${ }^{\prime \prime}{ }^{\prime \prime}$ | $34^{\prime}$ | $6^{\prime \prime} 0^{\prime \prime}$ | 180 | Light 2'0"; loaded $3^{\prime \prime} 1^{\prime \prime}$ | Light $3^{\prime} 10^{\prime \prime}$; loaded |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Landing craft, utility, diesel, steel, 135', Navy design LCU 1610 class. | LCU |  | $135^{\prime \prime} 3^{\prime \prime}$ | $29^{\prime}$ | (a) | 165.1 | $\begin{gathered} \text { Loaded } \\ 3^{\prime} 6^{\prime \prime} \end{gathered}$ | $\underset{6^{\prime} 0^{\prime \prime}}{\text { Loaded }}$ |
| Landing craft, mechanized, diesel, steel, 56 ', MARK VI, Navy design LCM (6) (fig. 5-13). | LCM | STD-B | $56^{\prime}$ | $14^{\prime \prime} 1^{\prime \prime}$ | 5'95\%' | 28 | $\begin{gathered} \text { Loaded } \\ 3^{\prime} 0^{\prime \prime} \end{gathered}$ | $\begin{gathered} \text { Loaded } \\ 4^{\prime \prime} 8^{\prime \prime} \end{gathered}$ |
| Landing craft, mechanized, diesel, steel, 69', MARK VIII, Navy design LCM (8)) (fig. 5-14). | LCM <br> LQP | STD-A | $73^{\prime \prime} 8^{\prime \prime}$ | $21^{\prime}$ | $9^{\prime \prime} 5^{\prime \prime}$ | 57.8 | Light $3^{\prime} 0^{\prime \prime}$; loaded $3^{\prime} 0^{\prime \prime}$ | Light $3^{\prime} 6^{\prime \prime}$; loaded $5^{\prime} 0^{\prime \prime}$ |
| Landing craft, vehicle, personnel (LCVP). | EGYP- |  | $35^{\prime \prime} 9^{\prime \prime}$ | $10^{\prime} 11^{\prime \prime}$ | ---- | 8.48 | $20^{\prime \prime}$ | $3^{\prime \prime} 0^{\prime \prime}$ |

[^23]| Fuelcapacity (gal.) 3,450 | Fuel consum (gal. per hr) 34 | Speed (knots) | Operating(nange(nilicalmiles | Capacity |  | Cargo space dimensions |  | $\underset{\text { opening }}{\text { Ramp }}$ | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $\begin{gathered} \text { Cargo } \\ (L T O N) \end{gathered}$ | Troop | $\frac{i}{\text { êngth }}$ | Width |  |  |
|  |  | 6.5 | 700 | 161 | 300 | 101 $1^{\prime} 0^{\prime \prime}$ | $\begin{aligned} & \text { See } \\ & \text { remarks } \end{aligned}$ | $12^{\prime} 6^{\prime \prime}$ | (1) Fresh water capacity: 1,730 gallons. |
|  |  |  |  |  |  |  |  |  | (2) Cargo space width-Bow to frame 10: $121 / 2^{\prime}$ to $26^{\prime}$. Frame 10 to frame 28.: 26 '. |
|  |  |  |  |  |  |  |  |  | Frame 28 to stern:' 26 ' to 14'. |
| 3,700 | 34 | 7. | 700 | 150 | 300 | $\begin{aligned} & 52 \prime \\ & 22^{\prime} \end{aligned}$ | $\begin{aligned} & 29^{\prime} 6^{\prime \prime} \text {; } \\ & 14^{\prime} 4^{\prime \prime} . \end{aligned}$ | $14^{\prime} 4^{\prime \prime}$ | Fresh water capacity: 9,563 gallons. |
| ( ${ }^{\text {a }}$ | ( ${ }^{\text {a }}$ | ${ }^{6} 9$. | ${ }^{\text {b }} 1,200$ | 170 | ( ${ }^{\text {a }}$ ) | ( ${ }^{\circ}$ | ( ${ }^{\text {a }}$ | 14'0" | Fresh water capacity not available. |
| 450 | 26 | 8 | 124 | 32 | c 80 | $37^{\prime \prime}{ }^{\prime \prime}$ | $11^{\prime \prime} 0^{\prime \prime}$ | $11^{\prime} 0^{\prime \prime}$ |  |
|  |  |  |  |  | ${ }^{4} 120$ |  |  |  |  |
| 1,146 | 34 | 9 | 303 | 53.5 | ${ }^{\text {c }} 200$ | 42'9" | $14^{\prime \prime} 6^{\prime \prime}$ | $14^{\prime} 6^{\prime \prime}$ |  |
| 200 | 13 | 7 | 102 | 3.6 | ${ }^{\text {c }} 36$ | 17'3' | 7'5' | $7{ }^{\prime \prime}$ |  |

## 5-10. Amphibians

| Nomenclature | Desio-nation | Classi- | Length(overala) | $\begin{gathered} \text { Beam } \\ \text { (Overal) } \end{gathered}$ | Height(overall) | Light diasplacement (LTON) <br> 6.4 | Draft |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |
| Landing vehicle, wheeled, 21/2-ton, $6 \times 6$, GMC model DUKW 353. | DUKW | STD-C | 31'0' | 8'2" |  |  | DLoaded $3^{\prime} \mathbf{6}^{\prime \prime}$ | "Loaded $4^{\prime \prime} 3^{\prime \prime}$ |
| Lighter, amphibious (LARC-V), self-propelled, diesel, aluminum, 5-ton, design 8005 (fig. 5-15). | LARC | STD-A | $35^{\prime \prime} 0^{\prime \prime}$ | 100' | $10^{\prime \prime} 2^{\prime \prime}$ | 8.48 | ${ }^{\text {b }}$ Light $3^{\prime} 3^{n}$; loaded $41^{\prime \prime}$ | ```'Light 3'9"; loaded 4'3'``` |
| Lighter, amphibious (LARC-XV), self-propelled, diesel, aluminum 15-ton design 8004. | LARC | STD-A | 45'0" | 14'7" | ${ }^{4} 15^{\prime} 6^{\prime \prime}$ | 20.81 | ${ }^{\text {b Light }}$ $4^{\prime} 0^{\prime \prime}$; loaded 4'11" | ${ }^{\text {b }}$ Light $4^{\prime} 11^{\prime \prime}$; loaded E'6" |
| Lighter, amphibious (LARC-LX), self-propelled, diesel, steel, 60ton, 61 ft , design 2308 (fig. 5-16). | LARC ${ }^{\text {e }}$ | STD-A | 62'6 ${ }^{\prime \prime}$ | 26'7" | ${ }^{\prime} 19^{\prime} 5^{\prime \prime}$ | 87 | ```'Light 6'2'; loaded 7'11'``` | ${ }^{b}$ Light 7'5"; loaded $8^{\prime \prime} \mathbf{8}^{\prime \prime}$ |
| Landing vehicle, tracked, personnel, model 5 (LVTP5A1) ${ }^{8}$ | LVTP(5) | ---- | 29'8" | 11'81/2" | ${ }^{6} 10^{\prime} 1 / 2^{\prime \prime}$ | 31.2 | ---- | ---- |


| Landing vehicle, tracked, engineer, model 1 (LVTE1)' | LVTE1 | --- | 3991/4" | ${ }^{\prime} 12^{\prime} 87 / 16^{\prime \prime}$ | 10'81/2" | 36.9 | ---- | ---- |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Landing vehicle, tracked, recovery, model 1 (LVTR1A1)* | LVTR1 |  | 31/9 ${ }^{\prime \prime}$ | 11/81/2" | ${ }^{1} 17{ }^{\prime} 6^{\prime \prime}$ | 33.5 | ---- | .-.- |
| Landing vehicle, tracked howitzer, model 6 (LVTH6A1) ${ }^{\text {m }}$ | LVTH6 | ---- | $29^{\prime \prime}{ }^{\prime \prime}$ | 11'81/2" | ${ }^{n} 13^{\prime} 41 / 2^{\prime \prime}$ | 33.2 | ---- | --- |

[^24]

5-11. Navy Transport Vessels ${ }^{\text {a }}$

| Nomenelature | Designation | Class | Type | Length (overall) | Beam | Displacoment (LTON) |  | Draft |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Light | Loaded | Light | Loaded |
| Amphibious force flagship. | AGC | Mount McKinley | C2-S-AI | 459'6" | $63^{\prime}$ | 6,450 | 15,295 | $15^{\prime}$ | $24^{\prime}$ |
| Attack transport | APA | Haskell | VC2-S-AP5 | 455 '3" | 62'2" | 6,720 | 12,450 | 14' | 28'6 ${ }^{\prime \prime}$ |
| Attack transport | APA | Bayfield | C3-S-A2 | 491'71/2" | $69^{\prime \prime}{ }^{\prime \prime}$ | 8,100 | 16,100 | 15'6" | $26^{\prime} 6^{\prime \prime}$ |
| Attack transport | APA | Paul Revere | C4-S-1 | 563'6" | $76^{\prime}$ | 10,709 | 18,000 | $20^{\prime}$ | 27' |
| Attack cargo ship | AKA | Tulare | C4-S-1B | 563 '6" | $76^{\prime}$ | 9,050 | 17,500 | $24^{\prime}$ | 28' |
| Attack cargo ship | AKA | Andromeda | C2-S-B1 | 459'3' | 62'11/2" | 7,430 | 12,800 | $16^{\prime}$ | $28^{\prime}$ |
| Attack cargo ship | AKA | Rankin | C2-S-AJ3 | 459'1' | $63^{\prime}$ | 6,456 | 14,160 | $16^{\prime}$ | 27'7" |
| Transport | AP | Geiger | P2-S1-DN3 | 533'7" | $73^{\prime \prime}{ }^{\prime \prime}$ | 17,600 | 19,600 | ---- | 27'1" |
| Transport | AP | General | P2-S2-R2 | 622'6" | $75^{\prime} 6^{\prime \prime}$ | 11,828 | 20,175 |  | 25'6" |
| Transport | AP | General <br> (Ex Admiral) | P2-SE2-R1 | 608'11" | $76^{\prime \prime}$ | 9,676 | 22,574 | ---- | 29'2' |
| Transport - | AP | General | C4-S-A1 | 522'10" | 71'8' | 10,034 | 16,750 | ---- | $26^{\prime \prime}$ |
| High speed transport .-. | APD |  | EX-DE | $306{ }^{\prime}$ | 37' | 1,400 | 2,180 | ---- | 13' |
| Transport submarine | APSS | Sea Lion | EX BALAD | $3116^{\prime \prime}$ | $27^{\prime}$ | 1,590 | 1,900 | ---- | 17' |
| Landing ship vehicle ... | LSV | Comet | C3-ST-14A | 499' | 78' | 7,605 | 18,150 | 17' | 27' |
| Landing ship vehicle .-- | LSV | Sealift | C4-ST-67A | 540' | 83' | 11,130 | 21,700 | ---- | $29^{\prime}$ |

[^25]| Speed (knots) | Cruising range (nazutical miles) | $\begin{gathered} \text { Cargo } \\ (\text { LTON }) \end{gathered}$ | Cargo space | Capacity <br> Craft | $\begin{gathered} \text { Boom } \\ (\mathrm{LTON}) \end{gathered}$ | Troops | Remarka |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ${ }^{\text {c }} 15.5$ | ${ }^{\text {c } 21,000 ~}$ | ---- | 12,360 cu ft | $\begin{aligned} & 3 \text { ea-LCVP } \\ & 3 \text { ea-LCPL } \end{aligned}$ | 4 ea-10 | $\begin{aligned} & 474 \\ & \text { (approx) } \end{aligned}$ | Equipped with helicopter platform. |
| 18.0 | 20,500 | $\begin{gathered} { }^{4} 446- \\ 714 \end{gathered}$ | $\begin{array}{r} 13,788 \mathrm{sq} \mathrm{ft} \\ 123,198 \mathrm{cu} \mathrm{ft} \end{array}$ | $\begin{aligned} & 2 \mathrm{ea}-\mathrm{LCM}(6) \\ & 22 \mathrm{ea-LCVP} \\ & 1 \mathrm{ea}-\mathrm{LCPL} \\ & 1 \mathrm{ea}-\mathrm{LCPR} \end{aligned}$ | $\begin{aligned} & 1 \mathrm{ea}-35 \\ & 8 \mathrm{ea-10} \\ & 6 \mathrm{ea}-5 \end{aligned}$ | 1,565 |  |
| 17.2 | 11,630 | $\begin{gathered} \mathrm{d} 446- \\ 714 \end{gathered}$ | $\begin{array}{r} 15,892 \mathrm{sq} \mathrm{ft} \\ 154,238 \mathrm{cu} \mathrm{ft} \end{array}$ | $\begin{aligned} & 4 \text { ea-LCM (6) } \\ & 18 \text { ea-LCCPP } \\ & 3 \text { ea-LCPL } \\ & 2 \text { ea-LCPR } \end{aligned}$ | $\begin{aligned} & 2 \mathrm{ea}-30 \\ & 6 \mathrm{ea}-10 \end{aligned}$ | 1,647 |  |
| 20 | 12,000 | 1,500 | $\begin{aligned} & 10,487 \mathrm{sq} \mathrm{ft} \\ & 138,974 \mathrm{cu} \mathrm{ft} \end{aligned}$ | $\begin{aligned} & 1 \text { ea-hel } \\ & 7 \text { ea-LCM (6) } \\ & 12 \text { ea-LCVP } \end{aligned}$ | $\begin{aligned} & 2 \mathrm{ea-60} \\ & 1 \mathrm{ea-30} \\ & 3 \mathrm{ea-10} \\ & 2 \mathrm{ea-8} \\ & 2 \mathrm{ea-5} \end{aligned}$ | 1,600 | Equipped with helicopter platform. |
| 20 | 12,000 | 4,375 | $\begin{array}{r} 33,363 \mathrm{sq} \mathrm{ft} \\ \mathbf{3 3 0 , 9 8 4} \mathrm{cu} \mathrm{ft} \end{array}$ | $\begin{aligned} & 9 \mathrm{ea}-\mathrm{LCM}(6) \\ & 15 \mathrm{ea}-\mathrm{LCVP} \\ & 3 \mathrm{ea}-\mathrm{LCPL} \end{aligned}$ | $\begin{aligned} & 2 \mathrm{ea-5}-5 \\ & 6 \mathrm{ea}-10 \\ & 1 \mathrm{ea-40} \\ & 3 \mathrm{ea-60} \end{aligned}$ | 321 | Equipped with helicopter platform. |
| 16 | 14,280 | $\begin{aligned} & 1,335- \\ & 1,600 \end{aligned}$ | $\begin{array}{r} 40,949 \mathrm{sq} \mathrm{ft} \\ 299,797 \mathrm{cu} \mathrm{ft} \end{array}$ | $\begin{aligned} & 2 \mathrm{ea}-\mathrm{LCM}(3) \\ & 6 \mathrm{ea}-\mathrm{LCM}(6) \\ & 14 \mathrm{ea} \mathrm{LCVP} \\ & 2 \mathrm{ea}-\mathrm{LCPL} \end{aligned}$ | $\begin{array}{r} 10 \mathrm{ea}-5 \\ 4 \mathrm{ea}-10 \\ 2 \mathrm{ea}-30 \end{array}$ | $\begin{aligned} & \mathrm{d} 86- \\ & 326 \end{aligned}$ |  |
| 15 | 16,200 | ---- | $\begin{array}{r} 27,304 \mathrm{sq} \mathrm{ft} \\ 316,823 \mathrm{cu} \mathrm{ft} \end{array}$ | $\begin{aligned} & 7 \mathrm{ea}-\mathrm{LCM}(6) \\ & 1 \mathrm{ea}-\mathrm{LCM}(3) \\ & 14 \mathrm{ea}-\mathrm{LCVP} \\ & 1 \mathrm{ea} \text { LCPR } \\ & 1 \mathrm{ea} \mathrm{LCPL} \end{aligned}$ | $\begin{aligned} & 4 \mathrm{ea-5} \\ & 2 \mathrm{ea-10} \\ & 4 \mathrm{ea}-35 \end{aligned}$ | $\begin{gathered} 66 \\ 126 \end{gathered}$ |  |
| 20 | 18,752 | 2,351 | ----------- |  | 8 ea-10 | 1,930 |  |
| 19 | 12,167 | 2,137 | 109,000 cu ft |  | 8 ea-8 | 2,422 |  |
| 21 | 15,468 | 3,605 | $110,293 \mathrm{cu} \mathrm{ft}$ | ---------- | $\begin{array}{r} 10 \mathrm{ea}-5 \\ 4 \mathrm{ea}-10 \end{array}$ | 1,937 |  |
| 17 | 12,550 | --- | $67,000 \mathrm{cu} \mathrm{ft}$ | ---------- | $\begin{aligned} & 4 \mathrm{ea}-1 \\ & 6 \mathrm{ea-} 3 \end{aligned}$ | 3,146 |  |
| 24 | 5,100 | 85 |  | $\begin{aligned} & 2 \text { ea-LCVP } \\ & 2 \text { ea-LCPR } \end{aligned}$ | 1 ea - 5 | 162 |  |
| 13 | 8,000 | 30 | ----------- | ---------.- | -- | 76 |  |
| 18 | 13,000 | 8,050 | $\begin{array}{r} 60,000 \mathrm{sq} \mathrm{ft} \\ 176,500 \mathrm{cu} \mathrm{ft} \end{array}$ | ----------- | $\begin{array}{r} 4 \mathrm{ea}-10 \\ 16 \mathrm{ea}-15 \\ 2 \mathrm{ea}-60 \end{array}$ | 12 | 700 vehicles. Ramp rated at 60 LTON. |
| 20 | 10,000 | --- | $\begin{array}{r} 99,030 \mathrm{sq} \mathrm{ft} \\ 946,800 \text { cu ft } \end{array}$ | ----------- | ------- | 12 | Incomplete data. |



Figure 5-2. Boat, picket, steel, 46 feet 4/12 inches design 4003.

## 5-12. Maritime Administration Vessel Classification System

a. Method. The classification system established by the United States Maritime Administration is based upon three groups of letters and numbers. The first group (prefix) indicates the type of vessel, such as cargo or passenger, and its approximate size. The second group (intermediate) indicates the type of machinery, number of screws, and passenger
accommodation. The third group (suffix) indicates the particular design of the type of vessel and modifications. For example: C2-S-AJ1 describes a cargo ship between 400 and 450 feet long (C2) ; single screw, steam machinery ( S ), and the AJ design (AJ), in its original version (1).
b. Prefix Designations.
(1) Other than emergency and Victory types.


Figure 5-s. Boat, picket, diesel, wood, 64 feet 11 inches, design 4002.

| Single letter | Class of vessel | 1 | 2 | Length des | $\underset{4}{\text { nation (lood }}$ | (terline in feat) | ${ }_{6}$ | 7 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C | Cargo, unlimited service, under 100 passengers. | $\begin{gathered} \text { Under } \\ 400 \end{gathered}$ | 400-450 | 450-500 | 500-550 |  |  |  |
| P | Passenger, unlimited service, over 100 passengers. | $\begin{gathered} \text { Under } \\ 500 \end{gathered}$ | 500-600 | 600-700 | 700-800 | 800-900 | 900-1,000 | Over 1,000 |
| B | Barge ..-..--...-.... | $\begin{gathered} \text { Under } \\ 100 \end{gathered}$ | 100-150 | 150-200 | 200-250 | 250-300 |  |  |
| L | Great Lakes tankers (ore, grain). | $\begin{gathered} \text { Under } \\ 400 \end{gathered}$ | 400-450 | 450-500 | 500-550 | 550-600 | 600-650 |  |
| N | Coastwise cargo --.- | $\begin{gathered} \text { Under } \\ 200 \end{gathered}$ | 200-250 | 250-300 | 300-350 | 350-400 | 400-450 | 450-500 |
| R | Refrigerator | $\begin{gathered} \text { Under } \\ 400 \end{gathered}$ | 400-450 | 450-500 | 500-550 |  |  |  |
| S | Special | $\begin{gathered} \text { Under } \\ 200 \end{gathered}$ | 200-300 | 300-400 | 400-500 | 500-600 | 600-700 |  |
| T | Tanker | $\begin{gathered} \text { Under } \\ 450 \end{gathered}$ | 450-500 | 500-550 |  |  |  |  |
| V | Towing vessels . ... . | Under <br> 50 | 50-100 | 100-150 | 150-200 |  |  |  |
| Z | Conversion* |  |  |  |  |  |  |  |

"For conversions of established types, " $Z$ " is prefixed to original designation with new final number in some cases.
(2) Emergency and Victory types. .

| $\begin{aligned} & \text { Double } \\ & \text { letter } \end{aligned}$ | Class of vessel | Length designation (load waterline in feet) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| EC | Emergency cargo (Liberty ship) | Under 400 | 400-450 | 450-500 | 500-550 |
| ET | Emergency tanker | 450 |  |  |  |
| VC | Victory cargo | Under 400 | 400-450 | 450-500 | 500-550 |



Figure 5-4. Boat, passenger and cargo, diesel, steel, 65 feet 6 inches, design 2001.
(3) Older designs. The following older designs have prefixes similar to those in (1) above, but do not follow the same system for the intermediate and suffix portions. The letters or words after the hyphen are simply distinguishing characters.
C1-A
C1-B
C2-Diesel

C2-F
C2-G
C2-Modified
C2-S
CT-Seas shipping
C2-SU Reefers
C2-T
C2-Turbine
C3-A (P\&C)
C3-Diesel

| C3-E |  |  |  |
| :---: | :---: | :---: | :---: |
| C3-IN (P\&C) |  |  |  |
| C3-M |  |  |  |
| C3 (P\&C) Diesel |  |  |  |
| C3 (P\&C) Turbine |  |  |  |
| C3-P (P\&C) |  |  |  |
| C3-Turbine |  |  |  |
| c. Intermediate letter or group. |  |  |  |
| Type of machinery | Type of propeller | Under 18 passengers | Over 12 passengers |
| Steam | Single | S | S1 |
| Motor | Single | M | M1 |
| Turboelectric | Single | SE | SE1 |
| Diesel-electric | Single | ME | ME1 |
| Gas turbine --. | Single | G | G1 |
| Gas turboelectric.- | Single | GE | GE1 |
| Steam ---------- | Twin | ST | S2 |
| Motor | Twin | MT | M2 |
| Turboelectric | Twin | SET | SE2 |
| Diesel-electric -... T | Twin | MET | ME2 |


| Tupe of machinery | Tupe of propeller | Under 12 passengers | Over 12 passengers |
| :---: | :---: | :---: | :---: |
| Gas turbine | Twin | GT | G2 |
| Gas turboelectric | Twin | GET | GE2 |
| Steam | Stern wheel | SW | SO |
| Motor | Stern wheel | MW | MO |

d. Suffix. The third group, or suffix, identifies the particular design and indicates the approximate time the design originated. The alphabetical letters are assigned in series. Therefore, if there is only one letter, this indicates that the design originated earlier than one having two letters. The figure following the letter or letters in the suffix indicates that it is either the original design of that particular alphabetical designation or a modification thereof. The original design is always numbered 1 .

## 5-13. Below-Deck Capacities



[^26]| Veased (Hull desion) | $\begin{aligned} & \text { Hatech } \\ & \text { No. } \end{aligned}$ | Hatch dimenoions | $\begin{aligned} & O_{\text {twpeer }} \end{aligned}$ | Cargo capo Lorver 'tween | (MTON) <br> Hold | Deep tanks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C3-S-A2 | 1 | 3591/2"x19'91/2" | 812 | 1,130 | 1,079 |  |
|  | 2 | 29911/2"x23/91/2" | 830 | 1,381 | 1,396 |  |
|  | 3 | 37'31/2"x23'91/2" | 1,244 | 1,553 | 2,002 |  |
|  | 4 | 29,91/2"x23'9112" | 1,164 | 1,255 | 1,419 |  |
|  | 5 | 39,91/2"x23'91/2" | 1,009 | 1,704 | 212 |  |
| Total |  |  | 5,059 | 7,023 | 6,108 |  |
| C4-S-A. 4 | 1 | 17'9"x16'8" | ${ }^{\text {c } 496}$ | ${ }^{4} 340$ | 141 |  |
|  | 2 | $26^{\prime 1} 0^{\prime \prime} \times 17{ }^{\prime \prime}{ }^{\prime \prime}$ | ${ }^{\text {c } 1,139 ~}$ | ${ }^{\text {d }} 1,258$ | 772 |  |
|  | 3 | 26'10"x17'9" | 798 | 651 |  | $\bullet 1,084$ |
|  | 4 | 26'10" ${ }^{\prime \prime} 17{ }^{\prime \prime} 9^{\prime \prime}$ | 803 | ${ }^{\text {d }} 1,533$ | 994 |  |
|  | 5 | $26^{\prime 1} 0^{\prime \prime} \times 17^{\prime \prime} 9^{\prime \prime}$ | 765 | ${ }^{\text {d }} 1,515$ | 1,017 |  |
|  | 6 | 26 ${ }^{\prime} 10^{\prime \prime} \times 17^{\prime \prime}{ }^{\prime \prime}$ | 795 | 782 | 1,636 |  |
|  | 7 | 179'x17'1" | ${ }^{1} 583$ | ${ }^{\text {² }} 454$ |  |  |
| Total |  |  | $\overline{5,379}$ | $\overline{6,533}$ | $\overline{4,560}$ | $\overline{1,084}$ |
| C4-S-B5 | 1 | 20'0"x18'0" | 608 | 293 |  |  |
|  | 2 | $27^{\prime \prime} 6^{\prime \prime} \times 20^{\prime \prime}$ | 1,160 | 1,128 | 704 |  |
|  | 3 | $27^{\prime \prime} 6^{\prime \prime} \times 20^{\prime \prime}{ }^{\prime \prime}$ | 702 | 641 | 603 | 837 |
|  | 4 | $30^{\prime \prime} 0^{\prime \prime} \times 20^{\prime \prime}$ | ${ }^{\text {¹, }}$,626 | 764 | 1,047 |  |
|  | 5 | $30^{\prime \prime} 0^{\prime \prime} \times 20^{\prime \prime}$ | ${ }^{\text {E }} 1,623$ | 772 | 1,055 |  |
|  | 6 | $30^{\prime} 0^{\prime \prime} \times 20^{\prime \prime} 0^{\prime \prime}$ | ${ }^{1} 1,540$ | 794 | 998 |  |
|  | 7 | 20'3"x18.0" | 95 | 482 | 358 |  |
| Total |  |  | 7,354 | 4,874 | 4,765 | 837 |
| C4-S-1a (Mariner) | 1 | 19'6"x17'9" | 402 | 453 | 305 |  |
|  | 2 | $29^{\prime} 10^{\prime \prime} \times 23^{\prime \prime} 10^{\prime \prime}$ | 731 | 865 | 637 |  |
|  | 3 | $3910{ }^{\prime \prime} \times 29^{\prime} 10^{\prime \prime}$ | 1,050 | 1,454 | 1,284 |  |
|  | 4 | 39'10"x29'10" | 1,006 | 1,500 | 1,528 |  |
|  | 5 | $39^{\prime} 10^{\prime \prime} \times 29^{\prime} 10^{\prime \prime}$ | 1,044 | 410 | 401 | 953 |
|  | 6 | $39^{\prime} 10^{\prime \prime} \times 29^{\prime} 10^{\prime \prime}$ | 965 |  | 1,646 | 298 |
|  | 7 | 29'10"×24'10" | 1,627 |  | 856 |  |
| Total |  |  | 6,825 | 4,682 | 6,657 | 1,251 |
| FS Freighter | 1 | $20^{\prime} 0^{\prime \prime} \times 16^{\prime \prime} 0^{\prime \prime}$ |  |  | 251.8 |  |
|  | 2 | $28^{\prime \prime} 0^{\prime \prime} \times 16^{\prime \prime} 0^{\prime \prime}$ |  |  | 284.75 |  |
|  | - - | - | ---- | ---- | $\overline{536.55}$ |  |

a Special cargo locker on upper 'tween level between hatches Nos. 3 and 4.
b Includes $\mathbf{8 6}$ MT in trunked hatch.
c Includes upper deck and seeond deck.
d Includes third deck and first platform.

- Liquid cargo space.
₹ Includes refrigerated cargo space.
- Includes main 'tween deck.


## 5-14. Vehicles-Loading Capacities

These figures reflect general loading conditions and by no means represent the maximum vehicle capacities of the vessels. No allowance has been made for stacking or double
decking. All below-deck stowage is fore and aft except in the case of $1 / 4$-ton trucks and $11 / 2$-ton trailers, which are stowed both fore and aft and athwartship.
a. C4-S-1a (Mariner).

| $\begin{aligned} & \text { Hatch } \\ & \text { No. } \end{aligned}$ | Location | Trailer, caroo, <br> $11 / 8$-ton | Truck, utility, 1/4-ton | 3/4T4x4 | $\begin{gathered} \text { Truck, cargo } \\ \text { 1/ETGXx } \\ \text { LWB } \end{gathered}$ | ${ }^{5}{ }_{L}^{T}{ }_{W}^{6 x}{ }^{6 x}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | On deck | 20 | 20 | 11 | 7 | 4 |
|  | 'Tween deck: |  |  | 12 | 6 | 4 |
|  | Upper | 16 | 20 | 12 | 4 | 0 |
|  | Lower | 10 | 14 | 9 | 3 | 0 |
|  | Hold | 5 | 9 | 6 | 10 | 7 |
| 2 | On deck | 23 | 33 | 20 | 10 | 7 |
|  | 'Tween deck: Upper | 23 | 37 | 22 | 11 | 7 |
|  | Upper | 21 | 26 | 15 | 9 | 7 |
|  | Hold -- | 11 | 15 | 9 | 5 | 2 |
| 3 | On deck | 42 | 52 | 30 | 20 | 10 |
|  | 'Tween deck: |  | 61 | 38 | 25 | 13 |
|  | Upper -- | 48 | 52 | 32 | 21 | 13 |
|  | Lower -- | 44 32 | 36 | 22 | 14 | 9 |
| 4 | On deck | 36 | 52 | 26 | 18 | 10 |
|  | 'Tween deck: |  | 69 | 38 | 20 | 14 |
|  | Upper | 46 | 69 | 38 | 20 | 14 |
|  | Lower | 46 44 | 69 | 30 | 16 | 12 |
|  | Hold | 44 |  | 28 | 20 | 12 |
| 5 | On deck .-.. 'Tween deck: | 36 | 54 |  |  |  |
|  | Upper | 56 | 72 | 42 | 18 | 14 |
|  | Lower | 58 | 74 | 44 | 18 | 14 |
|  | Hold | 56 | 72 | 42 | 16 | 12 |
|  | Deep tank | 28 | 36 | 14 | 6 | 2 |
| 6 | On deck | 40 | 54 | 30 | 20 | 12 |
|  | 'Tween deck | 47 | 65 | 36 | 18 | 14 |
|  | Hold | 30 | 34 | 20 | 12 | 9 |
|  | Deep tank | 4 | 10 | 0 | 0 | 0 |
| 7 | On deck | 27 | 37 | 22 | 12 | 7 |
|  | 'Tween deck | 33 | 42 | 23 | 11 | 7 |
|  | Hold | 9 | 10 | 6 | 4 | 0 |
| b. C1-B. |  |  |  |  |  |  |
| $\begin{aligned} & \text { Hatch } \\ & \text { No. } \end{aligned}$ | Location | Trailer, cargo, | Truck, utility, 1/4-ton | 3/4T\&x4 | Truck, eargo : $1 / 2 T_{B}^{6 x}$ LWB | $5 \cos _{L W B}^{6 x}$ |
|  | On deck | 14 | 14 | 12 | 5 | 7 |
|  | 'Tween deck: |  |  | 12 | 6 | 4 |
|  | Upper | 18 | 21 | 12 | 6 | 5 |
|  | Lower | 18 | 21 | 12 9 | 4 | 4 |
|  | Lower hold | 13 | 14 | 9 |  | 7 |
| 2 | On deck | 21 | 25 | 18 | 12 | 7 |
|  | 'Tween deck: |  | 46 | 25 | 13 | 12 |
|  | Upper | 37 37 | 42 | 25 | 15 | 12 |
|  | Lower hold ${ }^{\text {* }}$ | 36 | 34 | 21 | 13 | 11 |
| 3 | On deek | 21 | 23 | 14 | 10 | 5 |
|  | 'Tween deck | 42 | 44 | 30 | 17 | 12 |
|  | Lower | 42 | 41 | 28 | 13 | 12 |
|  | Lower hold* | 42 | 41 | 28 | 13 | 9 |

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| $\begin{aligned} & \text { Hatch } \\ & \text { No. } \end{aligned}$ | Location | Trailer, cargo. <br> 1 $1 / 2$-ton | Truek, utility, 1/4-ton | S/4T\&x |  | $5 \underset{L}{T} \underset{B}{\sigma x}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 4 | On deck | 21 | 21 | 14 | 10 | 7 |
|  | 'Tween deck: |  |  |  |  |  |
|  | Upper | 41 | 39 | 26 | 14 | 12 |
|  | Lower | 37 | 36 | 24 | 12 | 10 |
| 5 | On deck | 18 | 16 | 12 | 7 | 5 |
|  | 'Tween deck | 23 | 23 | 15 | 7 | 5 |
|  | Hold | 10 | 10 | 12 | 6 | - |

- Number of vehicles (except 5 -ton, $6 \times 6$ ) can be doubled by flooring over one layer of vehicles and loading a second lager directly on top. The depth of only these two holds will permit such double decking.
c. EC2 (Liberty).

| Hatch No. | Location | $\begin{aligned} & \text { Trailer, } \\ & \text { cargo, } \\ & \text { 1 } 1 / \text { /eton } \end{aligned}$ | Truek, utility, <br> 1/4-ton | 3/4T4x4 | $\begin{aligned} & \text { Tresek, cargo } \\ & 21 / 2 T G x \theta \\ & L W B \end{aligned}$ | ${\underset{L W B}{T}{ }^{T} x^{6} .}^{6}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | On deck | 22 | 22 | 14 | 9 | 6 |
|  | 'Tween deck ---.-. - | 27 | 28 | 23 | 12 | 8 |
|  | Lower hold | 24 | 28 | 18 | 10 | 5 |
| 2 | On deck | 36 | 41 | 20 | 13 | 8 |
|  | 'Tween deck -.-.---- | 44 | 54 | 30 | 21 | 12 |
|  | Lower hold _------- | 42 | 48 | * 30 | *18 | 12 |
| 3 | On deck | 14 | 22 | 10 | 6 | 4 |
|  | 'Tween deck ------- | 28 | 36 | 25 | 14 | 6 |
|  | Lower hold _------- | 28 | 32 | *22 | 12 | 6 |
| 4 | On deck _---------- | 20 | 31 | 16 | 11 | 8 |
|  | 'Tween deck ------- | 37 | 41 | 27 | 16 | 8 |
|  | Lower hold _------- | 15 | 20 | 18 | 10 | 2 |
| 5 | On deck _----------- | 22 | 31 | 14 | 11 | 6 |
|  | 'Tween deck ------- | 34 | 44 | 25 | 16 | 9 |
|  | Lower hold _--..--- | 11 | 20 | 20 | 6 | 2 |

*Based on no centerline bulkhead, which may or may not be standard equipment.


Figure 5-5. Crane, barge, diesel-electric, steel, 60 long tons, design 413D.
d. VC2 (Victory).

| $\begin{aligned} & \text { Hatch } \\ & \text { No. } \end{aligned}$ | Location | Trailer. cargo, $1 / 8$-ton | Truck, utility, 1/4-ton | 3/4T4x4 | $\begin{gathered} \text { Truck, caroo } \\ \text { \& } 1 / 2{ }_{2} x_{B} \end{gathered}$ | $5 \underset{L W B}{T}{ }^{6} x{ }^{6}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | On deck | 12 - | 14 | 6 | 5 | 4 |
|  | 'Tween deck: |  |  |  |  |  |
|  | Upper - | 16. | 15 | 9 | 5 | 0 |
|  | Lower | 18 | 16 | 9 | 6 | 3 |
|  | Hold | 13 | 15 | 8 | 4 | 3 |
| 2 | On deck | 16 | 18 | 12 | 7 | 4 |
|  | 'Tween deck: |  |  |  |  |  |
|  | Upper | 26. | 29 | 17 | 10 | 4 |
|  | Lower | 24 | 25 | 17 | 10 | 5 |
|  | Hold | 21. | 21 | 14 | 8 | 3 |
| 3 | On deck | 29 | 25 | 18 | 13 | 8 |
|  | 'Tween deck: |  |  | 29 | 17 | 12 |
|  | Upper | 48 | 48 | 30 | 18 | 12 |
|  | Hold | 46 | 44 | 30 | 18 | 8 |
| 4 | On deck | 25 | 23 | 18 | 13 | 8 |
|  | 'Tween deck | 48 | 49 | 34 | 16 | 14 |
|  | Hold | 49 | 49 | 31 | 18 | 13 |
| 5 | On deck | 25 - | 25 | 17 | 6 | 4 |
|  | 'Tween deck | 31 | 30 | 20 | 12 | 6 |
|  | Hold | 19 | 20 | 12 | 7 | 3 |

Figure 5-6. Crane, barge, diescl-electric, revolving, steel, 89 long tons, design $264 B$.


Figure 5-7. Barge, deck cargo, nonpropelled, steel 570 tons, 110 feet, design 7005.


Figure 5-8. Barge, deck, cargo, nonpropelled, steel, 585 tons, 120 feet, design 231 A.


Figure 5-9. Barge, deck and liquid cargo, nonpropelled, steel, 578 tons or 4,160 barrels, 120 feet, design $231 B$.


Figure 5-10. Barge, deck cargo, nonpropelled, steel, 180 tons, 81 feet, sectionalized, nesting, design 7001.


Figure 5-11. Lighter, beach discharge, deck cargo, diesel, steel, 398 feet, design 5002.



Figure 5-13. Landing craft, mechanized, diesel, 56 feet, Mark VI, Navy design, LCM (6).

$\underline{a}$



Figure 5-15. Lighter, amphibious (LARC-V), self-propelled, diesel, aluminum, 5 tons, design 8005.


Figure 5-16. Lighter, amphibious (LARC-LX), self-propelled, diesel, steel, 60 tons, 61 feet, design 2303.
e. C1-M-AV1.*

| $\begin{aligned} & \text { Hatch } \\ & \text { No } \end{aligned}$ | Location | Trailer, cargo, 1/2-ton | Truek, utility. 1/4-ton | 3/4T4x4 | Truck, cargo 21/2TGX6 LWB | ${ }^{5} \underset{L}{T} \underset{W}{G x}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | On deck -- | 14 | 20 | 13 | 7 | 4 |
|  | 'Tween deck | 23 | 30 | 16 | 10 | 3 |
|  | Hold | 13 | 16 | 7 | 4 | 2 |
| 2 | On deck | 24 | 30 | 18 | 10 | 8 |
|  | 'Tween deck | 46 | 51 | 28 | 19 | 10 |
|  | Hold | 45 | 51 | 28 | 19 | 10 |
| 3 | On deck | 22 | 28 | 14 | 10 | 6 |
|  | 'Tween deck | 37 | 44 | 27 | 17 | 9 |
|  | Hold | 37 | 44 | 26 | 15 | 9 |

[^28]
## 5-15. United States Navy Ship and Service Craft Designators

In the following lists the arrangement within the major categories and subcategories is alphabetically by symbols.
Where the identifying classification and hull number of a naval vessel is preceded by the letter " $E$," it indicates that the particular vessel or craft is "Experimental." Similarly the prefix " $T$ " indicates that the vessel is assigned to MSTS (Military Sea Transportation Service).

The addition of the suffix " $N$ " to the identifying classification indicates that that particular vessel has nuclear propulsion.
a. Combatant Vessels.
(1) Warships. $\quad$

## Aircraft Carriers:

Attack Aircraft Carrier -......... CVA
Nuclear Power Aircraft Carrier .- CVAN
Small Aircraft Carrier ........... CVL
ASW Support Aircraft Carrier ... CVS
Battleships:
Battleship -...-.-.-................... BB
Cruisers:
Heavy Cruiser ....................... CA
Guided Missile Heavy Cruiser .... CAG
Guided Missile Cruiser ........... CG
Nuclear Power Guided Missile Cruiser

CGN
Light Cruiser -....-................... CL
Anti-Aircraft Light Cruiser -...... CLAA
Guided Missile Light Cruiser ....- CLG
Destroyers:
Destroyer -...........-.-.-.....-. DD
Nuclear Power Destroyer -.......- DDN
Guided Missile Destroyer .......... DDG
Radar Picket Destroyer -.-........ DDR
Frigate ----- -...................... DL
Guided Missile Frigate ........... DLG
Nuclear Power Guided Missile
Frigate DLGN
Submarines:
Submarine -........................... SS
Fleet Ballistic Missile Submarine - SSB
Nuclear Power Fleet Ballistic Mis-
sile Submarine
SSBN
Guided Missile Submarine ........ SSG
Nuclear Power Guided Missile
Submarine
Nuclear Power Submarine ........ SSN
(2) Amphibious Warfare Ships. Amphibious Force Flagship .....- AGC
Attack Cargo Ship .-............... AKA
Attack Transport .................... APA
High Speed Transport ............. APD
Transport Submarine -.............. APSS
Inshore Fire Support Ship .......- IFS
Amphibious Transport Dock ....- LPD
Amphibious Assault Ship.........- LPH
Dock Landing Ship --.-............- LSD
Medium Landing Ship ............ LSM
Medium Landing Ship (Rocket) .- LSMR
Support Landing Ship (Large)
Mk. III .-............................ LSSL
Tank Landing Ship ................ LST
Vehicle Cargo Ship ................. LSV
(3) Mine Warfare Ships.

Minelayer, Destroyer ............... DM
Mine Countermeasures Support
Ship
Minehunter, Auxiliary .-........... MHA
Minehunter, Coastal ................. MHC
Minelayer, Fleet -.-.-.-.-........... MMF
Minelayer, Auxiliary .............. MMA
Minelayer, Coastal -................. MMC
Minesweeper, Auxiliary ........... MSA
Minesweeper, Coastal .............. MSC
Minesweeper, Coastal (old) .-... MSC(o)
Minesweeper, Fleet (steel hulled) - MSF
Minesweeper, Ocean (Nonmagnetic) MSO
Minesweeper, Special ....-........-. MSS
(4) Patrol Ships.

Escort Ship -----.-.-.-.-........... DE
Guided Missile Escort Ship ...... DEG
Radar Picket Escort Ship -...... DER
Submarine Chaser (173') .-........ PC
Escort (180') .......-. .-.............. PCE
Rescue Escort (180') .-..-.-.-....... PCER
Submarine Chaser (Hydrofoil) ..- PCH
Submarine Chaser (136') .......... PCS
Patrol Escort --.-.-.-.-............. PF
Motor Gunboat --...................... PGM
Fast Patrol Boat -...-.-.-.......... PTF
Yacht -..-.-.-....................... PY
Submarine Chaser (110') .-......-. SC
(5) Command Ships.

Command Ship
CC
b. Auxiliary Ships.

Destroyer Tender --.--------.-.-. AD
Degaussing Ship -.-..-.-.-........... ADG
Ammunition Ship -..-.-.-........... AE

Combat Store Ship ................... AFS
Miscellaneous -.---.---.-.-.-.-.-. AG

Escort Research Ship -............ AGDE
Hydrofoil Research Ship .......... AGEH
Missile Range Instrumentation Ship ..... AGM
Major Communications Relay Ship ..... AGMR
Oceanographic Research Ship ..... AGOR
Radar Picket Ship ..... AGR
Surveying Ship ..... AGS
Coastal Surveying Ship ..... AGSC
Satellite Launching Ship ..... AGSL
Auxiliary Submarine ..... AGSS
Hospital Ship ..... AH
Cargo Ship ..... AK
Cargo Ship, Dock ..... AKD
Light Cargo Ship ..... AKL
Net Cargo Ship ..... AKN
Stores Issue Ship ..... AKS
Cargo Ship and Aircraft Ferry ..... AKV
Net Laying Ship ..... AN
Oiler ..... AO
Fast Combat Support Ship ..... AOE
Gasoline Tanker ..... AOG
Replenishment Fleet Tanker ..... AOR
Submarine Oiler ..... AOSS
Transport ..... AP
Self-propelled Barracks Ship ..... APB
Small Coastal Transport ..... APC
Repair Ship ..... AR
Battle Damage Repair Ship ..... ARB
Cable Repairing or Laying Ship ..... ARC
Internal Combustion Engine Repair Ship ..... ARG
Landing Craft Repair Ship ..... ARL
Salvage Ship ARS
Salvage Lifting Ship ..... ARSD
Salvage Craft Tender ..... ARST
Aircraft Repair Ship ..... ARV
Aircraft Repair Ship (Aircraft) ..... ARVA
Aircraft Repair Ship (Engine) ARVE
Submarine Tender ..... AS
Submarine Rescue Ship ..... ASR
Auxiliary Ocean Tug ..... ATA
Fleet Ocean Tug ..... ATF
Seaplane Tender ..... AV
Advance Aviation Base Ship ..... AVB
Guided Missile Ship ..... AVM
Small Seaplane Tender ..... AVP
Aviation Supply Ship ..... AVS
Auxiliary Aircraft Transport ..... AVT
Distilling Ship ..... AW
Unclassified Miscellaneous ..... IX
c. Service Craft.
Large Auxiliary Floating Dry Dock AFDB
Small Auxiliary Floating Dry Dock ..... AFDL Medium Auxiliary Floating Dry Dock AFDM
Barracks Ship (non-self-propelled) APL ..... ARD
ARDM Medium Auxiliary Repair Dry Dock ..... LCU
Minesweeping Boat ..... MSB

| Minesweeper, Inshore | MSI |
| :---: | :---: |
| Target and Training Submarine | SST |
| Submersible Craft | X |
| Miscellaneous Auxiliary | YAG |
| Open Lighter | YC |
| Car Float | YCF |
| Aircraft Transportation Lighter | YCV |
| Floating Crane | YD |
| Diving Tender | YDT |
| Covered Lighter (self-propelled) | YF |
| Ferryboat or Launch | YFB |
| Yard Floating Dry Dock | YFD |
| Covered Lighter (non-selfpropelled) | YFN |
| Large Covered Lighter | YFNB |
| Dry Dock Companion Craft | YFND |
| Lighter (special purpose) | YFNX |
| Floating Power Barge | YFP |
| Refrigerated Covered Lighter (self-propelled) | YFR |
| Refrigerated Covered Lighter (non-self-propelled) | YFRN |
| Covered Lighter (Range Tender) | Y FRT |
| Harbour Utility Craft | YFU |
| Garbage Lighter (self-propelled) | YG |
| Garbage Lighter (non-selfpropelled) | YGN |
| Dredge | YM |
| Gate Craft | YNG |
| Fuel Oil Barge (self-propelled) | YO |
| Gasoline Barge (self-propelled) | YOG |
| Gasoline Barge (non-self-propelled) | YOGN |
| Fuel Oil Barge (non-self-propelled) | YON |
| Oil Storage Barge | YOS |
| Patrol Craft | YP |
| Floating Pile Driver | YPD |
| Floating Workshop | YR |
| Repair and Berthing Barge | YRB |
| Repair, Berthing and Messing Barge | YRBM |
| Floating Dry Dock Workshop (Hull) | YRDH |
| Floating Dry Dock Workshop (Mach.) | YRDM |
| Radiological Repair Barge | YRR |
| Seaplane Wreckage Derrick | YSD |
| Sludge Removal Barge | YSR |
| Large Harbour Tug | YTB |
| Small Harbour Tug | YTL |
| Medium Harbour Tug | YTM |
| Drone Aircraft Catapult Control Craft | YV |
| Water Barge (self-propelled) | YW |
| Water Barge (non-self-propelled) | YWN |

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A- Deadweight tons, salt water B- Draft (feet) to bottom of keel C- Displacement tons, salt water D- Tons per inch immersion

Figure 5-17. Deadweight scale for a Victory ship.

## 5-16. U.S. Army Marine Fleet Classification System

Each vessel in the transportation terminal battalion marine fleet bears an individual serial number, preceded by one of the following applicable prefixes.
LARC (LX) - lighter, amphibious, self-propelled, diesel, steel, 60-ton, 61-foot, design 2303
BC barge, dry cargo, non propelled, medium ( 100 feet through 149 feet)
BCDK _-...-. conversion kit, barge, deck enclosure BCI _._-_-_-_ barge, dry cargo, inland waterways, nonpropelled, medium ( 100 feet through 149 feet)
BCLI -. .-.-- barge, dry cargo, inland waterways, nonpropelled, large ( 150 feet and over)
BPC ___-_ barge, railroad carfioat
BCS _........ nested barge
BD .-.-.-. - crane, floating
BDL .-....-.- lighter, beach discharge
BG _-_-_- barge, liquid cargo, nonpropelled
BGI _-_---- barge, liquid cargo, inland waterways, nonpropelled
BK _-...... barge, dry cargo, nonpropelled
BKI _-.-.... barge, dry cargo, inland waterways, nonpropelled
BPL _-_---- barge, pier, nonpropelled
BR -------- barge, refrigerated, nonpropelled
BRI ----_- barge, refrigerated, inland waterways, nonpropelled
BRO .-.-.-. .- barge, oil
BSP _-.-.-.- barge, self-propelled
BSPI _-_-_ barge, self-propelled, inland waterways
BT -.---..- barge, training, nonpropelled
F _-_-_-_-.-. fireboat
FB _-_--_- ferryboat
FD _--.-.-. drydock, floating
FMS ------- repair shop, floating, marine repair, nonpropelled
FS _-------- freight and supply vessel, large (140 feet and over)
FSM $\qquad$ freight and supply vessel, medium (100 feet through 139 feet)

## 5-17. Vessel Deadweight Scale

a. Purpose. The vessel deadweight scale (fig. 5-17) is designed to furnish vessel tonnages and the effects of these tonnages on the mean draft of the vessel.
(1) Column A represents the number of long tons that may be carried in the vessel including fuel, stores, water, dunnage, and cargo, or any material that may be placed in the vessel, excluding equipment and machinery necessary for operation of the vessel.
(2) Column $B$ represents the vessel's mean draft in feet and inches. This scale is graduated from the least possible draft of 8 feet to a maximum draft of 29 feet.
(3) Column C (displacement tonnage in salt water) represents the weight of the ship plus any material in or on the vessel.
(4) Column D (tons per inch immersion) denotes the number of long tons required to lower the vessel 1 inch with any given draft.
b. Use. The deadweight scale is used by the cargo planner to determine the long tons that may be placed in a vessel to reach the required draft. For example, a vessel loaded with 9,000 long tons will have a mean draft of 25 feet $41 / 2$ inches at the beginning of the voyage and, using 50 long tons of fuel, stores, and water per day at sea, will have used 500 long tons through a period of 10 days, thus reducing the mean draft to 24 feet 6 inches. From these figures, the cargo planner can determine the vessel's draft at the completion of the trip, and he will know whether the draft is correct for the type of harbor where the cargo will be discharged.

## c. Cargo Deadweight Tonnage.

(1) In the deadweight column of the scale, the figure 0 is listed directly opposite the light ship weight. The figures above 0 indicate weight added to the vessel in the form of fuel, stores, and cargo. All weight placed in the vessel increases the ship's mean draft and, by adding 10,805 long tons to the light ship, the vessel is forced down in the water to a maximum mean draft of 28 feet $63 / 4$ inches for sailing in summer salt water.
(2) Certain complications may be involved in determining the cargo deadweight tonnage of the vessel. For instance, the ship may have a fixed ballast that is not entered in the deadweight scale. In such an event, the ship's officers add this to the number of tons of fuel, stores, and water that are on board. Also, they note the location of the ballast in the ship. This must be deducted from the deadweight tonnage, together with the fuel, stores, and water to give a correct cargo deadweight tonnage. When the vessel is at a mean
draft of 28 feet $68 / 4$ inches, summer ; salt water, it is in a condition known as displacement loaded, and, should weight in excess of 10,805 long tons be loaded in a light ship, it would be forced down in the water below the legal loadline for summer zone and would not be allowed to sail.
(3) To prevent overloading the vessel, the weight of the fuel, stores, dunnage, and water should be determined and deducted from the vessel deadweight tonnage to determine the maximum number of tons of cargo that may be placed in the vessel to bring it down to its marks.

## Section III. TERMINAL AND WATER TRANSPORT OPERATIONS

## 5-1.8. Elements of Terminal Planning

$a$. In the planning data for terminal and related water transport operations, the basic period of time is a 20 -hour working day. This is generally considered a complete round-theclock working day for terminal operations; it is based on two 10 -hour shifts. The remainder of the day is taken up in mealtime and shift changes. In forward areas, where enemy action may cause additional delays, 15 hours per day should be used as a planning figure. For general planning purposes, a transportation terminal service company (TOE 55-117) or its equivalent is considered capable of discharging 720 short tons per 20 -hour working day. See also paragraph 5-22.
b. The three elements normally considered in terminal planning are-
(1) Estimation of the existing terminal capacity or the total tonnage and personnel that can be received, processed, and cleared through the terminal in a day.
(2) Determination of the terminal workload required to support the particular operation, expressed as target cargo tonnage and number of personnel per day.
(3) Estimation of base development requirements necessary to increase the terminal capacity to meet the target tonnage, including requirements for construction, equipment, and personnel.

## 5-19. Terminal Capacity

a. Terminal throughout capacity is determined by three major factors. In all instances, one of these is the limiting and thereby the determining factor. For planning purposes, each of the three factors may be expressed in terms of short tons per day. All three factors should be accurately estimated even though the limiting factor may be obvious. These estimates indicate the facilities where improvement effort will yield the greatest return in terms of tonnage-movement capability. The three major factors are-
(1) Terminal reception capacity: the number and type of ships that can be moved into the harbor or coastal area of the terminal per day.
(2) Terminal discharge capacity: the number of tons of cargo and personnel that can be discharged in the terminal per day.
(3) Terminal clearance capacity: the amount of cargo and personnel that can be moved through and out of the terminal per day.
b. A checklist for terminal capacity estimation is given below. Further information and procedures for estimating terminal capacity are provided in FM 55-8, FM 55-51, and FM 101-10.

FM 55-15

Collect these data:

| Channel depths <br> Obstructions |  |  |  |
| :---: | :---: | :---: | :---: |
|  |  |  |  |
|  |  |  | Enemy air activity |
| Enemy surface activity |  |  |  |
| Enemy submarine activity |  |  |  |
| Climate and seasons |  |  |  |
| Weather and the characteristics |  |  |  |
| Minefields or contaminated areas |  |  |  |
| Capabilities in combating obstacles |  |  |  |
| Tactical dispersion requirements |  |  |  |
| Wharf facilities |  |  |  |
| Beach capabilities |  |  |  |
| Discharge rates ashore -... |  |  |  |
|  |  |  |  |
| Discharge rates in the stream <br> Anchorage area <br> Extent of destruction or contamination |  |  |  |
|  |  |  |  |
| Climate and seasons Weather and tide characteristics |  |  |  |
|  |  |  |  |
| Weather and tide characteristics -.-. Cargo-handling equipment available - |  |  |  |
|  |  |  |  |
| Floating craft and equipment available |  |  |  |
|  |  |  |  |
| Availability of local labor --... <br> Space reserved for local economy |  |  |  |
| Enemy activity |  |  |  |
| Capability of rail facilities |  |  |  |
| Capacity of highway facilities Capacity of inland waterway facilities |  |  |  |
|  |  |  |  |
| Capacity of inland waterway facilitiesCapacity of pipeline facilities |  |  |  |
| Capacity of pipeline facilities |  |  |  |
|  |  |  | Enemy activity |

## 5-20. Determination of Terminal Workload

The terminal workload is assigned by the theater commander and is the mission of a particular terminal. The mission assignment is a target tonnage based on the terminal's throughout capacity. Target tonnage consists of initial and anticipated tonnages. Initial tonnage is the amount of cargo the terminal organization is expected to handle before its capability is increased by base development. Anticipated tonnage is the amount of cargo required at a future specified date to support a particular operation and to build up a reserve supply for the support of future operations. When the target tonnage assignment is made, the terminal commander makes an estimate of the construction, equipment, and personnel required to increase the terminal capacity to handle the anticipated tonnage. The actual capability of the terminal is dependent upon its sustained ability to receive and clear the daily capacity over a period of time.

Compute these factors:
To determine:
(1) Evaluate to determine water terminal reception capacity.
(2) Evaluate to determine

Water terminal through put capacity.
(1) Classification of alongside berths.

|  | General |  |  |  | Tankèr |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Berth dimensions |  |  |  | Class | Berth dimensions |  |  |  |
|  | Length |  | Depth |  |  | Length |  | Depth |  |
|  | Feet | Meters | Feet | Meters |  | Feet | Meters | Feet | Meters |
| A | 565 | 172 | 31-30 | 9.4-9.1 | T-A | 600 | 183 | 34 | 10.4 |
| B | 460 | 140 | 29-23 | 8.8-7.0 | T-B | 525 | 160 | 31 | 9.4 |
| C | 350 | 107 | 22-18 | 6.7-5.5 | T-C | 450 | 137 | 26 | 7.9 |
| D | 250 | 76 | 17 | 5.2 | T-D | 250 | 76 | 14 | 4.3 |
| E | 200 | 61 | 13 | 4.0 |  |  |  |  |  |
| F | 100 | 30 | 7 | 2.1 |  |  |  |  |  |

(2) Anchorage berths.
(a) Anchorage berth diameter formulas. The following formula is used to find the diameter for anchorage berths:

$$
\frac{2(7 D+2 L)}{3}=\text { diameter in yards }
$$

where
$D=$ depth of water in feet
$L=$ length of vessel in feet
Note 1. Diameter in yar̀ds $\times 0.9144=$ diameter in meters.
Note 2: Bottom characteristics, landmarks, and underwater obstacles must be taken into consideration when selecting an anchorage sité.
(b) Classification of anchorage berths.

| Class | Yards | Diameter | Meiers | Feet | Depth of water |
| ---: | :---: | :---: | :---: | :---: | :---: |
| Meters |  | Type of vessel |  |  |  |

c. Wharf Capacity. Terminal capacity estimates are based on the use of all available wharf facilities. All facilities suitable for handling general cargo should be included in the estimate-for example, open or covered terminals, naval wharves, ship-repair and fittingout wharves, bulk-cargo wharves, and specialpurpose wharves. If the use of a particular wharf is doubtful and its capacity has been included in the estimate, a clarification should be given. Wharf capacity is materially affected by the factors discussed below.
(1) Type. The type of wharf must be considered by the analyst. The general term "wharf" includes both quays and piers. A quay is a wharf parallel with the shoreline of a basin or harbor with water and accommodations for ships on one side only. A pier is a wharf which projects into the harbor or basin
with water and accommodations for ships on both sides. There are several kinds of piers, such as T-head, L-head, and marginal.
(2) Layout. The analyst must also consider the layout of the facility. This includes adequacy of approaches, stacking space on the landward side, raised or depressed tracks, curbs, fences, deck surfacing material, transitshed space, number and size of transit-shed doors, and the depth of high and low water alongside.
(3) Weather. Weather, particularly during extreme conditions, has a direct bearing on the use of estimated capacity of a wharf.
(4) Alinement. The alinement of the face of the wharf is an important factor. The angle points and curvatures along the wharf face must be considered. If they are excessive, the
usable linear footage must be reduced appropriately.
(5) Deck.
(a) Load capacity. The load capacities of the wharf deck and of the transit shed floor are of prime importance. A rule-of-thumb method for determining the adequacy of the load capacity is the present use of the wharf. If it is known that a certain cargo is normally handled, a fair load-capacity evaluation may be made.
(b) Height. The height of the wharf deck must be considered in relation to the tidal rise. Generally, a wharf should be at least 5 feet ( 1.5 meters) above high-tide level.
(c) Working space. The working space is determined by the type of wharf, the length and width of the wharf apron, the wharf's decking, and its exits. The working space must be wide enough to allow general cargo to be unloaded and cleared without undue delay. Dimensions shown below can be used in planning. Local customs, specialized wharves, and unusual construction may permit variations in these figures.

1. Wharf length. For planning purposes, 100 feet ( 30 meters) of wharf is required for each hatch or each lighter to be discharged. The discharge rate (para 5-22) for ships and coasters is reduced 20 to 25 percent for each 100 -foot reduction in wharf length under the minimum required. In determining lighterage facilities, length more than 100 feet but less than the next 100 -foot unit is disregarded. For example, a 150 -foot (45-meter) wharf accommodates only one lighter; a 250 -foot ( 75 -meter) wharf accommodates two lighters, etc.
2. Wharf width. A wharf working area of at least 60 feet ( 18 meters) is necessary for proper cargo handling and shipside clearance when discharging from only one side of a wharf. When both sides of a wharf are used simultaneously, each side should have a 45 -foot (14-meter) working space.
(d) Depth alongside. Fluctuations in tide levels affect the discharge of cargo, especially where tidal variation is great and ships need the advantage of high tides to
reach their berths. If the wharves are not located in wet docks and if the tidal variations are extreme, the discharge-capacity estimate should be adjusted to reflect this condition. The effective terminal discharge capacity may be reduced as much as 50 percent if alongside depths are reduced below the operable minimum by the tidal range. Under normal conditions, the water should be at least 30 feet ( 9 meters) deep at low tide. (A minimum of 30 feet is used for planning purposes because this depth accommodates virtually all deep-draft dry-cargo vessels.)
(e) Physical condition. Physical condition must be considered when the usefulness of a wharf is evaluated, for deterioration or damage may limit its capacity.
d. Lighterage Discharge. Wharves used by lighters should be within a reasonable distance of a sufficient number of anchorages and moorings. Lighterage berths are assigned in units of 100 feet ( 30 meters) for each lighter (taken to the nearest 100 feet). The unit measurement must be used realistically-length of wharf more than 100 feet but less than the next 100 -foot unit is disregarded (a 350 -foot (107-meter) wharf accommodates three lightters at the same time). All alongside berths with depths of less than 18 feet ( 5.5 meters) are considered lighter berths.
e. Local Conditions. Conditions may vary with localities and sometimes may be very unusual. When necessary, berth, wharf, and lighter discharge factors must be adjusted or reduced to meet emergencies imposed by local conditions.

## 5-22. Discharge Rates

a. Commercial-Type Loading. For planning purposes, the average ship is considered to be 500 feet long and 60 feet wide with five hatches, the average coaster 350 feet long and 35 feet wide with four hatches, and the average lighter 100 feet long and 35 feet wide. This excludes landing craft and amphibians. The figures given below for ships and coasters in the steam indicate tonnage discharged from the ship or coaster into lighters. The limiting factors are the number of lighters available
and the wharf space provided for their discharge. Number of lighters required is based upon the number of hatches, the size of the lighters, and the turnaround time. The following discharge rates are based on average sizes of the type of vessels indicated.
(1) Average ship, alongside or in stream720 short tons or 643 long tons per 20 -hour day.
(2) Average coaster, alongside or in stream- 500 short tons or 446 long tons per 20-hour day.
(3) Average lighter alongside wharf180 short tons or 160 long tons per 20 -hour day.
b. Specialized Loading. When maximum unloading efficiency is the governing factor rather than economy of cargo space, the principles of combat loading should be employed. For this specialized loading, mixture of cargo types within ships' holds should be kept to a minimum, and each hatch must be self-sustaining.
(1) Stowage of cargo should be blocked vertically in each hatch; this saves time by reducing the number of times the cargo gear must be rerigged or shifted. Within each cargo space, drafts of cargo should be palletized, netted, or containerized; they should not be tiered unless MHE is available to move cargo from the wings to the hatch square. When cargo is palletized, at least four pallets in each hatch square should have birdles intact so that no time will be wasted in breaking the stowage.
(2) Vehicles should not be floored over and tiered, even if space is available, as bulling vehicles to the square on the upper tier and clearing the flooring and shoring is time consuming. So far as possible, trailers should be stowed with their prime movers. Unit cargo may be loaded in vehicles to the lowest reducible height if the cargo-gear capacity is not exceeded. Powered vehicles must be in running condition with fuel tanks three-quarters full.
(3) Unloading time for each hatch is computed at time of prestowage, using a profile loading diagram (fig. 5-18) for the ship. The
profile loading diagram may be filled out from the information in the storage plan. Time factors for hatch opening, shift of gear, and all drafts are added to obtain the total unloading time for each hatch. This total is entered in the tabulation for the hatch on the profile loading diagram.
(4) Rig and boom capacities differ among hatches for each design of cargo vessel. In general, 5 -ton booms are installed to serve each hatch and one or more hatches are also served by jumbo booms of from 30 - to 60 -ton capacity. The limiting load factor of the rig is the safe working load of the wire rope multiplied by the number of parts. The normal safe load for a single-rigged yard-and-stay rig is $6,600 \mathrm{lb}$ for $5 / 8^{\prime \prime}$ wire and $8,000 \mathrm{lb}$ for $3 / 4^{\prime \prime}$ wire (improved plow steel) in good condition. Heavier weights must be lifted by doubled yard-andstay rigs, swinging booms, four-boom rigs, or jumbo booms.
(5) Average weights of drafts:
(a) Palletized general cargo-1 STON
(b) Palletized ammunition- $11 / 2$ STON
(c) CONEX-5 STON
(d) Vehicle weights depend upon type and preloading.
(6) Unloading time can be computed by using the following factors as guidance:
(a) Single-rigged yard-and-stay, 5 minutes per draft (pallets, $1 / 4$-ton trucks and trailers, $11 / 2$-ton trailers, empty $3 / 4$-ton trucks).
(b) Doubled yard-and-stay, or doublepurchase swinging-boom rig, 10 minutes per draft (CONEX, empty $21 / 2$-ton truck).
(c) Jumbo-boom rig, 15 minutes per draft (vehicles heavier than $21 / 2$-ton truck, APC, tanks).
(d) To open hatch, 15 minutes average ( 25 minutes for weatherdeck hatch; 10 minutes for 'tween-deck hatch).
(e) To shift rig, 30 minutes.
(7) Unloading time estimates for specially equipped vessels, such as roll on/roll off and LPH equipped with special ramps, elevators, pallet conveyors, monorails, or other devices, must be developed from experience gained during loading or from records kept on the vessel.


Figure 5-18. Profile loading diagram.
(8) Detailed guidance on combat loading, commodity loading, and selective loading is contained in FM 60-30. Loading diagrams for U.S. Navy Amphibious Force vessels, as well as standard maritime commission design vessels should be secured from the combat cargo officer assigned to an individual vessel. It will be found that while these vessels may be of the same design, their loading capacity for each hold will differ.

## 5-23. Temporary Storage Areas

To plan for temporary storage areas for cargo, use the figures given below.
a. Open Storage. Approximately 10,000 square feet of open storage area is required for each 560 short tons, or 500 long tons, or 1,000 measurement tons of cargo. Average stack height should be 6 feet.
b. Covered Storage. Approximately 8,000 square feet of covered storage area is required
for each 560 short tons, or 500 long tons, or 1,000 measurement tons of cargo. Average stack height should be 8 feet. Generally, 10 percent of 1 day's target tonnage will require covered storage.

## 5-24. Personnel and Equipment Requirements

For planning purposes, one terminal service company (TOE 55-117) or its equivalent in personnel and equipment is required for each ship berth in a water terminal or for each 720 short tons of the terminal's daily capacity. Paragraph 5-21 lists the factors for determining ship berth space.

## 5-25. Estimating Water-Terminal Capacity

The following example demonstrates the recommended procedure for estimating waterterminal capacity based upon the steps and data outlined in the preceding paragraphs and using the habor chart shown in figure 5-19.
a. Wharf Facilities.

| Wharf No | Length |  | Width |  | Minimum depth |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Feet | Meters | Feet | Meters | Feet | Meters |
| 1 | 1,060 | 323 | 80 | 24.4 | 32 | 9.8 |
| 2 | 490 | 150 | 60 | 18.3 | 30 | 9.2 |
| 3 | 580 | 177 | 90 | 17.4 | 30 | 9.2 |
| 4 | 535 | 163 | 100 | 30.5 | 34* | 10.4* |
| 5 | 125 | 38 | 54 | 16.5 | 8 | 2.4 |
| 6 | 295 | 90 | 60 | 18.3 | 15 | 4.6 |
| 7 | 450 | 137 | 75 | 22.9 | 22 | 6.7 |
| 8 | 210 | 64 | 60 | 18.3 | 16 | 4.9 |

*Each side.
b. Anchorage Areas.
(1) There is sufficient area inside the harbor to anchor three ships where they can be worked continuously.
(2) In good weather, two vessels can be anchored and worked outside the breakwater.
(3) Winds, swells, tides, and tidal currents present no unusual problems.
c. Discharge Tonnage.
(1) At deep-draft wharfage.

| Wharf No. | Victory ship berths | Discharge rate (STON per day) |
| :---: | :---: | :---: |
| 1 | 2 | $2 \times 720=1,440$ |
| 2 | 1 | $1 \times 720=720$ |
| 3 | 1 | $1 \times 720=720$ |
| 4 | 2 | $2 \times 720=1,440$ |
| Total |  | ----------4,320 |



Figure 5-19. Harbor chart for terminal capacity estimation.
(2) At lighterage wharves.

| Wharf No. | Lighter berthe | Discharge rate (STON per day) |  |
| :---: | :---: | :---: | :---: |
| 5 | 1 | $1 \times 180=$ | 180 |
| 6 | * 3 | $3 \times 180=$ | 540 |
| 7 | 4 | $4 \times 180=$ | 720 |
| 8 | 2 | $2 \times 180=$ | 360 |
| Total |  |  | 1,800 |

Wharf No. 6 is only 295 feet long. In paragraph 5-21. three lighters require 300 feet. However, the 5 -foot shortage will not affect operations appreciably if three lighters are docked here.
(3) Alternate method. If only the total length of wharfage is known, this length in feet may be multiplied by 1.2 for alongside discharge and by 1.4 for lighterage discharge. The quantities thus obtained are conservative planning figures; they are expressed as long tons discharged per day.
d. Rate of Discharge From Ships at Anchor to Lighters. According to the chart, three ships can be anchored inside the breakwater, and two can be anchored and worked outside the breakwater in good weather. Therefore, in good weather, cargo can be discharged from ships to lighters at the rate of $(3+2) \times 720$ $=3,600$ short tons per day.
e. Summary of Daily Terminal Capacity.
(1) Discharged alongside deep-draft wharves-4,320 short tons per day.
(2) Discharged from lighters to wharves $-1,800$ short tons per day.
(3) Transferred from ships to lighters3,600 short tons per day.
(4) The maximum discharge per day is 1,800 short tons because lighter wharfage is the limiting factor (para 5-19a). Therefore, the total daily terminal capacity is 6,120 short tons: 4,320 short tons alongside; 1,800 short tons by lighter.
f. Personnel and Equipment Requirements. Personnel and equipment requirements to maintain the above daily tonnage figure may be determined by dividing 6,120 short tons by 720 short tons (daily terminal service company discharge capability). Therefore, nine terminal service companies (TOE 55-117) or their equivalent in personnel and equipment and the necessary lighterage support will be
required to maintain the discharge capacity of this terminal.
g. Weather Considerations. Advance study must be made to determine the probable effect of bad weather on the rate of discharge and other factors in water terminal capacity. Continuous records of daily discharge plotted against weather and surf conditions prove valuable in planning future discharge at the same and similar terminals.

## 5-26. Inland Waterways Service

$a$. The use of inland waterways for military purposes is normally envisaged only in underdeveloped areas in which alternate modes are either lacking or insufficient. These waterways are to be used principally for civilian traffic and for the restoration of the local economy. Further, it is assumed that rehabilitation of these waterways will be undertaken by local authorities and that a minimum of military effort will be diverted for the purpose, except where designated for immediate military use and equipment salvage. Inland waterways can be used to relieve the pressure on other modes of transportation; they are especially useful for moving nonperishable supplies.
b. When required, an inland-waterway service may be formed to control and operate a waterway system, to formulate and coordinate plans for using inland-waterway transport resources, and to provide for the integration and supervision of local civilian facilities used in support of military operations. This operational organization may vary in size from a single barge crew to a complete inland-waterway service, depending upon the requirements. It may be composed entirely of military personnel or may be manned by local civilians supervised by military units of the appropriate transportation staff section.
c. Although an inland-waterway service may be operated by a terminal command, a terminal battalion composed of appropriate terminal service, harbor craft, boat, and/or amphibian units will most often be employed in this capacity. A typical inland-waterway organization is shown in figure 5-20.

ORGANIZATION FOR TRANSPORTATION INLAND WATERWAYS SERVICE


Figure 5-20. Organizational chart, transportation inland waterways service.

## 5-27. Characteristics Affecting Inlandwaterway Capabilities

When determining the capability of an inland waterway, the following must be considered:
a. Restricting widths and depths of channel.
b. Vertical and horizontal bridge clearance.
c. Location of dams and other bars to navigation.
d. Location of locks, dimensions, and timing.
e. Seasonal floods and droughts, their frequency and duration.
$f$. Normal freezeup and opening dates.
g. Hazards to navigation, such as rapids and falls.
$h$. Speed and fluctuation of current.
$i$. Waterway maintenance requirements.
$j$. Changes of channel.

## 5-28. Waterway Capacity Estimates

a. Limiting Factors. Factors, other than waterway characteristics, which limit waterway capacity are-
(1) Availability of suitable barges or craft.
(2) Availability of suitable operating personnel.
(3) Availability and adequacy of terminals and terminal facilities.
b. Turnaround Time. This factor is defined as the time required for a barge or craft to load, travel to destination, unload, return to origin, and be ready to resume loading. It has considerable effect on waterway capacity and involves:
(1) Length of haul, taken as round trip distance.
(2) Speed in still water-4 miles per hour (3.4 knots or 6.43 Kmph ).
(3) Speed and direction of current.
(4) Loading and unloading time-computed at 8.4 short tons per barge per hour.
(5) Time consumed in locks.
(6) Operating hours per day-normally taken as 20, allocating the remaining 4 for maintenance, refueling, restoring, etc.
c. Capacity Determination, Craft Available to Fill or Exceed Waterway Capacity. When
sufficient barges or craft are available to fill or exceed waterway capacity, the daily tonnage that may be moved over the waterway is equal to one-half the number of craft per day that can be passed through the most limiting constriction (for example, a lock, lift bridge, narrow channel, etc.) times the average net capability of the craft in use.
d. Capacity Determination, Craft Not Available to Fill or Exceed Waterway Capacity. The following formula may be used to determine the number of tons a given number of barges can transport a given distance daily:
Number of barges $\times$ tons per barge
$\times$ hours of operation per day
Turnaround time in hours $=$ Tons moved daily
Example: Determine the daily tonnage 20 barges of 270 short tons capacity each can move 60 miles forward with no lost time in locks and negligible effect due to current.

Travel time per barge $=\frac{2 \times 60}{4}=30$ hours
$\begin{gathered}\text { Loading and unloading } \\ \text { time per barge }\end{gathered}=\frac{2 \times 270}{8.4}=64.3$ hours
Turnaround time per barge $=30+64.3=94.3$ hours
20 barges $\times 270$ tons per barge
$\frac{\times 20 \text { hours daily availability }}{94.3 \text { hours turnaround time }} 1,145.3$ short tons daily

## 5-29. Floating Craft Requirements

a. Cargo Craft. To determine the number of barges or cargo craft required to move a given tonnage a given distance forward daily, use the following formula:

$$
\begin{aligned}
& \text { Daily tonnage } \times \text { hours } \\
& \text { turnaround time } \\
& \frac{\text { Tons per barge } \times \text { hours }}{\text { of operation daily }}
\end{aligned}=\text { Number of barges required. }
$$

Example: Determine the number of barges having a capacity of 500 short tons required to move 1,000 short tons daily a distance of 100 miles forward, assuming no lost time in locks and negligible effect due to current.

Travel time per barge $=\frac{100+100}{4}=50$ hours

Loading and unloading time per barge $=\frac{2 \times 500}{8.4}$ $=119$ hours
Turnaround time per barge $=50+119=169$ hours

$$
\frac{\begin{array}{c}
1,000 \text { tons daily } \times 169 \text { hours } \\
\text { turnaround time }
\end{array}}{\frac{500 \text { tons per barge } \times 20 \text { hours }}{\text { daily operation }}}=\frac{16.9 \text { barges }}{\text { barges required. }} 17
$$

b. Tugs and Towboats. Since a single tug or towboat can normally be used to tow more than one barge and since loading time is not a consideration in tug or towboat availability, it follows that fewer tugs than barges will be required in any given situation. To determine the number of tugs or towboats required to efficiently operate a given number of barges in a given situation, use the following formula:

> Total number of barges $\times$ turn-
> around time for tugs in days
> Number of barges per tow $\times$ turn-
> around time for barges in days

Example: Determine the number of tugs required to operate 400 barges, when each tow consists of 5 barges, turnaround time for barges is 4 days, and turnaround time for tugs is 2 days.
$\left.\frac{400 \text { barges } \times 2 \text { days tug }}{\text { turnaround }} \frac{\text { tur }}{5} \begin{array}{l}\text { barges per tow } \\ \text { turnaround }\end{array}\right) 40$ tugs required.
c. Adequacy of Terminal Facilities. Port facilities include berthing space and cargo handling equipment. Generally, lack of terminal facilities does not restrict inland waterway movement, for usually temporary berthing facilities can be constructed. Without mechanical handling facilities, general cargo can be handled at the rate of 10 tons per hour per barge. With forklifts, at least 30 tons per hour per barge can be handled. Nevertheless, when existing port facilities are inadequate and additional facilities cannot be improvised, the existing port facilities may be the most restrictive factor in the entire movement. In such a case, the capacity of port facilities determines the inland-waterway movement capability. This problem cannot be solved by using formulas; its solution requires careful analysis and sound judgment.

## 5-30. Inland Terminal Capacity

Checklist for estimation of inland terminal throughput capacity.*

Collect these data:


## Transit sheds, yards, and areas

Local labor available
economy

Capacity of highway facilities

Compute these factors:
To determine:

1) Evaluate to determine inland terminal reception capacity.
(3) Evaluate to determine inland terminal clearance (output) capacity.

## 5-31. The United States Inland-Waterway System

a. General. Practically all of the navigable inland waterways of the United States are either on or east of the Mississippi River. Those west of the Mississippi are along the Texas gulf coast, the Missouri River, Sacramento River in California, Columbia River in Oregon, and Puget Sound in Washington. The inland waterways support approximately 8 percent of the total freight moved commercially in the United States. Of the approximately 50,000 persons employed, about two-thirds are vessel personnel. Excluding the Great Lakes system, the inland-waterway service uses over 5,000 propelled and 14,000 nonpropelled vessels. Typical cargo carried on these waterways is shown below.
Percent ofType of eargototal cargo
Seashells ..... 5.27
Animal products (inedible) ..... 22
Grain and grain products ..... 1.34
Coffee, raw or green ..... 04
Sugar ..... 23
Molasses ..... 23
Soybeans ..... 32
Logs ..... 5.35
Lumber and lumber products ..... 49
Pulpwood ..... 48
Woodpulp ..... 10
Paper and paper products .....  31
Anthracite coal ..... 30
Bituminous coal and lignite ..... 25.00
Coke ..... 14
POL ..... 34.50
Building cement ..... 48
Clays and earths .....  51
Sulphur ..... 72
Percent ofType of eargo
Limestone ..... 81
Salt ..... 09
Sand, gravel, crushed rock ..... 13.30
Iron and steel ..... 2.43
Aluminum ores and scrap ..... 05
Copper ores and scrap ..... 09
Construction and mining machinery ..... 09
b. Depths, Navigable Distances, and Average Freight for Principal Waterways. ${ }^{1}$


[^30]c. Important Waterways, Terminals, Critical Distances, Depths, and Cargo. The table below gives general planning information for inland-waterway transportation in the United States. Some of the important waterways and terminals are shown, and typical commercial cargo is included since this could be of interest to a strategic planner. When a move on an inland waterway is contemplated, the planner should obtain a large-scale hydrographic map and plan the move in detail.



9 feet for improved portion, Pittsburgh, to above East Brady, 72 miles ( 116 km ); no specific depths for open channel portion (unimproved) above East Brady.

Coal, coke, sand, gravel, POL and POL products, glass, furnace slag, lignite crushed rock, nonmetallic minerals and products, iron and steel, iron ore, industrial chemicals.

Black Warrior, Warrior, and Tombigbee River System.

Principal terminals
Norfolk, Va., Elizabeth City, N.C., Washington, N.C., Wilmington, N.C., Georgetown, S.C.,
Charleston, S.C., Savannah, Ga., Jacksonville,
Fla., Palatka, Fla.
Sanford, Fla., St.
Augustine, Fla.,
Daytona Beach, Fla.,
West Palm Beach,
Fla., Miami Beach, Fla.

Critical distances
The main route extends 1,262 miles ( $2,300 \mathrm{~km}$ ) from Norfolk to Key West, Fla., with a $65-$ mile $(104.5 \mathrm{~km})$ alternate channel, known as the Dismal Swamp Canal Route (west of, and generally parallel to, the main route) extending south from Norfolk, through the Southern Branch of Elizabeth River, Deep Creek, Dismal Swamp Canal, Turners Cut, and Pasquotank River to its junction with the main route at the mouth of the Pasquotank River on Albemarle Sound, N.C.

Brimingham, Ala.,
Tuscaloosa, Ala.
Demopolis, Ala., Mobile, Ala.

The Black Warrior and Warrior Rivers, a single stream, rise in northern Alabama above Birming-
(1) Main route: 12 feet from Norfolk, to the Va.-N.C. state line, 27 miles (43.3 km ) ; 10 feet from Va.-N.C. line to Little River, S.C., at N.C.-S.C. state line, 308 miles ( 496 km ); 10 feet from Little River to Port Royal Sound, S.C. (near Beaufort), 210 miles ( 338 km); 9 feet from Port Royal Sound, to Fernandina, Fla. (Cumberland Sound), 165 miles ( 266 km) ; 12 feet from Fernandina to St. John River, Fla. (Jacksonville), 22 miles 35.4 km ); 12 feet from Jacksonville to Eau Gallie, Fla., 198 miles ( 319 km ), except for several shoals with limiting depth of 7.8 feet; 8 feet from Eau Gallie to Miami, 174 miles ( 280 km ) ; 6.5 feet from Miami, to Cross Bank, Fla., 64 miles ( 103 km ); 5 feet from Cross Bank to Key West, Fla., 94 miles (151 km ).
(2) Dismal Swamp Canal route: 8.6 feet in Deep Creek, Va., 3 miles ( 4.83 $\mathrm{km})$; 6.7 feet in Dismal Swamp Canal, Va. and N.C., 22 miles ( 35.4 km ); 9.2 feet in Turners Cut, N.C., 5 miles ( 8.05 km ); and 9.4 feet in Pasquotank River, N.C., 35 miles (56.4 km ).
9 feet from Mobile to Mile 444.6 on Mulberry Fork, Mile 447.6 on Sipsey Fork, and Mile 420.6 on Locust

Logs, paper, pulp, sand, gravel, fish, POL and POL products, fertilizer, pulp, acid phosphate, paperboard and pulpboard, seafood, seashells, automobiles, grain and grain products, sugar, soybeans, limestone, salt, iron and steel, industrial chemicals.

Iron ore, manganese ore, sulphur, coal, POL and POL products, clay and bentonite, logs, stone and

| Calumet-Sag Channel | Blue Island, Ill -....-. | 23.8 miles ( 38.3 km ) from its junction with the Chicago Sanitary and Ship Canal to Blue Island, the Little Calumet Rivers to Turning Basin No. 5. |
| :---: | :---: | :---: |
| Chesapeake Bay system (James, York, Rappahannock, and Potomac Rivers) | Norfolk, Va., Newport News, Va., Richmond, Va., Fredericksburg, Va., Washington, D.C., Baltimore, Md., Cumberland, Md. |  |
| Columbia River | Astoria, Ore., Vancouver, Wash., Portland, Ore., The Dalles, Ore., Kennewick, Wash., Rickland, Wash. | Mouth to Canadian border, 745 miles ( $1,200 \mathrm{~km}$ ). |

ham and unite with the Tombigbee River at Demopolis. From there the Tombigbee flows south, uniting with the Alabama River to form Mobile River 45 miles ( 72.4 km ) above the head of Mobile Bay The distance by water from Mobile to the vicinity of Birmingham is about 415 miles ( 668 km ).
23.8 miles ( 38.3 km ) from cago Sanitary and Ship Canal to Blue Island, the Little Calumet Rivers to Turning Basin No. 5.

Columbia River $\qquad$
, Ore, Vancouver, The Dalles, Ore., Kennewick, Wash Rickland, Wash.

Fork of the Black Warrior River.

9 feet for entire length --- -
Grain and grain products, soybeans, coal and lignite, POL and POL products, sulphur, sand, gravel, crushed rock, iron and steel, manganese, iron ore.
Logs, paper pulp, POL, fish, fertilizer, seashells, seafood, phosphate, pulpwood, automobiles, coal, coke, sand, gravel, sugar, lumber and shingles, lignite, sulphur, nonmetallic minerals, iron and steel, sulphuric acid, industrial chemicals, paper and paper products, naval stores.
Grain and grain products, coal tar products, vegetables and fruits, sawmill products, sand and gravel, coal, seafood, stone and rock, POL and POL products, sulphur, logs, hogged fuel, lumber, shingles and lath, iron and steel articles, iron and steel pipe and fittings, woodpulp, newsprint paper, printing paper, paper and paper products, wrapping paper, canned foods, cement, salt, crushed rock, chemicals and chemical products.

| Cumberland River | Burnside, Ky., Celina, Tenn., Nashville, Tenn., Eddyville, Ky. | 693 miles ( $1,115 \mathrm{~km}$ ) from junction of Poor and Clover Forks in Harlan County, Ky., to the mouth near Smithland, Ky., on the Ohio River; 55 miles ( 88.5 km ) from Wolf Creek Dam to Burnside, Ky., 194 miles ( 312 km ) are navigable. |
| :---: | :---: | :---: |
| Delaware River | Wilmington, Del., Philadelphia, Pa., Trenton, N.J. | 128.4 miles ( 207 km ) from Trenton to mouth at Delaware Bay (including auxiliary channel east of Burlington Island extending from main channel to East Burlington, 1.4 miles ( 2.25 km ) ) . |

## Controlling depthe <br> for specified locotions

Lock and Dam, Ore. (Mile 292); 12 feet at McNary Lock and Dam; 24 to 92 feet from McNary Lock and Dam to Kennewick Wash. (Mile 328) ; from
Kennewick to Canadian
border depths are variable due to regulation of reservoirs.
9 feet from mouth to Nashville, 194 miles ( 312 km ); 6 feet from Nashville to Niagara Shoals, 137.4 miles ( 221 km ); less than 1 foot, Niagara Shoals to Wolf Creek Dam, 129.3 miles ( 208 km ); 9 feet at Wolf Creek Dam.

9 feet from Pennsylvania Railroad bridge at Trenton to Trenton Marine Terminal, 1.3 miles ( 2.09 km ); 12 feet from Trenton Marine Terminal to upper end of Newbold Island, 5.5
miles ( 8.85 km ); 23 feet from upper end of Newbold Island to Philadelphia Harbor, 23.7 miles ( 38.2 km ) ; 27 feet (east side of channel) to 30.8 feet (west side of channel) through Philadelphia Harbor, 10.5 miles ( 16.9 km ); 35 feet from Philadelphia Navy Yard to mouth, 86 miles ( 138.5 km ). Auxiliary channel-18 feet, 1.4 miles ( 2.25 km )
5.5 feet for entire distance of both rivers- 228 miles ( 367 km ).

Typical cargo

Sand, gravel, sulphur, fluorspar, railroad ties, POL and POL products, sugar, molasses, coal, lignite, limestone, crushed rock, iron, steel.

POL and POL products, glass, furnace slag, coal, coke, sand, gravel, grain and grain products, canned foods, sugar, molasses, soybeans, lumber and lumber products, woodpulp, paper and paper products, clays and earths, gypsum, sulphur, crushed rock, nonmetallic minerals, iron ore and concentrates, iron and steel, chrome, nonferrous ores and metals, coal-tar products, sulphuric acid, industrial chemicals, fertilizer and fertilizer and fertilizer minerals.

[^31]Gulf intracoastal
waterway.

Houston Ship Channel.

St. Marks, Fla., Carrabelle, Fla., Panama City, Fla., Pensacola, Fla., Mobile, Ala., New Orleans, La., Lake Charles, La., Port Arthur, Tex., Orange, Tex., Beaumont, Tex., Galveston, Tex., Texas City, Tex., Baytown, Tex., Houston, Tex., Port Lavaca, Tex., Corpus Christi, Tex., Port Isabel, Tex., Brownsville, Tex.

Houston, Tex., Galveston, Tex.
ren River- 30.1 miles
( 48.5 km ) from mouth (Mile 149.5 ( 241 km ), Green River) to Bowling Green.
The main route extends 1,116 miles ( $1,795 \mathrm{~km}$ ) from St. Marks River to the Mexican border at Brownsville, Tex., with a $55-$ mile ( 88.5 km) arm, known as the Plaque Mine-Morgan City Alternate Route, from the Mississippi River at Plaque Mine, La. ( 113 miles ( 182 km) above New Orleans) to the main route at Morgan City, La. ( 100 miles ( 161 km ) west of New Orleans).

52 miles ( 83.6 km ) from Galveston, across Galveston Bay through the San Jacinto River and Buffalo Bayou, with a light draft extension channel 7 miles ( 11.3 km ) long from the Turning Basin to mouth of White Oak Bayou at Main Street, Houston, and a
(1) Main route: 12 feet from St. Marks River to Pensacola Bay, 245 miles ( 394 km) ; 10.5 feet from Pensacola Bay to Mobile Bay, 46 miles ( 74 km ); 11 feet from Mobile Bay to New Orleans, 134 miles ( 216 km ) ; 12 feet from Mississippi River to Calcasieu River, La., 239 miles ( 385 km); 17 feet from Calcasieu River to Sabine River, Tex., 27 miles ( 43.4 km); 11 feet from Sabine River to Galveston, 90 miles ( 145 km ); 10.9 feet from Galveston to Freeport, Tex., 42 miles ( 67.6 km); 11 feet from Freeport to Port O'Connor, Tex., 79 miles ( 127 km ); 11.6 feet from Port 0'Connor to Port Aransas, Tex., 61 miles ( 98.2 km ); 10 feet from Port Aransas to Brownsville, 153 miles ( 246 km ).
(2) Plaque Mine-Morgan City route: 9 feet for entire 55 miles ( 88.5 km ).
36 feet in Houston Ship Channel; 36 feet in Turning Basin; 10 feet in extension to White Oak Bayou; 10 feet in branch behind Brady Island.
crushed rock, iron and steel.

Seashells, coal, POL and POL products, iron and steel articles, iron and steel pipe and fittings, sulphur, acids, machinery and machines, clay, pulpwood, chemicals, alcohol, sugar, limestone, logs, salt, grain and grain products, molasses, soybeans, paper and paper products, lignite, cement, clays and earths, sulphur, sand, gravel, crushed rock, coal-tar products, industrial chemicals.

Seashells, grain and grain products, coffee, molasses, cotton, newsprint paper other paper and paper products, coal and lignite, POL and POL products, cement, clays and earths, sulphur, sand, gravel, crushed rock, iron and steel, coal-tar products,

## Critical distances

branch channel in the old channel of Buffalo Bayou behind Brady Island.

Hudson River .-......
New York, N.Y., Tarrytown, N.Y., Waterford, N.Y., Poughkeepsie, N.Y., Albany, N.Y., Troy, N.Y.

Grafton, Ill., Pekin, Ill., Peoria, Ill., Chicago, Ill.

## 155 ( 249 km ) miles from New York City (Battery) to Waterford.

Illinois waterway -...
Ininois waterway ---

Kanawha River $\qquad$

Henderson, W.Va., Point Pleasant, Va.

Controlling depth
for specified
locations

40 feet from New York City (Battery) to Spuyten Duyvil Creek. 13 miles ( 20.9 km ) ; 27 feet from Spuyten Duyvil Creek (Harlem River) to Albany, 131 miles ( 211 km ); 14 feet to Waterford, 11 miles ( 17.7 km ).

9 feet in the Illinois River from its mouth on Mississippi River at Grafton to Lockport, 291 miles ( 469 $\mathrm{km}) ; 16.8$ feet in the Chicago Sanitary and Ship Canal from Lockport to Damen Avenue, Chicago, 30 miles ( 48.3 km ); 21 feet in the Chicago river (South Branch) from Damen Avenue to Lake St., Chicago; 4.5 miles ( 7.24 km ); and 9 feet in the CalumetSag Channel from its junction with the Chicago Sanitary and Ship Cana to Blue Island, Ill., to Little Calumet and Calumet Rivers to Turning Basin No. 5, 23.8 miles ( 38.3 km ).

9 feet for the 90 miles ( 145 km ) above mouth.
Typical cargo
carried
commereially carried
commercially
sulphuric acid, industrial chemicals, fertilizer and fertilizer materials.

Copper ore and concentrates, sand and gravel, sugar, coal, lumber, shingles and lath, stone and rock, POL and POL products, coaltar, copper, syrup and molasses, woodpulp, grain and grain products, automobiles, cement, brick.

Newsprint paper, other
paper and paper products, sulphur, sand, gravel, iron and steel articles, grain and grain products, coal, POL and POL products, phosphate rock, chemicals, sugar, iron and steel scrap, limestone, cement, soybeans, molding sand, molasses, lignite, crushed rock, coal-tar products, fertilizer and fertilizer materials.
its jug Channel from its junction with the Chicago Sanitary and Ship Canal to Blue Island, Ill., the Little Calumet and Calumet Rivers to Turning Basin No. 5, 23.8 miles ( 38.3 km ).

97 miles ( 156 km ) from junction of New and Gauley Rivers in W.Va. to mouth at Point Pleasant on Ohio River. The navigable portion extends 90 miles ( 145 km ) upstream from mouth.

Sand and gravel, coal, coke, POL and POL products, sulphur, acids and other chemicals, furnace slag, alcohol, iron and steel, coal-tar products.

| Kentucky River $\ldots . . .$. | Beattyville, Ky., Carroll- <br> ton, Ky. |
| :---: | :---: |
| Mississippi River ..... |  |
|  | Minneapolis, Minn., |
|  | St. Paul, Minn., St. |
|  | Louis, Mo., Cairo, Ill., |
|  | Memphis, Tenn., Vicks- |
|  | burg, Miss., Baton |
|  | Rouge, La., New |
| Orleans, La. |  |

258.6 miles ( 416 km ) from where it is formed by the confluence of the north and middle forks, about 4 miles ( 6.44 km ) east of Beattyville to mouth at Carrollton.

2,350 miles ( $3,780 \mathrm{~km}$ ) from its source in Lake Itasca in central Minnesota to the Gulf of Mexico ( 513 miles ( 826 km ) from Lake Itasca to Minneapolis, 853 miles ( $1,373 \mathrm{~km}$ ) from Minneapolis to mouth of Ohio River, 964 miles ( $1,550 \mathrm{~km}$ ) from mouth of Ohio River to Head of Passes, La., and 20 miles $(32.2 \mathrm{~km})$ from Head of Passes to Gulf of Mexico through Southwest Pass).

Sioux City, Iowa, Omaha, Neb., Council Bluffs, Iowa, St. Joseph, Mo., Kansas City, Kans., Kansas City, Mo., Independence, Mo., Jefferson City, Mo., St. Louis, Mo.
,464 miles ( $3,960 \mathrm{~km}$ ) from junction of the Jefferson, Madison, and Gallatin Rivers at Three Forks, Mont., to the mouth which enters the Mississippi River 17 miles ( 27.4 km ) above St. Louis. Regular commercial navigation only on the portion improved for navigation from Sioux City to the mouth, 762 miles ( $1,225 \mathrm{~km}$ ), consisting of two sections: 376 miles ( 606 km ) from Sioux City to the upper end of Quindaro Bend near

6 feet for entire length $\ldots$...
Sand, gravel, crushed rock, gasoline and other motor fuels, coal and lignite.

Commercial navigation above Minneapolis is prohibited by insufficient depths. From Minneapolis to the Gulf ( 1,837 miles ( 2,960 $\mathrm{km})$ ), the following controlling depths prevail: 9 feet, Minneapolis to Baton Rouge, 1,588 miles ( 2,560 km); 35 feet, Baton Route to Head of Passes, 229 miles ( 369 km ); and 40 feet from Head of Passes through Southwest Pass to the mouth of the Pass (Gulf of Mexico), 20 miles ( 32.2 km ).

9 feet from mouth to mouth of Big Sioux River at Sioux City, 762 miles ( $1,225 \mathrm{~km}$ ) ; $11 / 2$ to $21 / 2$ feet from mouth of Big Sioux to Fort Benton, Mont.

Coffee, sugar, molasses, syrup and honey, rubber, vegetable fibers, aluminum ore, alloys and scrap, grain and grain products, oilseeds (except flaxseed), cotton and cotton linters, sawmill products, sulphur, salt, POL, iron and steel products, fertilizer and fertilizer materials, soda products, alcohol, other chemicals, seashells, bauxite ore, sand and gravel, coal, logs and lumber, iron and steel pipe and fittings, machinery, automobiles, cement and concrete products, brick, bags and bagging, iron and steel scrap.

Grain and grain products, soybeans, molasses, logs, POL and POL products, sand, gravel, crushed rock, iron and steel, waterway improvement material, metal products and parts, wood posts, poles and piling, machinery and machines.

Monongahela River

New York State Barge Canal.

Pittsburgh, Pa., Fairmont, W.Va.

Critical distances
Kansas City, Mo., and 386 miles ( 622 km ) from Kansas City to the mouth.
128 miles ( 206 km ) from its formation by the junction of the Tygart and West Fork Rivers (about 1 mile south of Fairmont) to mouth at Pittsburgh.

There are 522 miles ( 840 km ) of waterways as follows: (1) Erie Canal from Waterford on the Hudson River to Tonawanda on the Niagara River, 338 miles ( 544 km ) ; (2) Oswego
Canal from Three Rivers
Point, N.Y., (on Erie
Canal 160 miles ( 258 km ) west of Waterford) to Oswego on Lake Ontario, 24 miles ( 38.6 km ); (3) Cayuga and Seneca Canals, 90 miles ( 145 km ), connecting with the Erie Canal near the confluence of the Seneca and Clyde Rivers; (4) Champlain Canal from Waterford, on the Hudson River (entrance to Erie Canal) to Whitesall at the south end of Lake Champlain, 60 miles ( 96.6 km ); (5) 10 miles ( 16.1 km ) of connecting channels to canal harbors at Utica, Syracuse, and Rochester.
 commercially
for specified
or specified
locations

Sand and gravel, coal, coke, fluorspar, sulphur, POL and POL products, sulphuric acid, iron and steel articles, pipe and fittings, ferrous scrap, furnace slag, nonmetallic minerals, coal-tar products, industrial chemicals.

Grain and grain products, POL and POL products, pulpwood, chemicals, fertilizer, paper and paper products, molasses, clay, scrap iron, pig iron and billets, sugar, bituminous materials.

14 feet in earth cuts, rock cuts, canalized rivers and lakes and in open rivers; 12 feet in locks.

9 feet for entire distance -- Grain and grain products, coal, railroad ties, coke,

Evansville, Ind., Cairo, Ill.

Sacramento River .-- Colusa, Calif., Sacramento, Calif., Benicia, Calif., San Francisco, Calif.

245 miles ( 394 km ) from mouth of river at Collinsville, Calif., to Red Bluff.

127 miles ( 204 km ) from mouth of New York Slough to Hills Ferry. The river consists of two sections: mouth to Stockton (navigable all year), 41 miles ( 66 km ) ; Stockton Channel to Hills Ferry (navigable April through June), 86 miles ( 138.5 km ).

Tennessee River ..... Knoxville, Tenn.,
Chattanooga, Tenn., Decatur, Ala., Florence, Ala., Paducah, Ky.

652 miles ( $1,050 \mathrm{~km}$ ) from its formation by the junction of the French Broad and Holston Rivers in eastern Tennessee, 4.4 miles ( 7.08 km ) above Knoxville to the mouth at Paducah on the Ohio River.

20 feet from mouth of river to Cache Slough, 15 miles ( 24.1 km ); 8 feet from Cache Slough to Sacramento, 44 miles ( 70.8 km ); 6 feet from Sacramento to Colusa, 85 miles; 2 feet from Colusa to Chico Landing, 49 miles ( 79 km ); 1.5 feet from Chico Landing to Red Bluff, 52 miles $(83.7 \mathrm{~km})$.

28 feet from mouth of New York Slough to Mormon Channel, Stockton, Mile 40; 22 feet (with other connecting channels 2 to 9 feet) to Edison Street, Stockton, Mile 41 (navigable all year); 4 feet from junction with Stockton Channel to Mossdale Bridge, Mile 16; 3 feet to Hills Ferry, Mile 86 (navigable April through June).
9 feet from mouth to Knoxville, 647.6 miles ( 1,040 km).
sand and gravel, stone and rock, POL and POL products, sulphur, fluorspar, lumber, shingles and lath, sulphuric acid, alcohol, other chemicals, tar, pitch, creosote, iron and steel articles (including pipe and fittings), automobiles, cement, iron and steel scrap, furnace slag.

Grain and grain products, sugar, beets, rock and stone, POL and POL products, canned foods, beet pulp, sand, gravel, fresh vegetables.

Canned milk, grain and grain products, fresh and canned vegetables, dried and canned fruits, molasses, POL and POL products, sand, gravel, crushed rock, iron ore, iron and steel, industrial chemicals.

Grain, coal, coke, clay, POL and POL products, sand, gravel, railroad ties, automobiles, lumber, soybeans, pulpwood, sulphur, limestone, salt, iron and steel, manganese, coal-tar products, chemicals.

## 5-32. Amphibious Operarions

a. Each amphibious landing differs in climatic, hydrographic, and topographic conditions, as well as in the military situation. These variable factors make it impractical to develop detail logistical planning data applicable only to beaches and their capacity to receive troops and cargo; however, certain general planning data can be developed.
b. Beach capacity is the amount of cargo that can be discharged over a given beach length within a stated interval of time. During the initial phases of an amphibious operation, beach capacity is limited to the beach or beaches over which the assault landing is being made; later, if necessary, overall capacity may be increased by the consolidation of beaches for more efficient operation and for the opening up of sheltered unloading points in rivers or bays. Experience has indicated that, during the assault phase of an operation, cargo can be landed and moved across beaches as follows, using (1) and/or (2) in appropriate combination:
(1) Average short tons of cargo per day per mile ( 1.6 km ) of beach-3,000. Average per 1,000 yards ( 914 meters) of beach-1,700.
(2) Average number of vehicles and personnel landed simultaneously per day per mile of beach- 675 vehicles, 4,725 personnel.
c. To insure successful accomplishment of an amphibious operation, equipment and supplies must be loaded so as to provide maximum support to the landing plan and the scheme of maneuver ashore. The manner in which a ship is loaded determines the order and speed with which equipment and supplies can be unloaded and made available for tactical employment. The composition of amphibious task forces will seldom, if ever, be alike. The methods of loading the ships assigned to transport an amphibious force normally will be determined after careful consideration of the following factors:
(1) Availability of shipping versus lift requirements for the operation.
(2) Unloading capability in the objective area versus desired rate of buildup ashore.
(3) Availability of time versus requirements for detailed and thorough coordination and planning.
(4) Availability of ship-to-shore means versus requirements for assault craft in the ship-to-shore movement.
(5) Desired rate of combat force buildup versus base development requirements during assault phase.
(6) Requirements for special equipment versus availability.
(7) Conflicts between time requirements and variable weather and climatic conditions.
d. Types of Military Loading.
(1) Administrative loading. Administrative loading makes maximuin use of troop billeting and cargo spaces. There is no regard for tactical considerations, unit integrity, or priority for unlöading. It is used when direct opposition from the enemy will not be encountered upon landing. This method of landing may be employed when personnel and cargo are transported to the objective area in followup shipping or wihen tactical employment immediately upon landing is not required. Technical details pertaining to administrative loading are contâined in TM 55-513.
(2) Combat loading.
(a) Combat loading is used for any operation in which opposition from the enemy is anticipated. Combat loading is designed to insure unit integrity âñd maximum unloading efficiency of the individual embarkation teams and the landing force as a whole. All other considerations, such as economy of space, must be subordinate. Selected units, with their essential combat equipment and supplies, are loaded in such a manner that they will be available to support the tactical plan upon debarkation. Ships must be loäded to provide for flexibility to meet possible changes in the tactical plan and to facilitate discharge of cargo to meet emergency calls for equipment or supplies. Two objectives of combat loading are-

1. That supplies and equipment loaded aboard ship are so stowed as to be available for unloading and delivery to the as-
sault forces at the time and in the order required to support the tactical situation ashore.
2. That the troops, equipment, and supplies are dispersed throughout the amphibious force shipping in such a manner that the loss or diversion of an embarkation team will not materially affect the tactical integrity of the force embarked in the remaining ships.
(b) There are three types of combat loading which may be employed, depending upon the mission, organization, types of equipment assigned to the force (including ships), and the planned tactical employment of the force. There are-
3. Combat unit loading. Combat unit loading is the loading of an assault troop organization, together with its essential combat equipment and supplies, in a single ship in such a manner that it will be available to support the tactical plan upon debarkation. Combat unit loading provides maximum flexibility to meet possible changes in the tactical plan.
4. Combat organizational loading. Combat organizational loading is the loading of a troop organization with its equipment and supplies on the same ship, but without regard to tactical considerations upon debarkation. It permits debarkation of complete units and equipment which will be available for tactical employment after assembly ashore. This method is more economical in ship space than combat unit loading.
5. Combat spread loading. Combat spread loading is the loading of troop organizations with their equipment and supplies on two or more ships. This method is commonly used in loading organizations equipped with numerous vehicles and/or large amounts of heavy equipment. Organizations so loaded are available for employment in the landing area upon reassembly of personnel and equipment after landing.
(c) Technical details pertaining to combat loading are contained in FM 60-30.
(3) Commodity loading. Commodity loading is a method of loading in which various types of cargo such as ammunition, rations, or boxed vehicles are stowed separately in order that each commodity can be discharged with-
out disturbing other cargo. It is also called block stowage. Portions of compartments are completely filled with items of the particular commodity and are separated from other commodities. Ships are often completely commodity loaded when the cargo consists of class V supplies.
(4) Selective loading. Selective loading is a method of loading and stowing equipment and supplies aboard ship in a manner designed to facilitate issue to designated units. Supplies and equipment are stowed so that they can be discharged and delivered on call. Selective loading differs from commodity loading in that all classes of supplies required to support specified units are loaded and stowed so as to be discharged according to planned and/or anticipated requirements.

## 5-33. Wheeled Amphibians

a. Characteristics.
(1) LARC-V. The combat payload of the LARC-V amphibian ranges from 5,000 to 10,000 pounds depending on the operating conditions. For planning purposes, the combat payload of the LARC-V is 10,000 pounds under ideal conditions; however, the payload may be reduced to 5,000 pounds, depending on wind, waves, or obstacles. Very unfavorable conditions may cause operations to cease entirely.
(2) $L A R C-X V$. This craft is intermediate in size between the LARC-V and the LARC-LX with a combat payload carrying capacity of 30,000 pounds under ideal conditions. This figure may be reduced depending upon immediate environmental factors.
(3) $L A R C-L X$. The combat payload of the LARC-LX ranges up to 120,000 pounds depending upon operating conditions. In extreme cases and under ideal conditions, the LARC-LX may transport 200,000 pounds. The combat payload will vary in accordance with operating conditions. Very unfavorable operating conditions could cause operations to cease entirely.
b. Operating Conditions. The various factors influencing operating conditions are shown below.

| Factors affecting operating conditions | Ideal | Operating conditions Favorable | Difficult |
| :---: | :---: | :---: | :---: |
| Wind | 10 mph ( 16 kmph ) or less | 10 to $15 \mathrm{mph}(16$ to 24 kmph). | Over 15 mph ( 24 kmph ). |
| Waves | Less than 1 ft | 1 to 3 ft | Over 3 ft . |
| Beach | Gentle slope, hard sand ${ }_{\text {-- }}$ | Abrupt slope, soft sand -- | Construction re-required. Mud. |
| Obstacles | None | Some | Prevalent. |
| Area behind beach -- | Good road net ---------- | Trails | Cross-country. |

c. Estimating Requirements. This requires computation of turn around time. The accepted average turnaround time factors used for planning purposes are listed below. Whenever possible, data derived from actual operating
experience should be substituted for these average factors. When estimating requirements, allowance should be made for the tactical situation and for possible adverse navigation, weather, and road conditions.

|  | LARC-V | LARC-LX |
| :---: | :---: | :---: |
| Loading time | 8-10 min | 25 min (heavy vehicles). |
| Unloading time | 8-10 min | 5 min (with unloading pit prepared). |
| Water speed | 10 mph ( 16 kmph ) | 8 mph ( 13 kmph ). |
| Land speed | 25 mph ( 40 kmph ) | 14 mph ( 23 kmph ). |

Note. Data on LARC-XV not available.
d. Turnaround Time. Turnaround time for wheeled amphibians may be estimated by using the following formula:

$$
T T=\frac{W \times 60}{R}+\frac{L \times 60}{R^{\prime}}+a+b+c
$$

where
$T T=$ turnaround time in minutes

* $W=$ water distance (round trip) in miles or kilometers
${ }^{*} L=$ land distance (round trip) in miles or kilometers
* $R=$ speed on water in miles or kilometers per hour
* $R^{1}=$ speed on land in miles or kilometers per hour
$a=$ loading time in minutes
$b=$ unloading time in minutes (not to exceed loading time)
$c=$ known delays in minutes
"If metric system is used, it must be adherel to for $W, L, R$, and $R^{\prime \prime}$.
e. Continuous Operations. For continuous operations, a planning factor of 75 percent availability of assigned amphibians is assumed because of maintenance requirements. To estimate the number of operational vehicles required for a particular mission, use the formula given below.

$$
V=\frac{H \times T T}{X}
$$

where
$V=$ number of operational vehicles
$H=$ number of hatches to be worked
$T T=$ turnaround time in minutes
$X=$ most restrictive factor $(a, b$, or $c$, whichever is greatest in solution of turnaround time in subparagraph $d$ above).

## 5-34. Logistics-Over-the-Shore (Lots) Operations

a. LOTS operations provide for the movement of cargo and personnel over the shore between ocean transportation and shoreside facilities. Beaches and other more difficult shorelines are used to the extent required. Figure 5-21 shows a typical transportation terminal battalion organization for LOTS operations.
b. LOTS operations include-
(1) Unloading cargo and personnel from ships into landing craft and/or amphibians.
(2) Moving cargo and personnel by landing craft and/or amphibians from ships to shore.
(3) Unloading landing craft at beaches.


Figure 5-21. A typical transportation terminal battalion organized for a LOTS .operation.
(4) Unloading amphibians at transfer points.
(5) Moving cargo from landing craft to temporary storage and/or segregation areas or to destination.
(6) Unloading at storage areas or transfer points.
c. Planning factors for LOTS operations are essentially the same as those for fixed terminal operations. Using ship's gear and stevedore labor provided by the forces offshore, ships normally can discharge cargo into special landing equipment as fast as beaches can receive and clear the loaded landing craft and amphibians. In an amphibious operation, the site selections for subsequent LOTS operations are included in the base development plan: Where LOTS operations are established independently, the selection of possible beach sites is made by the terminal commander in consultation with the proper naval authorities, by an extensive study of maps and hydrographic charts, and by reference to pertinent intelligence surveys, when available. Final determination of the feasibility of operations at possible sites is made by a detailed ground and water reconnaissance. The information may be compiled as shown on the sample reporting format (fig. 5-22). This completed form is accompanied by a detailed profile sketch of the beach and landing area as shown in figure 5-23.

## 5-35. Hydrographic Markings for Landing Operations

(fig. 5-24)
a. Hydrographic markings have been developed for use in beach operations in areas not otherwise suitably marked. They are normally installed by transportation personnel or by shore party personnel. They are not related to the aids to navigation maintained by the Coast Guard.
b. During the day, a pennant with alternate red and black vertical stripes is fastened to a buoy or stake to show the locations of rocks, shoals, or submerged obstacles. This pennant is replaced at night by a white light over a red light, both blinking.
c. Hydrographic markings for channels consist of the following:
(1) A red pennant by day and a steady red light at night mark the starboard side of the channel for boats coming from seaward.
(2) A black pennant by day and a blinking white light by night mark the port side.
(3) A black and white vertically striped pennant by day and a blinking green light at night mark a fairway.
(4) Two blinking green lights, one over the other, indicate a range (TM 55-508).


Figure 5-22. Characteristics of beaches and landing areas.


Figure 5-23. Beach profile diagram.

5-36. Beach and Debarkation Point Markers (fig. 5-25)
a. During the process of beach organization, debarkation points for various categories of supply and equipment are selected on each beach where they best support the tactical plan. Beach markers and debarkation point markers are erected by shore party personnel as soon as possible after the initial assault of an amphibious landing has been made.
$b$. Beach markers are large pieces of cloth
secured to supports and held aloft. Beaches under attack are given a color designation, such as Red Beach, Green Beach, etc., and beach markers are constructed in corresponding colors. The center of a beach is marked by a large square of cloth with the color facing seaward. The left flank of the beach, as seen from the sea, is denoted by a horizontal rectangle of the same color; the right flank is marked by a vertical rectangle, also of the same color. Debarkation-point markers are set up to indicate to the craft crews where the various types of cargo are to be landed.


Figure 5-94. Hydrographic markings for landing operations.

## BEACH MARKERS (FROM SEAWARD)



Figure 5-25. Beach and debarkation point markers.

## MISCELLANEOUS BEACH SIGNS



MEDICAL EVACUATION STATION


SHORE PARTY
SHORE PARTY


MINE-CLEARED AREA

Figure 5-25-Continued.

## UNLOADING POINT MARKERS



Figure 5-25-Continued.

## UNLOADING POINT MARKERS



Figure 5-25-Continued.

## Section IV. HOISTING AND CONVEYING DATA

## 5-37. Strength of Rope

$a$. The safe working capacity in tons for any size of manila rope is approximately equal to the square of the diameter in inches if a safety factor of 4 is used. In exceptional cases the rated safe working load may be exceeded, but under no circumstances should rope be loaded to more than twice its safe working capacity.
b. A rope sling over a hook is reduced in strength by approximately 30 percent. Sharp bends over corners further reduce the strength
of the rope. Sand or grit between the fibers or exposure to heat will destroy the fibers and rapidly reduce the strength of the rope.

## 5-38. Properties of Manila Rope

The following table is for new manila rope used under favorable conditions. As rope ages or deteriorates, progressively reduce safe loads to one-half of values given. To determine the safe working load of sisal rope, deduct onefifth from the safe working load of manila rope of the same size.

| Nominal diameter (inches) | Circumference (inches) | Weight per 100 feet (pounds) | Breaking strength (pounds) | Safe load (pounds)* |
| :---: | :---: | :---: | :---: | :---: |
| 1/4 | 3/4 | 2.0 | 600 | 150 |
| 3/8 | 11/8 | 4.10 | 1,350 | 335 |
| 1/2 | 11/2 | 7.50 | 2,650 | 660 |
| \%/8 | 2 | 13.3 | 4,400 | 1,100 |
| 3/4 | $21 / 4$ | 16.7 | 5,400 | 1,350 |
| 7/8 | 23/4 | 22.5 | 7,700 | 1,920 |
| 1 | 3 | 27.0 | 9,000 | 2,250 |
| 1/8 | $31 / 2$ | 36.0 | 12,000 | 3,000 |
| 11/4 | 33/4 | 41.8 | 13,500 | 3,380 |
| 11/2 | 41/2 | 60.0 | 18,500 | 4,620 |
| 1\%/4 | $51 / 2$ | 89.5 | 26,500 | 6,625 |
| 2 | 6 | 108.0 | 31,000 | 7,750 |
| 21/2 | 71/2 | 167.0 | 46,500 | 11,620 |
| 3 | 9 | 242.0 | 64,000 | 16,000 |

[^32]
## 5-39. Knots, Bends, and Hitches

Knots, bends, and hitches used to work lines aboard a vessel and in terminal operations are shown in figure 5-26.

## 5-40. Wire Rope

Wire rope varies considerably in construction characteristics and in the quality of steel used. In terminal operations, the most common rope constructions are 6 strands of 7 wires each and 6 strands of 19 wires each. The $6 \times 7$ wire
rope, being stiffer, is suitable for guys, stays, and other stabilized uses where the rope does not bend around sheaves or drums. The more pliable $6 \times 19$ wire rope is suitable for hoisting use involving sheaves and drums. For a given rope size and type of steel (plow steel is most commonly used) the strength of wire rope varies only slightly with the strand construction and number of strands. The maximum allowable working load is the breaking strength divided by the appropriate safety factor. Characteristics of $6 \times 19$ wire rope are as follows:

| DOUBLE-SHEET BEND <br> Tojoin two wet ropes of different diameters. | 2. <br> 3. <br> BOWLINE <br> To form aloop of any desired size that will not slip. | BOWLINE ON A BIGHT <br> Toform a loopwith a doublepurchase. To formaloop in a rope when the ends are not available. | OVERHAND KNOT <br> To prevent the end of a rope from unravelling. Toprevent the end from passing back through the sheave of a block. |
| :---: | :---: | :---: | :---: |
| SQUARE KNOT <br> Tojoin ends of the same rope. Totietogethertwo ropes of equal diameter. | SINGLE-SHEET BEND <br> Tojointworopes of different diameters. | Toobtain a double bearing surface on a hook. | To shorten a rope when ends are not available. Tobypass a weak section of a rope when ends are not available. |
| ROLLING HITCH <br> Toformahitch which will hold on aspar or rope yet will slide readily upona slight adjustment. | Tofasten guy lines to anchorages and spars. | TIMBER HITCH WITH TWO HALF HITGHES <br> To haula log, spar, guntube, or any long cylindrical object with the pull line parallel to the object drawn. | BLACKWALL HITCH <br> Tosecure a rope to a hook rapidly. |

Figure 5-26. Knots, bends, and hitches.

| Diameter (inchee) | Approximate weight per 100 feet (pounds) | Breaking etrength (short tona) |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | $\begin{gathered} \text { Mild } \\ \text { plow eteel } \end{gathered}$ | Plow eteel | Improved plow eteel |
|  | 10 | 2.07 | 2.39 | 2.74 |
| $1 / 4$ $5 / 16$ | 16 | 3.31 | 3.82 | 4.23 |
| $3 / 8$ | 23 | 4.6 | 5.3 | 6.1 |
| 7/16 | 31 | 6.2 | 7.1 | 8.9 10.8 |
| 1/2 | 40 | 8.5 | 9.4 12.0 | 10.8 13.7 |
| 9/16 | 51 | 10.8 | 12.0 | 16.6 |
| 5/8 | 63 | 12.6 | 14.4 | 23.7 |
| 3/4 | 90 | 18.0 | 28.6 | 32.2 |
| 7/8 | 123 | 24.3 | 28.0 | 42.0 |
| 1 | 160 | 31.6 | 36.5 | 53.0 |
| 11/8 | 203 | 39.8 | 46.0 | 65.0 |
| $11 / 4$ | 250 | 48.8 | 56.5 68.7 | 80.0 |
| $13 / 8$ | 304 | 59.4 | 68.7 | 92.5 |
| $11 / 2$ | 360 | 69.6 | 80.5 | 104.5 |
| 15/8 | 424 | 81.9 | 94.9 | 124.5 |
| $13 / 4$ | 492 | 95.0 | 110.0 | 155.5 |
| 2 | 640 | 123.6 | 143.2 | 150.5 |
| $21 / 4$ | 812 | 156.9 | 181.5 | 207.0 |
| $21 / 2$ | 1,000 | 193.4 | 223.3 | 306.0 |
| $23 / 4$ | 1,216 | 235.0 |  |  |

## 5-41. Wire Rope Safety Factors

| Type of eervice | Minimum eafety factor factor | Type of eervice | Minimum safety factor |
| :---: | :---: | :---: | :---: |
| Track cables | 3.2 | Haulage ropes | 6.0 |
| Guys | 3.5 | Derricks ----- | 6.0 |
| Miscellaneous hoisting equipment ---- | 5.0 | Small electric and air hoists | 7.0 |

## 5-42. Properties of Chains

| Normal ${ }_{\text {size }}^{\text {size }}$ of stock in inches | $\begin{gathered} \text { Approximate } \\ \text { weight } \\ \text { per } 100 \text { ft } \\ \text { pounds }) \end{gathered}$ | $\begin{aligned} & \text { Common } \\ & \text { imon } \\ & \text { (pounds) } \end{aligned}$ | Safe working load* |  | $\begin{gathered} \text { Special } \\ \text { eteel } \\ \text { pounds) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{gathered} \text { High- } \\ \text { grade iron } \\ \text { (pounds) } \end{gathered}$ | $\begin{gathered} \text { Soft } \\ \text { eteel } \\ \text { (pounds) } \end{gathered}$ |  |
|  | 73 |  | 1,530 | 1,800 | 2,620 |
| $1 / 4$ $5 / 16$ | 110 | ---- | 2,160 | 2,540 | 3,700 |
| 3/8 | 160 | 2,700 | 2,980 | 3,500 | 5,100 |
| 7/16 | 210 | 3,460 | 3,800 | 5,000 | 6,600 |
| 1/2 | 280 | 4,500 | 4,960 | 6,000 | 8,200 |
| 9/16 | 340 | 5,820 | 6,400 | 7,770 | 10,620 |
| 5/8 | 430 | 6,940 | 7,620 | 9,000 | 11,500 |
| 3/4 | 630 | 10,140 | 11,160 | 12,000 | 16,200 |
| 7/8 | 840 | 14,000 | 15,400 | 20,250 | 28,660 |
| 1 | 1,100 | 18,600 | 20,460 | 24,900 | 36,400 |
| $11 / 8$ | 1,300 | 23,200 | 25,600 | 31,100 | 45,400 |
| 11/4 | 1,580 | 28,600 | 31,500 | 38,300 | 55,900 67,600 |
| $13 / 8$ | 2,120 | 34,600 | 38,100 | 46,300 | 80,400 |
| $11 / 2$ | 2,520 | 41,200 | 45,400 | 55,200 | 83,600 |
| $15 / 8$ | 2,940 | 48,000 | 52,900 | 64,300 | 93,600 108,000 |
| $13 / 4$ | 3,360 | 55,300 | 61,000 | 74,200 | 123,000 |
| $17 / 8$ | 3,880 | 63,100 | 69,600 | 84,700 | 123,200 |
| 2 | 4,400 | 71,300 | 78,700 | 95,800 | 139,400 |

[^33]
## 5-43. Safe Working Loads of Slings

a. Stress or Tension. The stress or tension in each leg of a sling depends on the number of legs, the angles of the sling legs, and the total load. The total weight lifted is divided among the supporting sling legs and acts straight downward. As the horizontal angle of the leg decreases, the tension in the leg increases, since this tension is a function of the sine of the horizontal angle. Ordinarily, the hoisting line and the sling legs are of the same material and the same size, but this is not always the case. Sometimes the sling legs are of smaller material than the hoisting line, particularly when horizontal angles are large. The strength of the hoisting line determines the maximum lifting power of the combination. Since, preferably, the tension in each sling leg is less than or is equal to the tension in the hoisting line, the tension in each leg of a sling should be known. This can be computed by using the following formula:

$$
\begin{gathered}
T=\frac{W L}{N V} \\
T=\frac{W}{N \times \operatorname{sine} A}
\end{gathered}
$$

where
$T=$ tension in the leg, in pounds (depending upon the horizontal angle of the leg, this tension could be considerably more than the total load being lifted)
$W=$ weight lifted, in pounds
$L=$ length of the leg, in inches
$N=$ number of sling legs
$V=$ vertical distance from the sling platform or sling bar to the hook, in inches
$A=$ angle leg makes with the horizontal
b. Safe Working Loads. The safe working loads of rope, chain, and wire-rope sling combinations under various lift conditions are listed in $c$ through $e$ below. Due to the inherent loss of strength in the sling combinations (ties, splices, bends, etc.), appropriate reductions in the "straight pull" safe working loads have been made. The angles in each table are measured from the horizontal. In the unusual situations where triple slings are encountered, multiply quantities shown for double slings by one and a half.
c. Manila-Rope Slings. (Standard, threestrand manila-rope sling with a splice in each end.)

| Size |  |  | Double sling |  |  | Quadruple sting |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & \text { Circum- } \\ & \text { fercree } \\ & \text { finches) } \end{aligned}$ | Diameter (inehes) | $\begin{gathered} \text { Vertical } \\ \text { fift } \\ \text { (niftinfa) } \end{gathered}$ (pounds) |  |  | $\begin{gathered} \text { sob } \\ \text { anole } \\ \text { (pounda }) \end{gathered}$ | $\begin{gathered} \boldsymbol{c}_{\substack{\text { angle } \\ \text { anole } \\ \text { pound }}} \end{gathered}$ | $\begin{gathered} 45^{\circ} \\ \text { anole } \\ \text { (pound } \end{gathered}$ | $\left.\begin{array}{c} 300 \\ \text { anole } \\ \text { (poundq } \end{array}\right)$ |
| 3/4 | 1/4 | 108 | 187 | 153 | 108 | 374 | 306 | 216 |
| $11 / 8$ | 3/8 | 241 | 418 | 341 | 241 | 836 | 683 | 482 |
| $11 / 2$ | 1/2 | 475 | 822 | 672 | 475 | 1,645 | 1,345 | 950 |
| 2 | 5/8 | 791 | 1,370 | 1,119 | 791 | 2,740 | 2,238 | 1,582 |
| $21 / 4$ | 3/4 | 970 | 1,680 | 1,375 | 970 | 3,360 | 2,750 | 1,940 |
| $23 / 4$ | 7/8 | 1,382 | 2,395 | 1,945 | 1,382 | 4,790 | 3,890 | 2,764 |
| 3 | 1 | 1,620 | 2,805 | 2,290 | 1,620 | 5,610 | 4,580 | 3,240 |
| $31 / 2$ | $11 / 8$ | 2,160 | 3,740 | 3,060 | 2,160 | 7,480 | 6,120 | 4,320 |
| $33 / 4$ | $11 / 4$ | 2,430 | 4,205 | 3,437 | 2,430 | 8,410 | 6,875 | 4,860 |
| $41 / 2$ | $11 / 2$ | 3,330 | 5,770 | 4,715 | 3,330 | 11,540 | 9,430 | 6,660 |
| $51 / 2$ | $13 / 4$ | 4,770 | 8,250 | 6,750 | 4,770 | 16,500 | 13,500 | 9,540 |
| 6 | 2 | 5,580 | 9,670 | 7,900 | 5,580 | 19,340 | 15,800 | 11,160 |
| 71/2 | $21 / 2$ | 8,366 | 14,500 | 11,850 | 8,366 | 29,000 | 23,700 | 16,732 |
| 9 | 3 | 11,520 | 19,950 | 16,300 | 11,520 | 39,900 | 32,600 | 23,040 |

d. Chain Slings. (New wrought-iron chains.)

| d. | Single |  | ouble slino |  |  | druple slin |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Link atock diameter |  |  | $\begin{gathered} \left.\begin{array}{c} 45^{\circ} \\ \text { anole } \\ \text { pound } \end{array}\right) \end{gathered}$ | $\begin{gathered} 300 \\ \text { anole } \\ \text { (pounds) } \end{gathered}$ | $\begin{gathered} \boldsymbol{a n}^{600} \\ \text { angla } \\ \text { (poundes } \end{gathered}$ | $\underset{\substack{45^{\circ} \\ \text { anoule } \\ \text { pounds }}}{ }$ |  |
| 3/8 | 2,510 | 4,350 | 3,555 | 2,510 | 8,700 | 7,110 | 5,020 |
| 7/16 | 3,220 | 5,575 | 4,560 | 3,220 | 11,150 | 9,120 | 6,440 |
| 1/2 | 4,180 | 7,250 | 5,915 | 4,180 | 14,500 | 11,830 | 8,360 |
| 9/16 | 5,420 | 9,375 | 7,670 | 5,420 | 18,750 | 15,340 | 10,840 |
| 5/8 | 6,460 | 11,175 | 9,150 | 6,460 | 22,350 | 18,300 | 12,920 |
| 3/4 | 9,160 | 15,850 | 12,950 | 9,160 | 31,700 | 25,900 | 18,320 |
| 7/8 | 13,020 | 22,550 | 18,410 | 13,020 | 45,100 | 36,820 | 26,040 |
| 1 | 17,300 | 29,900 | 24,450 | 17,300 | 59,800 | 48,900 | 34,600 |
| $11 / 8$ | 21,550 | 37,350 | 30,550 | 21,550 | 74,700 | 61,100 | 43,100 |
| $11 / 4$ | 26,600 | 36,050 | 37,600 | 26,600 | 92,100 | 75,200 | 53,200 |
| $13 / 8$ | 32,200 | 55,750 | 45,600 | 32,200 | 111,500 | 91,200 | 64,400 |
| $11 / 2$ | 38,300 | 66,400 | 54,250 | 38,300 | 132,800 | 108,500 | 76,600 |
| 15/8 | 44,600 | 77,200 | 63,050 | 44,600 | 154,400 | 126,100 | 89,200 |
| $13 / 4$ | 51,300 | 88,750 | 72,500 | 51,300 | 177,500 | 145,000 | 102,600 |
| 17/8 | 58,700 | 101,500 | 83,000 | 58,700 | 203,000 | 166,000 | 117,400 |
| 2 | 66,200 | 114,500 | 93,500 | 66,200 | 229,000 | 187,000 | 132,400 |

e. Wire Rope Slings. (New improved plow-steel wire rope.)

| Diameter (inches) | Single sling Vertical <br> (pounds) | Double eling |  |  | Quadruple aling |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{gathered} 45^{\circ} \\ \text { anole } \\ \text { (pounds) } \end{gathered}$ | $\begin{gathered} 300 \\ \text { angle } \\ \text { (pounds) } \end{gathered}$ | $\begin{gathered} 800^{8} \\ \text { anole } \\ \text { (pounds) } \end{gathered}$ | $\left.\begin{array}{c} 4^{40^{\circ}} \\ \text { (poile } \\ \text { pound } \end{array}\right)$ | $\begin{gathered} 30^{\circ} \\ \text { anole } \\ \text { (pounda) } \end{gathered}$ |
| 1/4 | 1,096 | 1,899 | 1,552 | 1,096 | 3,798 | 3,105 | 2,192 |
| 5/16 | 1,690 | 2,925 | 2,390 | 1,690 | 5,850 | 4,780 | 3,380 |
| 3/8 | 2,460 | 4,260 | 3,485 | 2,460 | 8,520 | 6,970 | 4,920 |
| 7/16 | 3,560 | 6,170 | 5,040 | 3,560 | 12,340 | 10,080 | ,120 |
| 1/2 | 4,320 | 7,475 | 6,105 | 4,320 | 14,950 | 12,210 | 8,640 |
| 9/16 | 5,460 | 9,450 | 7,725 | 5,460 | 18,900 | 15,450 | 10,920 |
| 5/8 | 6,650 | 11,500 | 9,400 | 6,650 | 23,000 | 18,800 | 13,300 |
| 3/4 | 9,480 | 16,400 | 13,400 | 9,480 | 32,800 | 26,800 | 18,960 |
| 7/8 | 12,900 | 22,350 | 18,250 | 12,900 | 44,700 | 36,500 | 25,800 |
| 1 | 16,800 | 29,100 | 23,750 | 16,800 | 58,200 | 47,500 | 33,600 |
| $11 / 8$ | 21,200 | 36,700 | 30,000 | 21,200 | 73,400 | 60,000 | 42,400 |
| 11/4 | 26,000 | 45,000 | 36,800 | 26,000 | 90,000 | 73,600 | 52,000 |
| $13 / 8$ | 32,000 | 56,400 | 45,250 | 32,000 | 110,800 | 90,500 | 64,000 |
| 11/2 | 37,000 | 64,000 | 52,340 | 37,000 | 128,000 | 104,700 | 74,000 |
| $15 / 8$ | 41,800 | 72,400 | 59,200 | 41,800 | 144,800 | 118,400 | 83,600 |
| $13 / 4$ | 49,800 | 86,250 | 70,500 | 49,800 | 172,500 | 141,000 | 99,600 |
| 2 | 62,300 | 107,600 | 88,050 | 62,300 | 215,200 | 176,100 | 124,600 |
| $21 / 4$ | 82,900 | 143,500 | 117,400 | 82,900 | 287,000 | 234,800 | 165,800 |
| $21 / 2$ | 101,800 | 176,250 | 144,000 | 101,800 | 352,500 | 288,000 | 203,600 |
| 23/4 | 122,500 | 212,000 | 173,500 | 122,500 | 424,000 | 347,000 | 245,000 |

## 5-44. Safe Loads on Hooks

The data below are keyed to figure 5-27.


Figure 5-27. Cargo hook: critical dimensions.

| Diameter <br> of metal $A$ (inches) | Inside diameter of eye $B$ (inches) | Width of opening $C$ (inches) | Length of hook D (inches) | Safe load on hook (pounds) |
| :---: | :---: | :---: | :---: | :---: |
| 11/16 | 7/8 | 11/16 | $415 / 16$ | 1,200 |
| 3/4 | 1 | $11 / 8$ | $513 / 32$ | 1,400 |
| 7/8 | $11 / 8$ | 11/4 | $61 / 4$ | 2,400 |
| 1 | $11 / 4$ | $13 / 8$ | $67 / 8$ | 3,400 |
| $11 / 8$ | $13 / 8$ | $11 / 2$ | $75 / 8$ | 4,200 |
| $11 / 4$ | $11 / 2$ | 111/16 | $819 / 32$ | 5,000 |
| $13 / 8$ | $15 / 8$ | $17 / 8$ | $91 / 2$ | 6,000 |
| $11 / 2$ | $13 / 4$ | $21 / 16$ | $1011 / 32$ | 8,000 |
| $15 / 8$ | 2 | $21 / 4$ | 11 27/32 | 9,400 |
| $17 / 8$ | $23 / 8$ | $21 / 2$ | 139/32 | 11,000 |
| $21 / 4$ | $23 / 4$ | 3 | 14 13/16 | 13,600 |
| $25 / 8$ | $31 / 8$ | $33 / 8$ | $161 / 2$ | 17,000 |
| 3 | $31 / 2$ | 4 | 193/4 | 24,000 |

## 5-45. Minimum Groove Diameter of Sheaves and Drums

| $\underset{\substack{\text { Rope } \\ \text { diameter } \\ \text { (inches) }}}{ }$ | Minimum groove diameter in inches for given rope constructions * |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | ${ }_{6} \times 7$ | $6 \times 19$ | $6 \times 37$ | $8 \times 19$ |
| $1 / 4$ | $101 / 2$ | $81 / 2$ | ------ | $61 / 2$ |
| 3/8 | $153 / 4$ | $123 / 4$ | $63 / 4$ | $93 / 4$ |
| 1/2 | 21 | 17 | 9 | 13 |
| 5/8 | $261 / 4$ | $211 / 4$ | $111 / 4$ | $161 / 4$ |
| 3/4 | $311 / 2$ | $251 / 2$ | $131 / 2$ | $191 / 2$ |
| 7/8 | $363 / 4$ | $293 / 4$ | $153 / 4$ | $223 / 4$ |
| 1 | 42 | 34 | 18 | 26 |
| $11 / 8$ | $471 / 4$ | $381 / 4$ | 20 1/4 | 29 1/4 |
| $11 / 4$ | $521 / 2$ | $421 / 2$ | $221 / 2$ | $321 / 2$ |
| $11 / 2$ | 63 | 51 | 27 | 39 |

${ }^{\text {*Rope construction }}$ is in strands times wires per strand.

## 5-46. Blocks and Tackle

a. Blocks and tackle consist of sheaves (pulleys) and ropes arranged so as to obtain a mechanical advantage. As shown in figure 5-28, the force $P$ applied to the lifting end of the rope is much smaller than would be required to lift weight $W$ without using block and tackle. $P$ represents the pull on the rope that supports an equal part of the weight acting on the whole tackle.
b. Figure 5-29 depicts sample block and tackle riggings for manila and wire rope.

Single-, double-, and triple-sheave blocks are shown. Numbers on the illustration indicate the number of lines in the rigging.
(1) Block and tackle rigging for manilla rope. Permissible rope diameters are for new rope used under favorable conditions and normally with a safety factor of 4 . As rope ages or deteriorates, the safety factor must be increased progressively to 8 when determining the size rope to be used. The smallest permissible rope diameter is given in inches and the lead line pull in pounds.

|  | 2 single | 1 single, | Total number of aheav <br> 2 double | 1 double, 1 triple | $2 \text { triple }$ | Load to be lifted (in tons) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Rope | 1/2 | 7/16 | 3/8 | 3/8 | 3/8 | 1/2 |
| Pull | 540 | 380 | 280 | 220 | 185 |  |
| Rope | 3/4 | 5/8 | 1/2 | 1/2 | 1/2 | 1 |
| Pull | 1,100 | 740 | 560 | 445 | 370 |  |
| Rope | 7/8 | 3/4 | 5/8 | 5/8 | 1/2 | $11 / 2$ |
| Pull | 1,600 | 1,100 | 840 | 670 | 560 |  |
| Rope | $11 / 8$ | 7/8 | 3/4 | 5/8 | 5/8 | 2 |
| Pull | 2,200 | 1,500 | 1,120 | 890 | 745 |  |
| Rope | 5/16 | $11 / 8$ | 1 | 7/8 | 3/4 | 3 |
| Pull | 3,300 | 2,220 | 1,670 | 1,330 | 1,110 |  |
| Rope | $11 / 2$ | $11 / 4$ | $11 / 8$ | 1 | 1 | 4 |
| Pull | 4,440 | 2,960 | $15 / 16$ | $11 / 4$ | $11 / 8$ | 6 |
| Rope | -.-...- | $11 / 2$ | 2,220 | 1,780 | 1,480 |  |
| Pull | ------ | 4,450 | 3,330 | 2,670 | 2,220 |  |
| Rope | --.----- | --...--- | $15 / 8$ | 11/2 | $15 / 16$ | 8 |
| Pull | -- | ---. | 4,450 | 3.560 | 2,970 |  |

(2) Block-and-tackle rigging for plow steel wire rope. Permissible rope diameters are for rope in good condition (not excessively worn
or frayed). A safety factor of 6 is used. The smallest permissible rope diameter is given in inches and the lead line pull in pounds.


Figure 5-28. Examples of simple and compound tackle.


Figure 5-29. Sample block and tackle rigging for manila and wire rope.

|  | Total number of sheavee in blocke |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2 single | $\begin{aligned} & 1 \text { gingle, } \\ & 1 \text { double } \end{aligned}$ | 2 double | $1 \text { double. }$ $1 \text { triple }$ | 2 triple | be lifted (in tons) |
| Rope | 3/8 | 3/8 | 3/8 | 3/8 | 3/8 | 1 |
| Pull | 1,100 | 740 | 560 | 445 | 370 |  |
| Rope | 1/2 | 3/8 | 3/8 | 3/8 | 3/8 | 2 |
| Pull | 2,200 | 1,480 | 1,100 | 880 | 740 |  |
| Rope | 5/8 | 1/2 | 1/2 | 3/8 | 3/8 | 4 |
| Pull | 4,400 | 2,960 | 2,200 | 1,780 | 1,480 |  |
| Rope | 3/4 | 5/8 | 5/8 | 1/2 | 1/2 | 6 |
| Pull | 6,600 | 4,440 | 3,400 | 2,660 | 2,200 |  |
| Rope | 7/8 | 3/4 | 5/8 | 5/8 | 5/8 | 8 |
| Pull | 8,900 | 5,940 | 4,450 | 3,560 | 2,970 |  |
| Rope | 1 | 7/8 | 3/4 | 5/8 | 5/8 | 10 |
| Pull | 11,100 | 7,410 | 5,550 | 4,450 | 3,710 |  |
| Rope | $11 / 8$ | 1 | 7/8 | 3/4 | 3/4 | 15 |
| Pull | 16,640 | 11,100 | 8,350 | 6,670 | 5,550 |  |
| Rope | $11 / 2$ | $11 / 8$ | 1 | 7/8 | 7/8 | 20 |
| Pull | 22,200 | 14,800 | 11,100 | 8,900 | 7,400 |  |

c. Recommended Sizes of Tackle Blocks. The largest diameter of sheave for a given size of rope is preferred, when available, except that for $6 \times 37$ ( 6 strands, each with 37 wires) wire rope, the smallest diameter of sheave indicated below is suitable.

| W |  | Manila rope |  |
| :---: | :---: | :---: | :---: |
| $\begin{gathered} \text { Ropa } \\ \text { diameter } \\ \text { (inches) } \end{gathered}$ | Outarde <br> of sheave <br> (inches) | $\begin{aligned} & \text { Rope } \\ & \text { diameter } \\ & \text { (inches) } \end{aligned}$ | Length of bloek (inchee) |
| 3/8 | 6 to 8 | 1/2 | 4 |
| 1/2 | 8 to 10 | 5/8 | 6 |
| \%/8 | 10 to 12 | $3 / 4$ | 6 to 7 |
| 8/4 | 12 to 16 | 7/8 | 7 to 8 |
| 7/8 | 14 to 18 | 1 | 8 to 10 |
| 1 | 14 to 20 | 11/8 | 8 to 10 |
|  |  | 11/4 | 10 to 12 |
|  | , | 11/2 | 12 to 14 |
|  |  | 13/4 | 14 to 16 |

d. Effect of Block-and-Tackle Rigging on Strength of Wire Rope. Wire rope loses some of its tensile strength when it is passed around sheaves or drums. The amount of this loss depends upon variable factors, such as type and size of rope and diameter of sheave or drum. The table below shows percentage of reduction in the rated tensile strength for $6 \times$ 7 and $6 \times 19$ plow-steel wire rope when passed around sheaves or drums of various diameters. Obviously, the $6 \times 19$ rope is more adaptable for this use (para 5-40), for the percentage of tensile-strength loss for a given size of $6 \times 19$ rope is much less than for the $6 \times 7$ rope. It should also be noted from the table that the percentage of tensile-strength loss varies inversely with the size of the sheave or drum.

| $\begin{gathered} \text { Rope } \\ \text { diameter } \\ \text { (in.) } \end{gathered}$ | 6 strande, each with 7 wires Sheave or drum diameter ( $f t$ ) |  |  |  |  |  |  |  |  |  |  |  | 6 atrands, each with 19 wires Sheave or drum diameter (ft) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 | 2 | 3 | 4 | 6 | 8 | 10 | 15 | 20 | 1 | 2 | $s$ | 4 | 6 | 8 | 10 | 15 | 20 |
| 1/4 |  |  |  |  |  |  |  |  |  | 6.4 | 3.4 | 2.3 | 1.9 | 1.1 |  |  |  |  |
| 9/32 |  | 4.5 | 3.0 | 2.2 | 1.5 | 1.1 | . 9 | . 6 |  |  | 3.4 | 2.3 | 1.9 | 1.1 |  |  |  |  |
| 5/16 |  | 8.0 | 5.2 | 4.1 | 2.7 | 2.0 | 1.6 | . 9 |  | 8.9 | 4.5 | 3.2 | 2.4 | 1.6 |  |  |  |  |
| 3/8 |  | 10.0 | 6.8 | 5.1 | 3.4 | 2.5 | 2.0 | 1.4 |  | 10.4 | 5.2 | 3.5 | 2.6 | 1.7 |  |  |  |  |
| 7/16 |  | 13.7 | 9.1 | 6.9 | 4.6 | 3.4 | 2.7 | 1.9 |  | 11.8 | 5.9 | 3.8 | 3.0 | 1.9 | 1.5 |  |  |  |
| 1/2 |  | 14.0 | 9.2 | 7.0 | 4.6 | 3.5 | 2.8 | 1.9 |  | 13.6 | 6.8 | 4.6 | 3.4 | 2.3 | 1.7 | 1.4 |  |  |
| 9/16 |  | 16.3 | 11.0 | 8.2 | 5.5 | 4.1 | 3.3 | 2.2 |  | 15.6 | 7.8 | 5.4 | 3.9 | 2.7 | 2.0 | 1.6 |  |  |
| 5/8 |  | 17.2 | 11.5 | 8.6 | 5.8 | 4.3 | 3.4 | 2.3 |  | 17.6 | 8.8 | 5.9 | 4.4 | 3.0 | 2.2 | 1.7 |  |  |
| 3/4 |  | 20.5 | 13.7 | 10.3 | 6.8 | 5.1 | 4.1 | 2.7 |  | 20.6 | 10.3 | 7.0 | 5.1 | 3.5 | 2.6 | 2.0 |  |  |
| 7/8 |  |  | 16.7 | 12.5 | 8.3 | 6.3 | 5.0 | 3.3 |  | 25.9 | 13.0 | 8.7 | 6.5 | 4.3 | 3.2 | 2.6 | 1.7 | 1.3 |
| 1 |  |  | 19.7 | 14.7 | 9.8 | 7.4 | 5.9 | 3.9 |  |  | 14.8 | 9.8 | 7.4 | 4.9 | 3.7 | 2.6 3.0 | 2.0 | 1.3 |
| $11 / 8$ |  |  |  | 16.7 | 11.2 | 8.3 | 6.7 | 4.5 |  |  | 16.9 | 11.3 | 8.4 | 5.7 | 3.2 4.2 | 3.0 3.4 | 2.0 | 1.7 |
| $11 / 4$ |  |  |  | 18.2 | 12.2 | 9.1 | 7.3 | 4.9 |  |  | 18.8 | 12.6 | 9.4 | 6.3 | 4.7 | 3.4 3.8 | 2.5 | 1.9 |
| $13 / 8$ |  |  |  | 20.2 | 13.5 | 10.1 | 8.1 | 5.4 |  |  | 20.2 | 13.5 | 9.4 10.1 | 6.7 | 5.1 | 3.8 4.0 | 2.6 | 1.9 |
| $15 / 8$ |  |  |  | 23.1 | 15.4 | 11.6 | 9.2 | 6.2 |  |  |  | 15.3 | 11.5 | 7.7 | 5.8 | 4.6 | 3.1 | 2.0 |
| $13 / 4$ |  |  |  |  |  |  |  |  |  |  |  | 17.0 | 12.8 | 8.5 | 6.8 | 4.6 | 3.1 3.4 | 2.3 |
| 2 |  |  |  |  |  |  |  |  |  |  |  | 17.9 | 13.4 | 8.5 8.9 | 6.4 | 5.1 | 3.4 | 2.6 |
| $21 / 4$ |  |  |  |  |  |  |  |  |  |  |  |  | 13.4 16.0 | 8.9 10.7 | 6.7 8.0 | 6.4 6.4 | 3.6 4.3 | 2.7 3.2 |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 17.1 | 11.4 | 8.6 | 6.9 | 4.6 | 3.4 |
| $23 / 4$ |  |  |  |  |  |  |  |  |  |  |  |  |  | 12.7 | 9.6 | 7.6 | 5.1 | 3.8 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | 14.1 | 10.6 | 8.5 | 5.6 | 4.2 |

5-47. Cubic Capacities, Weights, and Dimensions of Various Grab Buckets (Clamshells)

| Capacity (cu yd) | $\begin{aligned} & \text { Weight } \\ & \text { (lb) } \end{aligned}$ $(l b)$ | Overall lenoth of opened bucket (in.) | $\begin{gathered} \text { Overall } \\ \text { length of } \\ \text { closed } \\ \text { bucket (in.) } \end{gathered}$ | Width of bucket (in.) | $\begin{gathered} \text { Capacity } \\ (c u y d) \end{gathered}$ | $\begin{aligned} & \text { Weioht } \\ & \text { (ib) } \end{aligned}$ | Overall length of opened bucket (in.) | Overall lenoth of closed. bucket (in.) | Width of bucket (in.) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| General-purpose bucket |  |  |  |  | $11 / 4$ | 3,900 | 94 | 80 | 44 |
| with ore bowl |  |  |  |  | $11 / 2$ | 5,175 | 102 | 87 | 46 |
| 1/2 | 1,700 | 72 | 48 | 36 | 13/4 | 5,300 | 108 | 92 | 46 |
| 3/4 | 2,700 | 85 | 60 | 40 | 2 | 5,800 | 101 | 87 | 52 |
| 1 | 3,200 | 99 | 67 | 40 | $21 / 2$ | 7,300 | 106 | 91 | 58 |
| $11 / 4$ | 3,400 | 99 | 67 | 47 | 3 | 9,000 | 111 | 97 | 64 |
| $11 / 2$ | 4,400 | 108 | 74 | 50 | Electric single-rope grab bucket |  |  |  |  |
| 15/8 | 4,600 | 108 | 74 | 54 |  |  |  |  |  |
| 2 | 5,500 | 108 | 76 | 62 |  |  |  |  |  |
| 21/2 | 7,400 | 120 | 84 | 63 |  | 1,200 | 51 | 40 | 33 |
| 3 | 8,000 | 120 | 84 | 74 | $1{ }^{1 / 4}$ | 2,600 |  |  |  |
| 4 | 12,000 | 141 | 104 | 74 | 1 | 4,600 4,700 | 76 88 | 56 | 48 |
| General-purpose bucket |  |  |  |  | $11 / 2$ | 4,900 | 88 | 61 | 59 |
| 1/2 | 1,500 | 70 | 56 | 29 | 2 | 9,000 | 105 | 73 | 67 |
| 9/4 | 3,000 | 83 | 71 | 37 | $21 / 2$ | 10,000 | 117 | 84 | 60 |
| 1 | 3,500 | 90 | 76 | 41 | 3 | 10,500 | 117 | 84 | 70 |

## 5-48. Data on Chain Hoists


©Spur-gear hoists of $12-, 16$-, and 20 -ton capacity have two operating chains. The pull on chains (column 14) and the amount of chain overhauled (column 5) is the total for the two chains.

## Section V. TERMS

## 5-49. Stowage

a. Bale Cubic Capacity. The space available for loading cargo, measured in cubic feet to the inside of the cargo battens on the frames
and to the underside of the beams. This measurement is used to compute the space available for general cargo.
b. Broken Stowage. The space lost in the
hold because of the contour of the ship and the shape of the cargo containers. A typical wellbalanced general cargo vessel will have from 10 to 15 percent broken stowage; a complete load of vehicles will use only 60 to 70 percent of the available cargo space.
c. Grain Cubic Capacity. The maximum space available for cargo measured in cubic feet to the inside of the shell plating and to the underside of the deck plating of a ship. This measurement is used to compute cubic space available for loading bulk commodities.
d. Stowage Factor. The figure that denotes the number of cubic feet required to stow 1 long ton of cargo. This factor is obtained by dividing 2,240 pounds by the weight, in pounds, of a cubic foot of the commodity to be loaded.

## 5-50. Vessel

a. After Perpendicular. The vertical line through the intersection of the afterside of the sternpost with the load water plane.
b. Baseline. The intersection of the central longitudinal vertical plane of the ship with a horizontal plane through the top of the keel at the midship section. In some cases the keel line and baseline are the same.
c. Center of Buoyancy. The center of the molded volume of the vessel below the waterline. It is at the center of gravity of the displaced volume of water. It shifts its position, both vertically and horizontally, as the floating vessel tips. The total upward pressure of the water may be regarded as concentrated through the center of buoyancy, about which it balances. The center of buoyancy and the center of gravity of a ship floating in equilibrium in still water must be in the same vertical line.
d. Down by the Head and Down by the Stern. A vessel is down by the head when the bow draft is greater than the stern draft. When the stern draft is greater than the bow draft, the vessel is said to be down by the stern.
e. Draft and Draft Marks. Draft marks are

6-inch numerals painted on the bow and stern of a vessel to indicate the depth to which the bow and stern are submerged. The bases of the numerals mark the even foot marks.
$f$. Drag. When the stern is deeper in the water than the bow, the vessel is said to have a drag. The number of feet that the stern is lower is the amount of drag. (This is not to be confused with design drag.)
g. Forward Perpendicular. The vertical line through the intersection of the forward side of the stem with the load water plane.
h. Freeboard. A term used to express the vertical distance on the side of a vessel from the edge of the main deck line to the water. Freeboard (statutory) is the assigned distance measured amidships vertically from the upper (freeboard) deck to the upper edge of the load line (Plimsoll mark).
i. Full and Down. A vessel is said to be full and down when all available cubic space has been utilized (full) and sufficient weight is aboard to submerge the vessel to her legal loadline (down).
j. Hogging. A vessel is said to be hogging when the weight at both the bow and the stern is greater than at the midships section, thus making the vessel tend to arch up or "hog" amidships.
k. Keel Line. The line of the fore and aft member running along the centerline of the ship at its lowest part.
l. Load Waterline ( $L W L$ ). The line, viewed horizontally, that represents the intersection of the ship's form with the plane of the surface of the water (load water plane) when the ship is floating with her designed load on board.
m. Loadline or Plimsoll Mark. The loadline or Plimsoll mark amidships on the hull of a vessel denotes the maximum draft to which the vessel may be loaded for a particular voyage, depending upon the area to be traveled and the season of the year. The top of the line $A B$ (line $S$ ) in figure $5-30$ indicates the summer loadline. For ease of observation, the cir-


Figure 5-so. Loadline or Plimsoll mark.
cled line $A B$ usually is placed next to the Plimsoll mark on a vessel that habitually loads in the same kind of water.
n. Midships Section. The vertical transverse (athwartship) section located at the midpoint between the forward and after perpendiculars. Usually this is the largest section of the ship.
o. Sagging. The opposite of hogging.
p. Stiff Ship. A ship is said to be "stiff" when it has excessive weight in the lower hold and insufficient weight in the 'tween decks. A stiff ship has a tendency to snap back from a roll in a sudden, jarring manner.
q. Tender Ship. A vessel with excessive weight in the 'tween decks and insufficient weight in the lower hold. A tender ship has a long, slow roll and a tendency to capsize.
$r$. Vessel Stowage Factor. This factor is the bale cubic capacity less estimated lost space divided by the cargo capacity tonnage less estimated weight of the deck cargo. It is the stowage factor for a particular vessel and cargo and should be employed to fully utilize both the cargo space and weight capacity of a vessel. An example of use is shown in (1) and (2) below.
(1) Example problem. Determine the ideal cargo for a Liberty ship with a $400,000-$ cubic-foot capacity after lost space is deducted and with a cargo capacity tonnage (less deckload) of 8,000 long tons.
(2) Solution:

Vessel stowage factor $=\frac{400,000}{8,000}=50$ cubic feet per long ton

A cargo of 50 cubic feet per long ton would fully utilize both space and weight capacity of
the vessel and would therefore be the ideal cargo. A cargo weighing more per unit of volume would make weight the limiting factor, thus wasting some cargo space. A cargo weighing less per unit of volume would make volume the limiting factor, thus wasting some of the weight capacity of the vessel.

## 5-51. Tonnage

a. Canal Tonnage (Panama or Suez). Derived from formulas of measurement prescribed by the respective canal authorities for the assessment of tolls. Space exemptions allowed are not uniform for the two canals, and, as a consequence, ships must carry a certificate for each.
b. Cargo Deadweight Tonnage. The total cargo and passenger capacity of a ship expressed in long tons. The figure is computed by deducting the weight of the fuel, water, stores, dunnage, and other items necessary for a voyage from the deadweight tonnage of the vessel.
c. Deadweight Tonnage. The carrying capacity of a ship in long tons. It represents the difference between the displacement light and the displacement loaded to the maximum draft allowed by law.
d. Displacement Ton. A unit of weight equal to the volume of a long ton of sea water ( $35 \mathrm{cu} . \mathrm{ft}$.). Used in computing the displacement of vessels.
e. Displacement Tonnage, Light. The weight of the ship in long tons excluding cargo, passengers, fuel, water, stores, dunnage, and other items necessary for use on a voyage.
f. Displacement Tonnage, Loaded. The weight of the ship in long tons, including cargo, passengers, fuel, water, stores, dunnage, and such other items as necessary for use on a voyage.
g. Equipment Tonnage. This is the tonnage arrived at from certain dimensions which take into consideration the exposed surfaces of the vessel both above and below water. It very closely approximates the gross tonnage in a vessel of ordinary construction. Equipment
tonnage is used primarily to determine the size of anchors, chains, hawsers, and other ship's gear.
h. Gross Ton. A unit of capacity of 100 cubic feet ( 2.8317 cubic meters) used for ascertaining the legal or registered tonnage of vessels. Also called a register or vessel ton.
i. Gross Tonnage. The entire internal cubic capacity of a ship expressed in gross tons. Also referred to as gross register tonnage.
j. Long Ton. A unit of weight, 2,240 pounds avoirdupois ( 1016.106 kg ).
$k$. Manifest Ton. The unit at which cargo is billed or manifested when the carrier has the option to assess freight charges on the basis of a ton weight, or a ton measurement, whichever affords the greater revenue. Also known as a revenue ton.
l. Measurement Ton. A unit of volume for cargo computed at 40 cubic feet. Also called a freight ton, stevedore ton, or ship ton.
$m$. Net Tonnage. The payload spaces remaining after deduction from the gross tonnage of space for the crew, powerplant, fuel, and operation of the vessel. Net tonnage is expressed in gross tons and is sometimes referred to as net register tonnage.
$n$. Short Ton. A unit of weight of 2,000 pounds ( 907.2 kg ).

## 5-52. Shipping

a. Bareboat Charter. A charter in which the bare ship is chartered without crew; the charterer, for a stipulated sum, taking over the vessel with a minimum of restrictions. Also called demise charter, barepole charter, or barehull charter.
b. Berth Terms. A form of charter under which the carrier is responsible for loading and unloading the cargo; these terms apply almost universally to partial cargoes.
c. Charter Party. An agreement by which a shipowner agrees to place an entire ship, or a part of it, at the disposal of a merchant or other person for the conveyance of goods,
binding the shipowner to transport them to a particular place, for a sum of money which the merchant undertakes to pay as freight for their carriage. Sometimes referred to simply as charter. Charters are either time, voyage, or demise (bareboat).
d. Free Alongside Ship (FAS). Trade term which implies that the goods should be placed by the shipper within reach of the ship's tackle in a condition fit for shipment. The exact meaning of the word "alongside" is sometimes determined by the custom of the port, but is generally a pure question of fact.
e. Free In and Out (FIO). A chartering term that means that the owner who charters his ship is responsible for all the usual costs of ship management with the exception of loading and discharging cargo and of putting the vessel in drydock if required to do so by the charterer.
f. Free of Address (FOA). A chartering clause which means that no address charges shall be made on the freight at the port of discharge.
g. Free of Turn. A chartering term which means that a steamer's time will commence to count for loading or discharging from her arrival, whether there is a berth available or not.
h. Free on Board ( $F O B$ ). A mercantile expression used in sale contracts which denotes that the goods have to be delivered by the shippers on board the vessel at a particular place, free of all charges.
i. Free Time. Chartering term which denotes the duration of time between the moment that the notice of readiness has been handed to the charterers and the beginning of lay days.
j. Freight Forward. A term which denotés that under the transportation agreement freight is payable by the consignee at port of destination. The opposite of freight prepaid.
k. Lay Days. Days allowed by charter party for loading and/or discharging cargo.

## 5-53. Tonnage Conversion Factors

a. General. Measurement ton cargo factors are utilized to compute ocean transportation requirements and required shipping capability in support of current and contingency plans and operations. This paragraph contains conversion factors to be utilized in converting the weight of initial equipment and other cargo commodities shown below to cubic measurement for ocean shipping purposes.

## b. Definitions.

(1) Initial equipment. Prescribed TA and TOE equipment deployed with a unit.
(2) MSTS Commodities.
(a) General cargo. Any commodity other than aircraft, ammunition and explosives, reefer, and special cargo as each is defined herein.
(b) Special cargo. All wheeled and tracked vehicles and any commodity which weighs more than 10,000 pounds or measures 35 feet or more in any dimension.
(c) Ammunition and explosives. Bombs fuses, TNT blocks, caps, handgrenades, powder, dynamite, or any other commodity which must be allocated isolated and specialized stowage space in a cargo ship or be carried in an ammunition ship or be loaded and discharged at an ammunition pier because of its highly explosive nature. Does not include small arms ammunition.
(d) Reefer. Perishable commodities such as meats, vegetables, fruits, butter, eggs, and poultry, which require refrigerated (chill or freeze) storage at prescribed temperatures while in transit to prevent deterioration or loss. Does not include semiperishable cargo stored in ventilated holds.
(e) Aircraft. Whole aircraft or complete fuselages whether or not engines are installed. Does not include repair parts, engines, aircraft repair supplies, or boxed aircraft.
c. Factors. Factors are provided for the three major weight categories, i.e., short ton (2,000 pounds), long ton ( 2,240 pounds) and metric ton (2,204.6 pounds).

| Cargo type Me | Measurement tons (40 cubic feet) per Short ton Longton Metricton |  |  |
| :---: | :---: | :---: | :---: |
| Initial equipment | 4.20 | 4.70 | 4.63 |
| MSTS Commodities: |  |  |  |
| General | 2.32 | 2.60 | 2.56 |
| Special | 4.73 | 5.30 | 5.21 |
| Ammunition | 1.04 | 1.17 | 1.15 |
| Reefer | 1.86 | 2.08 | 2.05 |
| Aircraft | 53.70 | 60.14 | 59.19 |
| Weighted Averages: |  |  |  |
| All MSTS Commodities (Excluding aircraft). | 2.5 | 2.8 | 2.76 |
| All MSTS Commodities (Including aircraft) $\qquad$ | 2.6 | 2.9 | 2.87 |

d. Application. For estimating ocean shipping requirements, users should convert weight to measure by applying the appropriate conversion factor shown above to the quantity of each type cargo involved. Only when this is not possible should the weighted average of all commodities be used. It should be noted that because of the large number of aircraft carried above deck the measurement ton is not an accurate measure of shipping space for movement purposes. Therefore, aircraft should be treated separately, if possible, and a weighted average is provided for this purpose.

## 5-54. Computation of Stowage Factor

a. A stowage factor is a relation of cube to weight. As applied to cargo, it is the ratio
of the number of cubic feet of space occupied by the cargo to the weight of the cargo in long tons. The units in which a stowage factor is expressed are stated as cubic feet per long ton.
b. The usual method of obtaining a stowage factor is-
(1) Determine the number of long tons of cargo by dividing 2240 pounds ( 1 long ton) into the number of pounds of cargo. The quotient of this division is then divided into the cubic foot measurement of the cargo, the answer of which equals the stowage factor.

Example:
(2) The above computations can be eliminated by using the stowage factor chart below. Using the figures appearing in (1) above, locate 40,320 in the "pounds" column. You will note that 40,320 pounds equal 18 long tons. Move along the same horizontal line to the right until 2,250 (the measurement of the cargo in cubic feet )is located. Move to the top of this column to find the cargo stowage factor, in this instance 125.

```
1000 cartons of rations weigh 40,320 pounds
18 long tons
18 (long tons) \(\frac{125}{2,250}\) (stowage factor)
        2240/40,320
        125 (stowage factor)
        18 (long tons) /2,250 (cubic measurement)
```

    factor, in this instance 125.
    

## Section VI. MISCELLANEOUS

## 5-55. Approximate Sailing Distances in Nautical Miles

Distances shown below are in nautical miles
because international distances over water are normally expressed in this unit of measure. To convert to statute miles, multiply by 1.15155 ; to convert to kilometers, multiply by 1.85325 .

| Distance from- | Distance to- |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Boston | New York | Charlcston | New Orleans | Los Angcles | $\begin{gathered} \text { Sancisco } \\ \text { San } \end{gathered}$ | Scattle |
| Caribbean and South America: |  |  |  |  |  |  |  |
| Argentina, Buenos Aires | 5,800 | 5,900 | 5,800 | 6,300 | - 8,300 | : 8,700 | ${ }^{4} 9,600$ |
| Brazil, Rio de Janeiro | 4,700 | 4,800 | 4,700 | 5,200 | - 7,300 | " 7,600 | " 8,400 |
| Chile, Valparaiso | ${ }^{\text {a }} 4,800$ | "4,600 | - 4,200 | 4,100 | 4,800 | 5,100 | 5,900 |
| Panama, Panama | 2,200 | 2,200 | 1,600 | 1,400 | 2,900 | 3,200 | 4,000 |
| Puerto Rico, San Juan | 1,500 | 1,400 | 1,100 | 1,500 | " 3,900 | ${ }^{\text {a }} 4,300$ | ${ }^{\text {a }}$ 5,100 |
| Trinidad, Port of Spain | 2,000 | 1,900 | 1,700 | 2,100 | ${ }^{\text {a }} 4,100$ | ${ }^{\text {: }} 4,400$ | ${ }^{-5,300}$ |
| Europe: |  |  |  |  |  |  |  |
| Belgium, Antwerp | 3,200 | 3,400 | 3,800 | 4,800 | ${ }^{4} 7,700$ | ${ }^{\mathrm{n}} 8,000$ | a 8,800 |
| France: |  |  |  |  |  |  |  |
| Bordeaux | 3,000 | 3,200 | 3,700 | 4,700 | - 7,600 | ${ }^{\text {a }} 7$ 7,900 | ${ }^{\text {a }} 8,700$ |
| Brest | 2,900 | 3,100 | 3,500 | 4,500 | - 7,400 | - 7,700 | ${ }^{\text {a }} 8,500$ |
| Le Havre | 3,000 | 3,200 | 3,600 | 4,600 | - 7,500 | ${ }^{\text {a }} 7,800$ | - 8,600 |
| Norway, Oslo | 3,900 | 4,100 | 4,400 | 5,300 | ${ }^{2} 8,200$ | " 8,600 | " 9,400 |
| United Kingdom: |  |  |  |  |  |  |  |
| Belfast | 2,900 | 3,000 | 3,400 | 4,400 | - 7,200 | ${ }^{4} 7,500$ | ${ }^{\text {a }} 8,300$ |
| Liverpool | 3,000 | 3,200 | 3,700 | 4,700 | ${ }^{-7,600}$ | " 7,900 | ${ }^{\text {a }} 8,700$ |
| Southhampton | 3,000 | 3,200 | 3,600 | 4,600 | " 7,500 | ${ }^{\text {a }} 7,800$ | "8,600 |
| Far East: |  |  |  |  |  |  |  |
| China, Shanghai | " 10,800 | ${ }^{\text {a }} 10,600$ | " 10,800 | ${ }^{\mathrm{n}} 10,000$ | 5,700 | 5,400 | 5,100 |
| Formosa, Keelung | " 10,932 | " 10,750 | ${ }^{\text {" } 10,339}$ | " 10,176 | 5,858 | 5,570 | 5,310 |
| Hong Kong | - 11,400 | " 11,200 | " 10,800 | ${ }^{\text {" } 10,600}$ | 6,400 | 6,000 | 5,700 |
| Japan, Yokohama | - 9,900 | " 9,600 | " 9,500 | " 9,100 | 4,800 | 4,500 | 4,200 |
| Korea, Pusan | - 10,547 | ${ }^{\text {a }} 10,365$ | n 9,954 | a 9,791 | 5,229 | 4,914 | 4,649 |
| Okinawa, Naha |  |  |  |  | 6,000 | 5,682 | 5,360 |
| Vietnam, Saigon | ${ }^{\text {b }} 10,586$ | " 12,085 | ${ }^{1} 11,190$ | ${ }^{*} 11,444$ | 7,200 | 6,882 | 6,573 |
| India-Burma-Pakistan: |  |  |  |  |  |  |  |
| Burma, Rangoon | 9,600 | 1) 9,800 | ${ }^{1} 10,200$ | ${ }^{1} 11,200$ | 9,000 | 8,600 | 8,200 |
|  |  |  |  |  | a ${ }^{\text {b }} 13,900$ | a ${ }^{14,200}$ | $\mathrm{a}^{\text {b }} 15,000$ |
| India: |  |  |  |  |  |  |  |
| Bombay | 8,000 | 1. 8,200 | 1) 8,600 | 1. 9,500 | ${ }^{515} 12,200$ | ${ }^{\text {n }}$ - 12,600 | a ${ }^{\text {h }} 13,400$ |
|  |  |  |  |  | 10,300 | 9,800 | 9,500 |
| Calcutta | 9,600 | 1) 9,800 | " 10,200 | ${ }^{1} 11,200$ | $\therefore 13,900$ | a ${ }^{\text {h }} 14,200$ | " ${ }^{\text {b }} 15,000$ |
|  |  |  |  |  | 9,500 | 9,000 | 8,700 |
| Pakistan, Karachi | 7,800 | 1) 8,200 | b 8,400 | 9,300 | 10,700 | 10,200 | 9,900 |
|  |  |  |  |  | " 12,000 | " 12,400 | ${ }^{\prime} 13,200$ |
| Mediterranean: |  |  |  |  |  |  |  |
| Algeria, Algiers | 3,400 | - 3,600 | h 4,000 | b 5,000 | An 7,700 | - 18,000 | - b 8,800 |
| France, Marseilles | ${ }^{\text {b }} 3,700$ | * 3,900 | - 4,300 | 1. 5,300 | * ' 8,000 | " b 8,200 | ab 9,000 |
| Greece, Piraeus | ' 4,500 | - 4,700 | " 5,100 | 1) 6,100 | an 7,800 | $\therefore \mathrm{ab} 8,100$ | $n$ - 8,900 |
| Italy: |  |  |  |  |  |  |  |
| Leghorn | - 3,900 | b 4,100 | 1. 4,500 | 1. 5,500 | " 1] 8,200 |  |  |
| Naples | - 4,000 | b 4,200 | b 4,600 | ${ }^{\text {n }} 5,600$ | "' 88,300 | " ' 8,500 | " 1 9,300 |
| Lebanon, Tripoli | - 4,100 | - 4,300 | 1) 4,700 | b 5,700 | " ' 8,400 | n ${ }^{\text {b }} 8,600$ | - 9,400 |
| Straight of Gibraltar | 3,000 | 3,200 | 3,600 | 4,600 | " 7,300 | " 7,500 | " 8,300 |
| Middle East: |  |  |  |  |  |  |  |
| Aden | b 6,300 | 1. 6,500 | 1) 6,900 | - 7,900 | " 10,600 | ${ }^{3} 10,900$ | - 11,700 |
| Egypt, Port Said | h 4,900 | b 5,110 | ${ }^{1}$ 5,500 | 1. 6,500 | * 9,200 | " 9,500 | ${ }^{*} 10,300$ |
| Iraq, Basra | 1) 8,300 | b 8,500 | .' 8,900 | 1) 9,800 | " 12,600 | " 12,900 | * 13,700 |
| Turkey, Istanbul | b 4,800 | - 5,000 | b 5,400 | b 6,400 | - 9,100 | " 9,400 | ${ }^{4} 10,200$ |

[^34]

Via Panama Canal.
${ }^{b}$ Strait of Gibraltar.

## 5-56. United States Buoyage System (fig. 5-31)

a. Buoys are wooden or metal floats of various shapes, sizes, and colors anchored to the bottom of harbors, bays, rivers, and channels. They are the road markers of the sea. The primary function of a buoy is to warn the mariner of some danger, obstruction, or change in the contours of the sea bottom, and to delineate the channels leading to various points, so that he may avoid the dangers and continue his course safely. The different types of buoys are identified by size, shape, coloring, numbering, and the signaling devices with which they are equipped. They are marked on charts so that the mariner can plot his course to avoid the potential hazards indicated.
$b$. The waters of the United States are
marked for safe navigation by the lateral system of buoyage. This system employs a simple arrangement of colors, shapes, numbers, and light characteristics to show the side on which a buoy should be passed when proceeding in a given direction. The characteristics are determined by the position of the buoy with respect to the navigable channels as the channels are entered from seaward. Not all channels lead from seaward, arbitrary assumptions have been applied at times in order to keep the system consistent, and the operator should consult the aids shown on his chart to determine the seaward direction of a channel. Some mariners use the expression "red right returning" to keep in mind the proper position of these buoys in relation to their vessels. The principal types of buoys are described below:


CAN BUOY
Marking Port Side of Channel From Seaward
nUN BUOY ${ }^{-2}$
Marking Starboard Side of Channel From Seaward


BUOY MARKING OBSTRUCTION
If Top Band Is Red, Keep Buoy To Starboard. If Top Band Is Black, Keep Buoy To Port.


QUARANTINE ANCHORAGE


FISH TRAP OR
net marker


ANCHORAGE
AREA


Figure 5-31. Buoyage system used in United States Waters.
(1) A spar buoy is usually a large log, trimmed and appropriately painted; it may also be constructed of steel plates, joined to form a slim cylinder. The shape of a spar buoy has no significance: it is used for any purpose. Coloring reveals the particular meaning of the buoy.
(2) A can buoy is constructed of steel plates and its shape is similar to that of an ordinary tin can. Normally it is used to designate the port side (entering from seaward), but may be used to mark the middle of a channel, a junction, or an obstruction. Color indicates the particular meaning. A can buoy is never used to mark the starboard side of a channel when entering. from seaward.
(3) A nun buoy is also constructed of steel plates and has a conical top. It is normally used to mark the starboard side of the channel, but may also be used for midchannel, junction, or obstruction marking; the color denotes the particular purpose. A nun buoy is never used on the port side of a channel.
(4) A lighted buoy is a metal float on which is mounted a short skeleton tower with a lantern at the top. It has no shape significance; its purpose is indicated by color.
(5) Bell buoys, gong buoys, and whistle buoys are metal floats with sound equipment installed. No special significance is attached to their shapes.
c. All United States buoys are painted with distinctive colors to indicate their purpose or the side on which they should be passed when entering from seaward.
(1) A black buoy marks the port side of a channel, or the location of obstructions which must be passed by keeping the buoy on the portside of the vessel when entering from seaward. It displays white or green lights at night.
(2) A red buoy marks the starboard side of a channel, or the location of obstructions which must be passed by keeping the buoy on the starboard side. It displays white or red lights at night.
(3) A red and black horizontally banded buoy marks a junction in the channel or an
obstruction which may be passed on either side. If the topmost band is black, the preferred channel will be followed by keeping the buoy on the port side when proceeding from seaward; if the topmost band is red, the preferred channel will be followed by keeping the buoy on the starboard side. This buoy may have white, red, or green lights.
(4) A black and white vertically striped buoy marks the fairway or midchannel, and should be passed close to, on either side. It displays a white light at night.
(5) Special-purpose buoys have distinctive colors and are usually spar buoys. They reveal the locations or anchorage areas, dredging operations, etc.
(6) Buoys used on the Intracoastal Waterway are similar to the preceding ones, but are characterized by a yellow border, and are discussed and illustrated in CG-193.
d. Buoys indicating the starboard side are marked with even numbers; those indicating the port side are marked with odd numbers. Midchannel, junction, and special-purpose buoys are not numbered, but may be lettered for identification. An example is the East Rockaway Inlet Bell Buoy, which carries black and white vertical stripes and the letters ERER standing for the station name.
$e$. Usually only buoys in key spots have lights; some unlighted buoys have reflectors which may be white, red, or green, and have the same significance as lights of the same colors. Black buoys have green or white lights; red ones have red or white lights. Midchannel buoys use white only, while obstruction (junction) buoys use the appropriate color to reveal the preferred channel. Channel buoy lights are usually slow flashing (not over 30 flashes per minute). If they mark important turns or dangerous areas, they will be quick flashing with 60 or more flashes per minute. Red and black horizontally banded buoys have interrupted quick flashing lights-a series of quick flashes with dark intervals of about 4 seconds between series. Midchannel buoys have shortlong flashing lights-groups consisting of a short flash and a long flash repeated at the rate of about eight per minute.

## 5-57. Storm Warning Signals

(fig. 5-32)
a. Small Craft Warning. One red pennant displayed by day or a red light over a white at night indicates winds up to 38 miles an hour ( 61 kilometers per hour) ( 33 knots) and/ or sea conditions dangerous to small craft operations.
b. Gale Warning. Two red pennants displayed by day or a white light above a red light at night indicate winds ranging from 39 to 54 miles an hour ( 63 to 87 kilometers per hour) ( 34 to 48 knots).
c. Whole Gale Warning. A single square red flag with a black center displayed during daytime or two red lights at night indicate winds ranging from 55 to 73 miles an hour ( 89 to 118 kmph ) ( 48 to 63 knots).
d. Hurricane Warning. Two square red flags with black centers displayed by day or a white light between two red lights at night indicate winds 74 miles per hour ( 119 kmph ) ( 64 knots) and above.

## 5-58. Beaufort's Scale

| Beaufort | Description of mind | Milea per hour (statute) | Miles per hour (nautical) |
| :---: | :---: | :---: | :---: |
| 0 | Calm | Less than 1 .. | Less than 1 |
| 1 | Light air | 1-3 | 1-3 |
| 2 | Light breeze | 4-7 | 4-6 |
| 3 | Gentle breeze | 8-12 | 7-10 |
| 4 | Moderate breeze. | 13-18 | 11-16 |
| 5 | Fresh breeze | 19-24 | 17-21 |
| 6 | Strong breeze.. | 25-31 | 22-27 |
| 7 | Moderate gale - | 32-38 | 28-33 |
| 8 | Fresh gale | 39-46 | 34-40 |
| 9 | Strong gale | 47-54 | 41-47 |
| 10 | Whole gale | 55-63 | 48-55 |
| 11 | Storm | 64-75 | 56-65 |
| 12 | Hurricane | Above 75 | Above 65 |

## DAYTIME SIGNALS



## NIGHT SIGNALS

SMALL CRAFT


GALE


Whole gale

hurricane


Figure 5-32. Storm warning signals.

## CHAPTER 6

## PLANNING

Note. The formats included in this chapter have been appropriately condensed for the transportation planner. Normally, these formats apply only in the initial stages of planning. See FM 101-5 for more detailed information and AR 380-5 for classification procedures.

## Section I. ORDERS AND STANDING OPERATING PROCEDURES

## 6-1. Operation Order

COPY No.
Issuing headquarters
Place of issue (may be in code)
Date-time group of signature
Message reference number
Operation order: Type and serial number. (Type is usually indicated in combined or joint operations but omitted within a single service. When required, a code title may also be included.)
References: Maps, charts, and other relevant documents.
Time zone: Used throughout the order; if unnecessary, omit.
Task organization: Task subdivisions or tactical components of the command and names and ranks of the commanders. (When a task organization is not listed, this information is included in paragraph 3 or in an annex.)

1. SITUATION. General information on the overall situation required to understand current circumstances.
a. Enemy forces. Composition, disposition, location, movement, estimated strength, identification and capability.
b. Friendly forces. Information on forces, other than those covered by this order, which may directly affect actions of subordinates.
c. Attachments and detachments. Units attached to or detached from the issuing unit (if not shown under task organization) and effective times. (If shown under task organization, appropriate reference is listed here.)
2. MISSION. A clear, concise statement of the task to be accomplished by the command and purpose of the task.

## 3. EXECUTION.

a. First subparagraph. Concept of the operation, including the commander's general plan for development and phasing of the operation, use of fire support, instructions on preparatory fires, and designation of unit making the main effort.
b. Following subparagraphs. Specific tasks of each element charged with executing tactical missions, including the organization for combat (if not given under task organization).
c. Final subparagraph "Coordinating Instructions." Details of coordination and control measures applicable to the command as a whole, in addition to instructions necessary for coordination or the general conduct of the operation and which apply to two or more elements if repetition in preceding subparagraphs would be cumbersome.
4. ADMINISTRATION AND LOGISTICS. Administrative instructions and method of providing combat service support for the operation, including allocation of critical supply items and special ammunition loads. Reference is made to any administrative order in effect or being issued separately. Subparagraphs following the sequence of the administrative order are included as required.
5. COMMAND AND SIGNAL. Instructions relative to command and operation of signal communications, construction, and photography, including reference to an annex. Includes the index and issue number of signal operations instructions (SOI) in effect, command post locations, designation of alternate command posts and axis of CP displacement. ACKNOWLEDGEMENT INSTRUCTIONS

Commander (name and grade)

## Annexes

Distribution
Authentication

## 6-2. Logistics Annex to Operation Plan or Order

COPY No.
Issuing headquarters
Place of issue (may be in code)
Date-time group of signature
Message reference number
Annex (logistics) to Operation Plan $\qquad$
References: Maps, charts, and other relevant documents.

1. GENERAL SITUATION. Information on the overall situation essential to understanding the logistical plan.
a. Enemy forces. Composition, disposition, location, movement, estimated strength, identification, and capability.
b. Friendly forces. Commanders' responsibilities affecting the logistical plan.
c. Attachments and detachments. Units attached to or detached from the issuing unit and effective times.
d. Assumptions. Assumptions on which the plan is based (normally applicable only to higher planning echelons).
2. MISSION. A clear, concise statement of the task to be accomplished by the command and the purpose of the task.
3. TASK FOR SUBORDINATE UNITS. Separate, lettered subparagraphs giving the specific task or responsibility of each subordinate command.

## 4. MATERIEL AND SERVICES.

a. Supply.
(1) Installations. Instructions to installation commanders on missions, issue and collection of supplies and material, locations and times of opening or closing of installations, operating units, supported units, stocks and levels, credits, and type of storage.
(2) Requirements. General statement on tonnage requirements, levels of supply to be achieved during different periods, and special information on certain items, such as water supply in the area where water is scarce.
(3) Requisition and procurement. Information on normal requisitioning and on local procurement.
(4) Distribution. Instructions on receipts, shipments, and issues.
(5) Civilian supplies. Instructions on issuing supplies to civilians.
(6) Salvage. Instructions on collection, classification, and disposition of salvage.
(7) Captured supplies. Instructions on reports, collection, segregation, and disposition of captured materials.
(8) Responsibilities.
b. Transportation.
(1) General. General information on policies.
(2) Motor. Traffic regulation and control.
(3) Rail. Locations, facilities, capacities, and restrictions.
(4) Water. Ports and beaches in use and to be placed in use, facilities, capacities, and restrictions. (Separate subparagraphs for ocean, coastal, and inland waterways.)
(5) Pipelines. Locations, sizes, capacities, and restrictions.
(6) Air. Airfield capacities and restrictions.
(7) Transportation movements. Instructions for management of the movement capability.
(8) Responsibilities.
c. Support.
(1) Organization. Support groups, trains, and depots; bivouacs and movement of unit trains; assignment or attachment of support units to subordinate units or commands.
(2) Support. Support installations, locations, operating units, and assignments to supported units; special missions, priorities, schedules, and limitations not covered in other orders. (May be divided more simply by types, such as maintenance, construction, utilities, and real estate.)
(a) Chemical. Decontamination and impregnation.
(b) Engineer. Construction, firefighting, maintenance, procurement, real estate, reproduction, and utilities.
(c) Medical. Medical, dental, and veterinary; laboratory, spectacle; special hospitalization, preventive medicine, health, and sanitation.
(d) Ordnance. Inspection, maintenance, procurement, waterproofing, and bomb disposal.
(e) Quartermaster. Bathing and fumigation, labor, laundry maintenance, personal effects service, procurement sales, remount service, and responsibility for salvage and petroleum supply and testing.
(3) Labor. Policies pertaining to the use of civilian (U.S. and non-U.S.) and prisoner-of-war personnel.
(4) Responsibilities.

## 5. MEDICAL: EVACUATION AND HOSPITALIZATION.

a. Evacuation. Dispensaries and clearing stations, locations, times of opening or closing, operating units, and units supported; policies, estimated rates, and channels for evacuation of injured, sick, and wounded, including prisoners of war and civilians.
b. Hospitalization. General instructions for all personnel, including prisoners of war and civilians, policies, locations, and capacities of hospitals.
c. Responsibilities.

## 6. MISCELLANEOUS.

a. Boundaries. Locations-present and proposed.
b. Headquarters. Locations of headquarters and instructions for movement.
c. Security. Instructions for protection and defense of installations and facilities.
d. Area damage control. Measures to reduce damage potential in logistical installations, including instructions pertaining to traffic control (may be issued as an overlay), evacuation, and hospitalization.
e. Reports. Types required, time due, and subject matter covered.
f. Conservation of supplies. General instructions for safeguarding, use, maintenance, and conservation of supplies.
g. Effective date of plan.
h. Responsibilities.

## ACKNOWLEDGMENT INSTRUCTIONS.

Commander (name and grade)
Appendixes
Distribution
Authentication

## 6-3. Administrative Order

(Subparagraphs which do not apply are omitted.)
COPY No.
Issuing headquarters
Place of issue (may be in code)
Date-time group of signature
Message reference number
Administrative order : Type and serial number. (Type is usually indicated in combined or joint operations but omitted within a single service. When required, a code title may also be included.)

References: Maps, charts, and other relevant documents.
Time zone: Used throughout the order; if unnecessary, omit.

1. GENERAL. Outline of the administrative plan; any orders that are not suitably covered by succeeding paragraphs; e.g., location of administrative area in a divisional order (may be issued as an annex or overlay); and traffic circulation plan (may be issued as an annex or overlay.)
2. MATERIEL AND SERVICES. Supplies (normal daily requirements), either by types of supply or by branches of service, transport, transportation services, repair and recovery (maintenance), construction, other services, allocation of labor, etc., in the order suitable to the staff procedures of the army concerned.
a. Supply. Installations concerned with the issue and collection of supplies and material; locations and, where applicable, time of opening or closing; operating units; supported units; stocks and levels; and credits. Instructions on submission of nonroutine reports or temporary changes regarding the submission of routine reports concerning the particular supplies listed; removal, collection, and disposition of, and reports concerning excess, salvage, and captured supplies; overall levels of supply; and methods or schedules of supply distribution. Organized in one of or a combination of the following methods:
Class of supply
Commodity of supply Type of installations
(1) Class I
(2) Class II
(3) Class III
(4) Class IV
(5) Class V
(6) Maps
(7) Water
(8) Special
(9) Excess
(10) Salvage
(11) Captured materiel
b. Transportation. Terminals and installations (rail stations, airfields, ports, and beaches), operating units, schedules (march tables, timetables, and entraining tables), control measures (traffic regulation and control, allocations, priorities, restrictions, route markings, and regulating points). (Items cover the entire transportation field and are not necessarily restricted to Transportation Corps operations.)
(1) Ocean.
(2) Inland waterway.
(3) Coastal.
(4) Motor.
(5) Rail.
(6) Pipeline.
(7) Air.
(8) Miscellaneous.
c. Support.
(1) Organization. Support groups, trains, and depots; bivouacs and movement of unit trains; assignment or attachment of service units to subordinate units or commands.
(2) Support services. Support installations, locations, operating units, and assignments to supported units, and special missions not covered in other orders.
(a) Chemical.
(b) Engineer.
(c) Medical.
(d) Maintenance.
(e) Quartermaster.
(f) Transportation.
d. Labor. Policies pertaining to the use of civilian (non-U.S. and U.S.) and prisoner-of-war personnel.

## 3. MEDICAL: EVACUATION AND HOSPITALIZATION.

a. Evacuation. Dispensaries, collecting stations, and clearing stations; locations, times of opening or closing; operating units; units supported; routes, means, schedules, and responsibilities for evacuation; evacuation and treatment policies.
b. Hospitalization. Hospitals (evacuation, station, general, field, convalescent) ; locations, times of opening or closing; and units supported.
4. PERSONNEL. Reporting procedures, replacement, discipline, law and order, prisoners of war, burials, morale, welfare, civilian employees, etc., in the order suitable to the staff procedures of the headquarters concerned. Under each subparagraph or specific personnel activity the following are listed when applicable: the operating installation, service, or depot; location and hour and date of opening or closing; the units operating the installation; attachment or assignment of operating personnel; the units or areas served; credits or quotas allocated to units; unit responsibility for movement or administration of personnel; reports required; requisitions or plans concerning personnel activities; references to previous orders, instructions, or standing operating procedure.
a. Strengths. Instructions for presenting personnel strengths.
b. Replacements. Requirements (present and anticipated), requisitioning allocating, processing and moving replacements, location and stockage of replacement units, and location of unit replacements.
c. Discipline, law, and order. Troop conduct and appearance, control, and disposition of stragglers, administration of military justice, and relations with civilians.
d. Prisoners of war. Collection, safeguarding, processing, evacuation, utilization, treatment, and discipline.
e. Recovery and disposition of remains. Cemeteries, evacuation, personal effects, and ceremonies.
f. Morale and personnel services.
(1) Morale. General instructions concerning morale.
(2) Personnel services. Leaves, rest and recreational facilities, decorations and awards, postal and finance services, religious activities, personal hygiene, special service activities, Army exchanges, welfare activities, and legal assistance.
g. Personnel procedures. Classification, assignment, promotion, transfer, reclassification, demotion, elimination, retirement, separation, training rotation, and personnel economies.
h. Headquarters management. Movement, internal arrangement, organizational, and operation; allocation of shelter for headquarters personnel.
i. Civilian personnel. Sources, procurement, utilization, administration, control, relation to military government, and relation to troops.
j. Miscellaneous. Personnel matters not specifically assigned to another general staff section.
5. CIVIL AFFAIRS. Allocation and deployment of civil affairs (CA) units, control of refugees, feeding and treatment of civil population, etc.
a. Civil affairs units. Locations of all CA units in area; procedures for requesting support of these units.
b. Government. Establishment of relationship between military and civil authorities; instructions for tactical units on seizure and protection of government offices, records, and personnel; issuance of proclamations, laws, ordinances, and notices.
(1) Law. Jurisdication of legal framework; authorization for closing local, criminal and civil courts; authorization and procedures for military courts.
(2) Public order and safety. Measures for control of, or assistance to, local government to restore public order and safety; collection and disposition of arms, ammunition, explosives, etc.; civil defense and integration of civil defense and military warning systems; control of liquor and narcotics.
c. Economy. Protection and prevention of exploitation of natural resources and other economic necessities.
(1) Commerce and industry. Designation of "Off Limits" areas. Specific responsibilities for safeguarding essential commerce and industry.
(2) Food and agriculture. Procedures for safeguarding agricultural stocks and food supplies; restrictions on troop use.
(3) Price control and rationing. Prevention of black marketing; control of requisitioning and purchasing of civilian supplies.
(4) Property control and protection.
(5) Public finance. Requirements for securing banks and funds; restriction of currency.
(6) Civilian supply. Use of civilian and military supplies for aid to civilians; procedures for distribution.
(7) Labor. Procurement of labor; restrictions on employment of civilians.
(8) Public works and utilities. Reestablishment as required; authorized military use.
(9) Public transportation. Reestablishment as required; authorize military use.
(10) Public communications. Reestablishment, protection, restrictions, and censorship; authorized military use.
(11) Civil information. Control and military use.
d. Public welfare.
(1) Health. Prevention and treatment of disease.
(2) Relief and supply. Minimum requirements for food, clothing, and shelter; provision, if necessary.
(3) Education. Preservation of educational systems and facilities, control measures.
(4) Refugees and displaced persons. Control, care, and disposition; location of facilities; instructions for evacuation requests.
(5) Arts, monuments, and archives. Security and protection.
e. Miscellaneous. Special instructions pertaining to civil affairs not covered above.
6. MISCELLANEOUS. Any special instructions not covered above.
a. Boundaries.
b. Headquarters.
c. Security.
d. Area damage control.
e. Reports.
f. Other administrative and logistical matters.

ACKNOWLEDGEMENT INSTRUCTIONS.

Commander (name and grade)
Annexes
Distribution
Authentication

## 6-4. Transportation Annex to Administrative Order (Sample)

COPY No.
10th U.S. Army
Location: (coordinates)
Time and date: $\qquad$
Annex $\qquad$ (Transportation) to ADMINO No. $\qquad$
References: Maps, charts, and other relevant documents.

1. SITUATION
a. Intelligence report No. $\qquad$ Hq 10th U.S. Army, Dated $\qquad$
b. Operations report No. $\qquad$ , Hq 10th U.S. Army, dated $\qquad$
c. TALOG furnishes necessary rail and water terminal transportation service in support of 10 th U.S. Army.
d. 5th U.S. Air Force furnishes necessary air transportation service in support of 10th U.S. Army.
2. MISSION. Transportation elements will provide transportation service support for assigned and attached troops of 10 th U.S. Army and transportation service support for Air Force units to base level.
3. EXECUTION.
a. 48th Trans Gp (Trk), $\quad$ (coordinates) , furnishes highway transportation service as directed.
(1) 264th Trans Bn (Trk), $\qquad$
(2) 265th Trans Bn (Trk) (coordinates)
(3) 266th Trans Bn (Trk), (coordinates).
(4) 267th Trans Bn (Trk), (coordinates)
(4) 267th Trans Bn (Trk), $\underbrace{\text { (coordies) }}_{\text {(coordinates) }}$.
b. 54th Trans Gp (Trk), $\xrightarrow[\text { (coordinates) }]{ }$, furnishes highway transportation service as directed.
(1) 465th Trans Bn (Trk),
(2) 467th Trans Bn (Trk), (coordinates).
(3) 468th Trans Bn (Trk), (coordinates).
(4) 469th Trans Bn (Trk), (coordinates).
(5) 488th Trans Bn (Trk), $\frac{\text { (coordinates) }}{\text { (coordinates) }}$.
c. 429th Support Gp, $\qquad$ furnishes field maintenance and supply support for Army fixed-wing and rotary-wing aircraft as required.
(1) 233d Trans Bn (TAAM \& Sup, DS),
(2) 234th Trans Bn (TAAM \& Sup, DS), (coordinates).
(coordinates)
(3) 235th Trans Bn (TAAM \& Sup, DS),
(4) 322d Trans Bn (TAAM \& Sup, GS), $\frac{\text { (coordinates) }}{\text { (cordites }}$; operates (coordinates) depot 631, C1 III-A items only, 5-day level; operates depot 632, C1 IV-A items only, 10-day level; supports all Army aircraft maintenance units.
d. 112th Aviation Bn $\qquad$ —.
(coordinates)
(1) Annex G (Army Aviation) to OPORD NO. 3, Hq 10th U.S. Army, dated $\qquad$
(2) Furnishes administrative support to Hq, 10th U.S. Army.
e. 113th Aviation Bn, $\qquad$ :
(coordinates)
Annex G (Army Aviation) to OPORD No. 8, Hq 10 th U.S. Army.
f. 433d Trans Bn (Trk), _ attached to 1st Corps effective $\qquad$ (coordinates)
g. 263d Trans Bn (Trk) $\qquad$ attached to 2d Corps effective $\qquad$ .
h. 463d Trans Bn (Trk), fective $\qquad$ (coordinates)
i. 257th Transportation Center (Movement Control), $\longrightarrow$, manages transportation movements within army area; operates TMOs and maintains liaison with appropriate technical services.
j. Alternate command posts and dispersal areas will be selected and maintained. All transportation units will be prepared to relocate on order.
k. Units will be prepared to perform secondary mission as infantry.
4. ADMINISTRATION AND LOGISTICS.
a. Supply.
(1) Supply levels.
(a) Primary depot- 10 days.
(b) Secondary depot-5 days.
(2) Regulated items.
(a) Aircraft.
(b) All engines and power trains.
(3) Resupply.

Requisition schedule-10th and 25th day each month; equipment out of commission for parts-requisition as necessary.
b. Service.
(1) Transportation: Annex G, 10th U.S. Army SOP.
(2) Loading and unloading: Responsibility of consignors and consignees.

## 5. COMMAND AND SIGNAL.

a. Reports: Annex F, 10th U.S. Army SOP.
b. Army ACofs G-4: $\qquad$ phone $\qquad$ (coordinates)
c. Communications: Annex G, 10th U.S. Army SOP.

ACKNOWLEDGEMENT INSTRUCTIONS

Appendixes
Distribution
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/s/
/t/
ACofS, G-4

## 6-5. Outline for Transportation Standing Operating Procedure for Major Commands

STANDING OPERATING PROCEDURES
(command)

1. PURPOSE. Outline of purpose.
2. SCOPE. Application and coverage.
3. UNIT PROCEDURES. Action required by subordinate units in preparation of unit SOP, including a definite statement that SOP procedures of subordinate units will be based on and conform to the SOP procedures of the issuing command.
4. RESCISSIONS. Any publications superseded or rescinded by the SOP, including fragmentary SOPs, orders, memorandums, bulletins, or other directives.
5. REFERENCES. Publications to be used in conjunction with the SOP.
6. DEFINITIONS. Terms or phrases used in the SOP defined, as required, to insure understanding and correct interpretation.
7. TRANSPORTATION ORGANIZATION. Missions, organizations, and functions (unless published elsewhere) of the following:
a. Office of the transportation officer.
(1) Transportation officer.
(2) Deputy transportation officer or executive officer.
(3) Staff sections.
(4) Liaison officers: United States Air Force, Military Sea Transportation Service, Army, allied, and others.
b. Field installations.
(1) Water terminals.
(2) Transportation supply depots.
(3) Transfer points and other special transportation activities.
(4) Transportation movements branch and other transportation organization.

## 8. ADMINISTRATION.

a. General. Application and implementation of command policies and directives.
b. Correspondence.
(1) Types. Types; instructions for preparing, forwarding, and handling; paper economy measures.
(2) Classified documents. Types of classification and authority to classify; handling, delivery, and receipting methods and procedures; security measures and responsibilities.
c. Personnel.
(1) General. Application and implementation of command policies and directives.
(2) Local civilian labor. Implementation of command policies and administrative procedures for procurement, utilization, and pay; application of provisions of Geneva Convention.
(3) Prisoners of war. Implementation of command policies and administrative procedures for procurement as labor; utilization, treatment, and security; application of provisions of Geneva Convention.
(4) Replacements. Responsibilities and procedures for requisitioning transportation replacements; implementation or elaboration of command policies and directives.
d. Reports. Types and number of administrative reports to be submitted; method and frequency of submissions (samples to be appended); application of reports control procedures.

## 9. INTELLIGENCE

a. General. Purpose and importance of transportation intelligence, transportation intelligence mission, types of intelligence, application of command directives (FM 55-8).
b. Collection of information. Collection agencies, essential elements of information, sources, coordination, collection plan, methods, reporting and disposition of captured enemy material for intelligence purposes.
c. Processing information. Responsibilities and procedures for recording, evaluating, and interpreting information.
d. Dissemination. Policies, methods, criteria, security classifications, transmissions, time considerations.
e. Usage. General application of intelligence to transportation operations and planning; precautions against enemy counterintelligence.
f. Counterintelligence. Objectives, responsibilities, and application to the transportation service.
g. Reconnaissance. Purpose and responsibilities.

## 10. PLANS

a. Transportation requirements. Responsibilities for maintaining current lists of transportation requirements for movement of the unit or its elements by rail, truck, inland waterway, and air.
b. Transport availability. Responsibilities for maintaining current lists of available transportation-organic, assigned, or attached to the unit, including local civilian transportation.
c. Entrucking plans. Responsibilities of subordinate units for maintaining current entrucking plans; designation of vehicles to transport personnel, supplies, and organizational equipment.
d. Traffic circulation plans. Statement that traffic circulation plans will be coordinated with traffic circulation plan of this headquarters.
e. Special operations. Statement that transportation aspects of subordinate troop plans for special operation (e.g., river crossing, pursuit, retrograde movement) will be coordinated with this headquarters.
f. Plans by units in reserve. Statement that plans by these units for forward or lateral movement will be coordinated with this headquarters.
g. Pooling organizational transportation. Procedures, including availability reports, unit responsibilities for furnishing commissioned and noncommissioned officers, maintenance of equipment, and administrative support of personnel.
h. Civil aid. Statement that services and subordinate units will submit plans in advance for movement of civilians and civil aid supplies, but that plans will not be implemented without prior approval.
i. Main supply routes and supply and service installations. Responsibilities and procedures for maintaining up-to-date plans for recommending main supply routes and service installations.

## 11. TRAINING

a. Responsibilities and procedures for preparing and supervising training programs of transportation units.
b. Responsibilities and procedures for exercising technical supervision over transportation training throughout the command.
12. DEFENSE AND DISPERSION. Implementation of command policies and directives; responsibilities of corps transportation units for area of defense; defense against airborne, bacteriological, nuclear, and chemical attack; sabotage; and infiltration and guerrilla warfare; procedures for reporting enemy activity.

## 13. AMPHIBIOUS OPERATIONS

a. General. This SOP standardizes normal procedures in the preparation and execution of amphibious operations and will apply unless otherwise prescribed.
(1) Subordinate units issue SOP to conform.
(2) References.
b. Planning. Consideration must be given to the following:
(1) Requirements of the tactical plan and the scheme of maneuver.
(2) Availability of landing craft and ships by type, size, cargo, personnel capacity.
(3) Establishing and maintaining close liaison with the Navy, the Air Force, and task-force commanders.
(4) Landing force embarkation and tonnage and the breakdown of equipment and supplies as indicated in tables to be submitted by taskforce commanders.
(5) Arranging and coordinating through channels for training appropriate personnel in unit loading and embarkation.
(6) Movement of the embarkation areas and delivery of equipment and supplies, including waterproofing, marking, and palletizing.
(7) Supervision within the embarkation area.
(8) Buildup period for supplies and ship turnaround time.
(9) Alternate logistical procedures or an entire alternate plan to support alternate tactical plans being considered.
c. Movement to the staging area.
(1) Warning orders.
(2) Method of movement-rail, highway, air, water.
(3) Control of movement.
d. Staging area.
(1) Reception.
(2) Spot delivery of equipment.
(3) Control points to control flow of equipment and personnel to embarkation points or assembly areas.

Assembly areas for temporary storage of equipment and supplies to be loaded on transports.
(5) Transportation to haul supplies and equipment from assembly areas to ships.
(6) Areas where final waterproofing can be completed.
(7) Facilities to prepare cargo not already processed for loading.
e. Embarkation of troops.
(1) Movement to embarkation point or assembly areas.
(2) Control of movement to vessels.
f. Movement to objective area. In accordance with naval directives.
g. Ship-to-shore movement.
(1) Debarkation of equipment, supplies, and service troops at the proper time to support tactical operation.
(2) Control and landing of emergency supplies.
(3) Evacuation of casualties by water.
h. Beach organization.
(1) Transportation unit reconnaissance party.
(2) Consolidation of supplies and transportation for subsequent logistical support of the landing force.
3. Control.
(a) Vehicular traffic.
(b) Transfer operations (buildup area).
(4) Communication between beach organization and control vessel and ships.

## 14. INSPECTIONS

a. Reference: SOP of higher headquarters relative to inspections.
b. Purpose.
c. Policy.
d. Types of inspections: vehicle utilization, transportation training, quality of maintenance and maintenance support, efficiency of operations, records system.
e. Frequency.
f. Procedures before making an inspection.
g. Procedures upon completing an inspection.
h. Reports on findings, including a sample format, number of copies, and distribution.
15. AIRBORNE OPERATIONS. Implementation of command policies and directives in establishing responsibilities and procedures for transportation unit participation in airborne operations.
16. COMMUNICATIONS
a. Communications for coordination of transportation.
b. Air-ground communications for coordination of airdrops and land transportation.
c. Reference to communications diagram.

Commander (name and grade)
Annexes
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## 6-6. Outline for Transportation Standing Operating Procedure for Units

STANDING OPERATING PROCEDURES
Unit
TABLE OF CONTENTS
Section I. GENERAL

1. APPLICATION. (Operations to which SOP applies.
2. PURPOSE
3. REFERENCES. (FMs, TMs, SOPs of higher headquarters, etc.)
4. RESPONSIBILITY FOR PREPARATION, CHANGES, REVISIONS
5. EFFECTIVE DATE

Section II. COMMAND, STAFF, LIAISON
6. ORGANIZATION
a. Normal.
b. Special internal attachments and organization.
c. Normal and special external attachments and support.
7. COMMAND POSTS
a. Normal location in relation to next higher headquarters.
b. Reporting change of location-coordinates and time.
c. Forward command posts.
(1) Situation for which required.
(2) How organized.
(3) Personnel and equipment.
8. STAFF DUTIES
a. Special or additional duties of staff officers.
b. Duties of special staff officers.
9. LIAISON
a. Duties of liaison officers.
b. Responsibilities for liaison-higher, lower, and adjacent units.
10. PLANNING RESPONSIBILITY

## Section III. ADMINISTRATION

11. GENERAL CHANNELS
12. REPORTS
a. Routine reports.
b. Special reports.
c. Submission.
(1) Title and reports-control symbol.
(2) Firm of report.
(3) Date due.
(4) Number of copies.
(5) Negative report required or permissible.
13. PROMOTION POLICIES
a. Officer.
b. Enlisted.
c. Battlefield.
14. COURTS-MARTIAL
a. Location jurisdiction.
b. Procedure for submitting cases.
15. MAIL
a. Handling of official mail.
b. Handling of personal mail.
16. LEAVES AND PASSES
a. Policy of command-conduct, VD control.
b. Authority to grant.
17. JOURNALS AND HISTORY
a. Responsibility for unit journal and history.
b. Maintenance of staff section journals.
18. DISTRIBUTION OF MILITARY PUBLICATIONS
19. HANILLING OF PRISONERS OF WAR
a. Reference to FM 19-40 and FM 27-10.
b. Special instructions for capturing unit.
20. AWARDS AND DECORATIONS
a. Channels.
b. Form.
c. Presentation.
21. ORDERS ) FM 101-5)
22. BILLETS AND BIVOUACS
a. Policies-occupation and clearance.
b. Billeting party.

Section IV. MOVEMENT
23. GENERAL (SOP of higher headquarters)
24. MOTOR MOVEMENT (FM 55-9 and FM 55-35)
a. Preparation of vehicles.
b. Motor marches.
(1) Strip maps.
(2) Route reconnaissance.
(3) Messing and refueling.
(4) Night marches.
(5) Makeup of march units and serials.
(6) Distances to be maintained.
(7) Speed and rate of march.
(a) Rate of march for column.
(b) Speed of lead vehicle.
(c) Permissible speed to catch up.
(d) Time length of march unit or serial.
(8) Posting of traffic guards during halt.
c. Movement by infiltration.
d. Conduct of personnel during movement.
(1) Passengers.
(2) Drivers.
25. VEHICLE AND EQUIPMENT OPERATIONS
a. Motor pool.
(1) Dispatch.
(2) Service.
(3) Maintenance.
b. Regulations for administrative vehicles.
26. RAIL MOVEMENTS
a. Action by S1—Movement policy.
b. Action by S 2.
(1) Reconnaissance report.
(2) Security.
c. Action by S3.
(1) Troop list.
(2) Coordination of loading plan.
(3) Transportation movement teams.
d. Action by S4.
(1) Initiation of transportation request.
(2) Provision for troop and guard mess.
(3) Procurement of blocking and dunnage.
(4) Preparation of shipping documents.
(5) Determination of rolling stock required.
(6) Preparation of loading schedules and area.

## 21. AIR MOVEMENT

a. Action by S1.
b. Action by S2.
c. Action by S3.
(1) Determination of craft required.
(2) Coordination of loading plan.
(3) Preparation of loading schedule and areas.
(4) Explanation of air-transportability technique.
d. Action by S 4 .
(1) Initiation of transportation request.
(2) Determination of availability of tiedown devices or material.
(3) Preparation of weight-of-equipment data for loading computation.
(4) Preparation of shipping documents.
(5) Determination of quantity and types of vehicles required to load and unload aircraft.
28. WATER MOVEMENT
a. Action by S1-Movement policy.
b. Action by S2.
(1) Reconnaissance report.
(2) Security.
c. Action by S3.
(1) Troop list.
(2) Coordination of loading plan.
(3) Transportation movement teams.
d. Action by S4.
(1) Initiation of transportation request.
(2) Provision of troop mess.
(3) Preparation of shipping documents.
(4) Determination of shipping required.
(5) Preparation of loading schedule and area.

## Section V. SECURITY

29. GENERAL: POLICIES AND RESPONSIBILITIES
30. SECURITY DURING MOVEMENT
a. Air guards.
b. Manning of vehicular weapons.
c. Camouflage during halts.
d. Advance, flank, and rear guards.
e. Action to be taken in case of attack.
(1) Air.
(2) Mechanized.
(3) Troops and guerrillas.
(4) Nuclear, biological, chemical.
31. SECURITY IN BIVOUAC
a. Camouflage.
b. Mines and boobytraps.
c. Placement of weapons in case of attack.
(1) Air.
(2) Mechanized.
(3) Troops and guerrillas.
(4) Nuclear, bacteriological, chemical.
d. Joint security.
e. Security plans.
f. Sentry posts and outposts.
32. ATTACK WARNING SIGNALS
a. Air.
b. Airborne.
c. Mechanized.
d. Troops and guerrillas.
e. Nuclear, biological, chemical.
33. FIRE SAFETY AND FIRE FIGHTING
a. Plans.
b. Fire personnel and duties.
c. Safety rules (motor pool, kitchen, etc.).
34. ALERT PLANS
a. Unit plan.
b. Alert roster.
c. Armament and equipment.
d. Phase system for alert warnings.
35. DESTRUCTION OF EQUIPMENT

Section VI. COMMUNICATIONS
36. AVAILABLE MEANS
37. ESTABLISHMENT OF COMMUNICATIONS
a. Organic communications.
b. Area communications support.
c. Responsibilities.
38. COMMUNICATION PROCEDURES
a. Voice radio.
b. Radio/wire integration (RWI).
c. Message.
d. Visual and sonic.
e. Reference to SOI and SSI of higher headquarters.
39. SIGNAL MAINTENANCE RESPONSIBILITIES
a. Commander.
b. Signal/Communications Officer.
c. Operators.
d. Users.

## Section VII. RECONNAISSANCE, INTELLIGENCE, AND COUNTERINTELLIGENCE

40. RECONNAISSANCE. Essential elements of information.

## 41. COMBAT INTELLIGENCE

a. Definition of "spot reports."
b. "Spot reports" required:
(1) Initial contact with enemy.
(2) Marked change in enemy disposition or situation.
(3) Attack by armored, air, or airborne forces.
(4) New units identified.
(5) Enemy strength, composition, and movement.
(6) Location of enemy installations.
(7) Use of chemicals or new weapons.
(8) New materials or equipment.
42. COUNTERINTELLIGENCE
a. Mail censorship.
b. Blackout discipline.
c. Information to be given if captured.
d. Signs and countersigns.
e. Destruction of classified documents.
f. Civilian control.
g. Secrecy discipline.
h. Information to press representatives.
43. CLASS I SUPPLY
a. Ration pickup.
b. Daily ration return and ration cycle.
c. Reserve rations carried.
(1) By unit.
(2) By individual.
d. Responsibility for attached units.

## 44. WATER

a. Authorized source.
b. Purification by expedient methods.
c. Water economy.
45. CLASS II AND IV SUPPLY
a. Requisition days for various services.
b. Pickup procedure.
c. Salvage turn-in procedures.
d. Droppage by battle-loss certificate.
46. CLASS III SUPPLY
a. Resupply.
b. Fuel reserve.
47. CLASS IIIA SUPPLY
a. Resupply.
b. Fuel reserve.

## 48. CLASS V SUPPLY

a. Method of requisitioning.
b. Forms used and certificates required.
c. Basic load.
d. Salvage.
49. MAINTENANCE OF VEHICLES AND EQUIPMENT
a. Category of maintenance.
b. Responsibility of maintenance officer.
c. Forms used.
d. Priorities.
50. REPAIR PARTS
a. Method of requisitioning.
b. Maintenance of stock levels.
c. Inspections of maintenance and levels.
d. Parts and equipment record.
51. EVACUATION CHANNELS FOR VEHICLES AND EQUIPMENT

By order of $\qquad$

Adjutant (name and grade)
Annexes. (May include Wearing of the Uniform, Reports Formats, Destruction of Classified Documents, Duties of Staff Officers, Staff Section SOPs, Loading Plans, Alert Plan, etc.)
Distribution
Authentication

## 6-7. Division Embarkation Order

Issuing unit
Place of issue (may be in code)
Hour and date of issue

File No.
Embarkation Plan No.
Maps: (Those needed for understanding the plan.).
References: (SOPs, operation order, administrative order, and other relevant material.).

## 1. ORGANIZATION FOR EMBARKATION

a. Troop list for each embarkation group. (May be issued in form of annex.)
b. Assignment of each embarkation group to shipping, schedule showing berthing of ships, date and hour loading will begin, and date and hour embarkation will be completed by each embarkation group; other information pertinent to the embarkation group; other information pertinent to the embarkation schedule may be included. (May be issued in form of annex.)
c. Advance parties.
(1) Composition.
(2) Functions.
(3) Movement to embarkation point. (Reference to SOP if applicable.)

## 2. SUPPLIES AND EQUIPMENT TO BE EMBARKED

a. Amounts and types of supplies and equipment to be embarked.
b. Preparation of supplies and equipment for embarkation. Reference may be made to appropriate SOP.
c. Allocation of division supplies and equipment to cargo assembly areas. (May be issued in form of annex with appendixes.)

## 3. EMBARKATION POINTS AND CARGO ASSEMBLY AREAS

a. Assignment of embarkation points and cargo assembly areas for loading. (May be in the form of a map, sketch, or overlay, and issued as an annex.)
b. Preparation of embarkation points and cargo assembly areas for loading; construction or improvement of exits and facilities in the embarkation area.
c. Assignment of mechanical loading devices, such as forklift trucks, cranes, roller conveyors, warehouse pallets, etc.

## 4. CONTROL

a. Establishment and functions of embarkation control office. (Functions may be covered in SOP.)
b. Traffic circulation and control system in embarkation area and between embarkation area and base camp.
c. Establishment of security posts for prevention of fire, sabotage, and pilferage in cargo assembly and deck areas.
d. Communications for embarkation. (References may be made to SOI.)

## 5. MOVEMENT AND EMBARKATION OF PERSONNEL

a. Schedule and method of movement from base camp.
b. Schedule and instruction for embarkation.

## 6. MISCELLANEOUS

a. Embarkation responsibilities and tasks. Responsibility of embarkation group commanders and tasks of officers, such as supply officer, motor transport officer, unit loading officer, etc.
b. Special loading instructions. Stowage of certain types of cargo, handling of fragile or dangerous items, etc.
c. Miscellaneous instructions not covered elsewhere.

## ACKNOWLEDGEMENT INSTRUCTIONS

By Command of Major General
s/Colonel, U.S. Chief of Staff

Annexes:
ALPHA—Organization of Embarkation Groups-Assignment of Shipping.

BRAVO-Loading Schedule.
CHARLIE-Supplies and Equipment to be Embarked.
DELTA—Embarkation Points and Cargo Assembly Areas. (Others as necessary.)

DISTRIBUTION :
OFFICIAL
s/Lt Col, U.S., ACofS, G4

## Section II. INTELLIGENCE

## 6-8. Transportation Intelligence

Transportation intelligence is the product resulting from the collection, evaluation, interpretation, analysis, and integration of all available information about air, land, and water transportation systems which are of immediate or potential military significance. Intelligence includes data on the characteristics, condition, development, organization, materiel, operation, maintenance, and construction of transportation systems and facilities. These data are essential to strategic, logistical, and tactical planning. Formats for recording and reporting transportation information and intelligence are shown in FM 30-16.

## 6-9. Transportation Intelligence Estimate

a. General. Transportation intelligence estimates are studies that describe, discuss, and apply interpreted data that, directly or indirectly, concern the transportation mission. These estimates are used by commanders in making sound and timely decisions and are part of the overall transportation estimate used to formulate the transportation plan. Since intelligence estimates are made after all available information has been collected and processed, they must be kept current by revision when new or additional information is received and processed. Estimates must be disseminated to appropriate planners in sufficient time to be useful. If there is not enough time for making and publishing of formal trans-
portation plans, intelligence estimated may be disseminated directly to the ultimate usersthe operating units.
b. Elements Considered. An estimate does not necessarily contain all of the elements listed below; content depends upon the transportation mission.
(1) Statement of the transportation mission.
(2) Characteristics of the area of operations and how they will affect this mission.
(a) Weather and climate: temperatures, wind conditions, rainfall, tide and river conditions, and a complete aeronautical weather forecast.
(b) Terrain features: critical terrain features, any obstacles known or suspected, soil trafficability, offshore gradient of beaches, surf, etc.
(c) Road and rail nets, including traffic bottlenecks: available lines of communication, capacity, condition, damage, repair work necessary.
(d) Bridges and tunnels: possible bottlenecks, such as bridges, tunnels, ruling grades, etc.
(e) Port and beach facilities and wharves.
(f) Airfields and other aircraft facilities.
(g) Inland waterways, locks, ports.
(h) Warehouses and other storage facilities.
(3) Characteristics of enemy transportation equipment.
(a) Locomotive characteristics and inventory.
(b) Freight and passenger equipment characteristics and inventory.
(c) Vehicle characteristics and inventory.
(d) Crane data.
(e) Waterway craft (inland waterway and oceangoing) characteristics and inventory.
(f) Aircraft characteristics and inventory.
(4) Transport capability of the enemy: air, water, motor, rail, miscellaneous. Include the enemy's capabilities to attack, defend, delay, withdraw, and reinforce, and probable areas involved, strengths, etc. Indicate how the transportation mission could be affected by each capability of the enemy, including such items as lines of communication apt to be lost or gained through enemy's use of each capability and increase or decrease in tonnage capability. (This could be done in an annex which lists probable' effect of each capability on each mode.)
(5) Conclusions, including effect of the intelligence estimate on U.S. and friendly forces.

## Section III. TRANSPORTATION ESTIMATE AND PLAN

6-10. Transportation Estimate TRANSPPORTATION ESTIMATE


Maps: (Sheet name, number, scale, and unit of measure series.)

1. MISSION. Mission of the command and of the transportation units in support of the tactical and logistical mission of the command. (May be obtained from orders from a higher headquarters or deduced from instructions or knowledge of the situation and may be expressed in terms of personnel and/or tons of cargo to be transported, discharged, and/or outloaded.)

## 2. THE SITUATION AND CONSIDERATIONS

a. Intelligence situation. Refer to pertinent intelligence estimate.
b. Tactical situation.
(1) Refer to current operation order.
(2) Present and planned disposition of major friendly tactical elements, with emphasis on those units defending lines of communication or transportation units and operations; effect of planned troop moves on transportation operations.
(3) All possible courses of action open to the command to accomplish the assigned mission.
(4) Concept of projected operations once the immediate mission is accomplished.
c. Logistical situation.
(1) Refer to current administrative order or overlay.
(2) Status of supplies and equipment in all transportation organizations of the command, highlighting any inadequacies.
(3) Any projected developments likely to affect the ability of transportation units to perform their mission from the logistical standpoint.
(4) Status of supplies and equipment in other support units to be employed in logistical support of transportation operations which might adversely affect accomplishment of the mission.
(5) All possible logistical courses of action, and the affects of each on possible friendly tactical courses of action.
d. Personnel situation.
(1) Refer to current administrative order or overlay.
(2) Status of personnel in all transportation units, including state of morale and any other considerations likely to have a bearing on their performance.
(3) Status of personnel in other support units to be employed in logistical support of transportation operations which might adversely affect accomplishment of mission.
e. Assumptions. Logical assumptions may be made when a sufficient amount of factual information is not available for the preparation of the estimate.
f. Transportation situation. All known information, as detailed as possible, on each mode of transportation activity.
(1) Transportation situation by modes. The format shown in (a) below should be modified as required for (b) through (j).
(a) Rail. Tabulate as shown.

|  |  | Strength <br> Actual | Facilities <br> Actual- | Equipment | Capability <br> Actual- |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Unit | Location | Auth | Required | Lacking | Potential |

(b) Motor.
(c) Inland waterway.
(d) Air.
(e) Water.
(f) Transportation movements.
(g) Staging areas.
(h) Transportation depots.
(i) Pipelines (even though not operated by transportation units).
(j) Troop carrier space.
(2) Transportation units courses of action. All courses of action open to transportation units for each possible logistical course of action set forth in c(5) above.
g. Special factors. Any other factors which might influence the choice of a course of action or the ability to perform mission, both from the transportation standpoint and from the overall view of the mission.
3. ANALYSIS. Statement and analysis of the effects of each logistical course of action listed in paragraph $2 \mathrm{c}(5)$ above on each mode of transportation.
a. Course of action.

| Mode of <br> activity | Effect on <br> personnel | Effect on <br> equipment | Effect on <br> facilities | Effect on <br> capabilities |
| :--- | :--- | :--- | :--- | :--- | *Same modes of activity as $2 \mathrm{f}(1)$ above.

b. Alternate course of action. Outline of alternate course (s) of action, if possible.

## 4. COMPARISON

a. Dominant transportation factors and modes most likely to be used.
b. A comparison, based on the information in paragraph 3, of the various logistical courses of action, including their effects on each mode and their capabilities thereof. (Through this weighing of advantages and disadvantages, the most favorable course of action from the transportation standpoint can be determined.)
c. Feasibility of the use of the various lines of communication, ports, and beaches in comparison with enemy capabilities, weather, terrain, etc.

## 5. CONCLUSIONS

a. Statement indicating whether the mission (para 1 above) can be accomplished from the standpoint of transportation support.
b. Statement indicating which of the possible logistical courses of action can best be supported from the transportation standpoint.
c. Statement calling attention to any considerations required should alternate courses of action be chosen.
(1) Number and type of transportation units required over and above those available for each course of action if mission cannot be supported.
(2) Personnel and/or equipment shortages in existing units which would prevent accomplishment of mission.
(3) Any repairs or construction work essential to successful accomplishment of the mission from the transportation standpoint.
(4) Any other transportation considerations which should be brought to the attention of the commander.


## Annexes

Distribution

## 6-11. Transportation Plan

(Any of the paragraphs and subparagraphs below may consist wholly, or in part, of references to the appropriate annexes, and the annexes in turn may be amplified by properly referenced appendixes. Each transportation mode should have a separate annex.)
TRANSPORTATION PLAN
(Number)

Transportation Section (Unit)
(Location)
(Date-time group)
Maps and references: Sheet name, number, scale, and unit of measure, series shown for each map. Other references include city plans, navigation charts, other plans bearing on the transportation plan, etc.

Task organization: Annex A, Task Organization.

## 1. SITUATION

a. Enemy forces. All capabilities of the enemy to hinder, disrupt, or otherwise affect the operations of the transportation units and other elements of the command, including such items as damage to lines of communications, use of mass destruction weapons, etc. (Annex B, Intelligence.)
b. Friendly forces. Units to be supported, location and strength, with emphasis on those units engaged in protection of lines of communication and transportation units or activities, including higher, adjacent, and supporting units of both U.S. and allied forces.
c. Characteristics of the area of operations.
(1) Weather. Temperatures, wind conditions, rainfall, tide and river conditions, aeronautical weather information, etc.
(2) Terrain and hydrography. Critical terrain features, soil trafficability, beach gradients, any known obstacles, and possible effect on the transportation modes.
(3) Lines of communication. All lines of communication and physical condition.
d. Attachments and detachments.
e. Assumptions and policies. Any pertinent policies and logical assumptions needed in preparing the plan; for example, proposed locations of major unit boundaries, troop strengths to be supported in different phases of the operation, etc.
2. MISSION. Mission of transportation units in support of the command.

## 3. EXECUTION

a. Concept of operation. The transportation officer's overall concept of the operation, including probable increases in supported units, additional territory to be supported, etc. (Annex C, Concept of Operations.)
b. Rail. Specific tasks assigned rail units. (Projected loads, schedules, facilities, lines of communication, etc., are best submitted in the form of an annex to the plan.)
c. Motor.
d. Air.
e. Water.
f. Inland waterway.
g. Transportation movements.
h. Staging areas.
i. Transportation depots.
j. Pipelines (even though not operated by transportation units).
k. Troop carrier space. Proposed use of air capacity allocated to the command although transportation organizations do not assign tasks. (As indicated in $\mathbf{b}$ above, similar information for each mode of transportation is best submitted in the form of an annex to the plan, the format of which should parallel that of the plan itself so far as practical.)

1. Coordinatong instructions.
(1) Defense and security. Reference to appropriate SOP or defense plan.
(a) Individual.
(b) Facilities.
(c) Lines of communication.
(d) Shipments.
(e) Censorship.
(f) Communications.
(2) Counterintelligence. Annex B, Intelligence.
(3) Technical intelligence. Annex B, Intelligence.
(4) Effective time and date.

## 4. ADMINISTRATION AND LOGISTICS

a. Administration.
(1) Policies. References to paragraph 1c above.
(2) Procedures. SOPs and related guides of higher headquarters not covered elsewhere in the plan.
(3) Required reports.
b. Logistics.
(1) Transportation supply. The following times are covered by reference to current SOPs when applicable.
(a) Levels of supply.
(b) Replacement factors and consumption rates.
(c) Requisition procedures and cycles.
(d) Emergency requisition procedures.
(e) Local procurement.
(f) Controlled items.
(g) Surplus material.
(h) Captured material.
(i) Salvage and scrap.
(j) Interservice supply.
(k) Class IV equipment.
(1) Equipment out of commission for parts procedures.
(2) Supply support of transportation mission by other services.
(3) Transportation maintenance. Maintenance facilities, indicated by mode, shop locations, and responsibilities of each maintenance unit.
c. Personnel.
(1) Policies.
(a) Use of local civilian personnel.
(b) Use of prisoners of war.
(c) Use of U.S. civilian personnel.
(2) Strengths.
(3) Replacements.
(4) Procedures.
5. COMMAND AND SIGNAL
a. Annex-Signal.
b. Command.
(1) Location of CPs of major commands.
(2) Locations of transportation movements branches.

ACKNOWLEDGMENT INSTRUCTIONS.

Commander (name and grade)
Annexes
Distribution
Authentication

## 6-12. Feasibility Test for Transportation Plan

## 1. GENERAL

a. This test is prepared to enable transportation staff planners to check the feasibility of a transportation plan (annex to administrative orders, letter of instructions, etc.) after the plan has been prepared.
b. The test has been prepared in checklist form. Paragraph 2 gives general considerations which apply to all modes of transportation, and the
remaining paragraphs lists items which apply to a specific mode. Some items which appear in the remaining paragraphs may seem to belong under the general paragraph; however, these items represent abnormal conditions which may have a drastic effect on that mode.
c. In using the checklist, consider the items listed in paragraph 2 for each mode in addition to the paragraph that applies to that mode.

## 2. GENERAL CHECKLIST ITEMS

a. Calculated risks. Calculated risks involved. Effect on the mission. Governing factors.
b. Weather and terrain. General considerations. Favorable or adverse effect on the mission.
c. Enemy action. Consideration of enemy guerrilla action, clandestine action, etc.
d. Political and economic situation. Interference with local economy: Friendly or unfriendly attitude of the civil population.
e. Transportation net. Integration of elements of the transportation net. Portions of the net reserved for civilian use. Emergency procedures for joint civil-military use. Engineer construction service support of the present net and future operations.
f. Allocation and utilization of modes. Optimum utilization of transport capacity. Utilization of supporting services' capacities. Allocation to modes of tasks commensurate with their capabilities and equipment. Adequate provisions for retrograde cargo.
g. Logistical support of operations. Support of modes in sufficient quantity and time to accomplish the mission; e.g., POL products, repair parts, etc.
h. Task organization.
(1) Clear definition of command relationships, missions, and functions.
(2) Troop list assignments consider
(a) Strength.
(b) Training.
(c) Morale.
(d) Available transport equipment.
i. Local civilian and prisoner-of-war labor. Availability of civilian and prisoner-of-war labor in the skills required. Requirement for mobile civilian labor units for phase II and phase III operation. Adequate administrative and logistical support.

## 3. MOTOR TRANSPORT

a. Requirements versus capabilities.
b. Traffic circulation plan
(1) Road net supports planned traffic.
(2) Requirement for additional highway regulation personnel.
(3) Adequate road repair and road maintenance support.
(4) A designation of routes (restricted, dispatch, etc.).
(5) Possible joint use of road net; i.e., can both combat forces (U.S. and/or allied forces) and civilian traffic use it simultaneously?
(6) Availability of hardstand, maintenance areas, truck parks, relay stations, transfer points.
(7) Marked routes, availability of marking signs.

## 4. RAIL

a. Requirements versus capabilities.
b. Unusual weather or terrain factors
(1) Are heavy rains due that may cause washouts, floods, or landslides?
(2) Is extreme subfreezing weather due?
c. Engineer maintenance and construction support for rehabilitation or for major repair of rail line.
d. Yards, roundhouse, repair shops.
e. Suitable water and fuel supplies (if steam locomotives are to be used).
f. Limiting factors:
(1) Bridge, weight, and clearance.
(2) Tunnel clearance.
(3) Roadbed and trackage.
(4) Rolling stock-condition, power, gage.
(5) Locomotives-condition, power gage.
(6) Train operations communications.

## 5. INLAND WATERWAY

a. Check requirements versus capabilities.
b. Weather and terrain. Freezeup or flood periods, tidal ranges. currents, fogs.
c. Obstructions. Low bridges, types of drawbridges. Natural obstructions such as heavy weeds that might foul propellers.
d. Locks. Locks controlled by assigned permanent personnel or the individual inland-waterway craft. Size of locks, time to pass through.
e. Channels. Required maintenance. Size, depth, and width.
f. Navigational aids. Sufficient fixed or mobile navigational aids for full utilization, day and night.
g. Requirement for intermediate transfers.
h. Condition of available craft.
i. Marine inland-waterway repair and maintenance support.
j. Inland-waterway facilities, docks, cranes.

## 6. PORTS AND BEACHES

a. Check requirements versus capabilities.
b. Port facilities :
(1) Floating cranes for heavy lifts.
(2) Piers, docks, warehouses, open ground areas.
(3) Road and rail nets.
(4) Navigational aids.
(5) Protected anchorage areas.
(6) Utilities (electricity, etc.).
(7) Harbor craft.
(8) Berth space, lengths, and depths.
c. Beach facilities:
(1) Anchorage areas.
(2) Routes of ingress and egress.
(3) Road and rail nets.
(4) Hardstand and open ground areas.
(5) Equipment (forklifts, cranes, etc.).
d. Weather and terrain:
(1) Ports:
(a) Tides and currents.
(b) Underwater obstructions.
(2) Beaches:
(a) Tides, currents, surf, gradient, tidal range.
(b) Underwater obstructions.
7. TRANSPORTATION MOVEMENTS
a. Sufficient teams accomplish transportation movements mission.
b. Adequacy of transportation movements plan to accomplish the mission. Flexibility or rigidity.
c. Location of teams located for maximum utilization.
d. Establishment of documentation procedures insure accomplishment of mission.
8. STAGING AREAS
a. Capability of processing planned workloads.
b. Adequate facilities.
9. TRANSPORTATION DEPOTS
a. Ability to support the mission.
b. Adequate facilities.
10. AIR
a. Check requirements versus capabilities.
b. Marginal weather :
(1) Low ceilings.
(2) Low visibility.
(3) Ice conditions (on ground) determining maintenance and time required to melt, plus closed hangar area.
(4) Temperatures to be encountered.
c. Terrain: Altitudes to be encountered (temperature and altitudes affect lift capabilities).
d. Navigational aids:
(1) Possibility of day and night operations.
(2) Ground stations:
(a) Ground controlled approach (GCA).
(b) Radio range.
(c) Instrument landing systems.
(d) Omnidirectional range (Omni range).
(e) Radar plotting station.
(3) Airborne navigational equipment.
e. Communications: Adequacy of unit communications, augmentation required.
f. Restrictions to flight:
(1) Maintenance of established air routes, including consideration of fire lanes.
(2) Degree of air superiority.
(3) Arrangements for weather reports from Air Force.
g. Adequacy and location of landing sites or airfields, plus facilities at such locations.
h. Maintenance :
(1) Condition of aircraft (number of hours previous operation).
(2) Maintenance units available.
(3) Repair parts available.
(4) Location and stock of depot support.
i. Degree of training of supported units in use of logistical air support.

## 11. FLEXIBILITY

a. Provision for rerouting or diversion.
b. Interchange points.
c. Transfer points.
d. Substitution of one mode for another.
e. Capability of handling emergency transportation tasks.

## CHAPTER 7

## MISCELLANEOUS

## Section I. THE TRANSPORTATION BRIGADE

## 7-1. General

The transportation brigade is a major subordinate unit of the field army support command (FASCOM) (fig. 7-1). It provides Army-wide transportation service primarily in support of the field army supply and replacement distribution system. However, at the direction of the field army commander, it may also provide tactical mobility transport. The FASCOM commander controls all allocation and use of the brigade's transport capability through the FASCOM movements program. (For detailed information concerning the transportation brigade, see FM 55-9.)

## 7-2. Mission

The mission of the transportation brigade is to provide the following services to all users of transportation in the field army.
a. Long-haul motor transport and, as required, local delivery of personnel and cargo.
b. Airlift capability for select cargo, person-
nel replacements, and patient evacuation, as required.
c. An augmentation for the operation of the field army highway traffic regulating system.
d. Movement planning and management for the field army.
e. Terminal transfer services, as required.
$f$. Transport for airdrops of personnel and material, as required.

## 7-3. Capabilities

The transportation brigade, with its assigned units, has the following approximate daily transport capabilities.
a. Movement of 1,350 tons of cargo by air.
b. Movement of 13,000 tons of cargo by motor transport in long-haul operations (para 7-4).
c. Transfer of 2,700 tons from one carrier to another. (Included in this capability is the temporary holding of in-transit cargo.)

## 7-4. Unit Capabilities (TOE) of Transportation Truck Companies ${ }^{1}$

| Type of truck company | TOE | Type ofcquipment | Pieces of equipment authorized | Pieces of equipment available | Local hauls |  | Line haul |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\begin{gathered} \text { Trips } \\ \text { day } \end{gathered}$ | Ton or gallons per day | Trips per | Tons or gallons per day |
| Light | 55-17 | 21/2-ton truck | 60 | 45 | 4 | 720 | 2 | 360 |
|  |  | 5 -ton truck | 60 | 45 | 4 | 1,080 | 2 | 540 |
| Light-medium | 55-67 | 5-ton tractor | 10 | 7 |  |  |  |  |
|  |  | 12-ton stake and platform trailer. | 20 | 14 | 4 | 360 | 2 | 192 |
|  |  | 21/2-ton truck | 60 | 45 | 4 | 720 | 2 | 384 |
| Medium | 55-18 | 5-ton tractor | 60 | 45 |  |  |  |  |
|  |  | 12-ton stake and platform trailer. | 120 | 90 | 4 | 2,160 | 2 | 1,080 |
|  |  | 5,000-gallon tank semitrailer | 60 | 45 | 4 | 900,000 | 2 | 450,000 |
|  |  | $71 / 2$-ton reefer semitrailer ${ }^{2}$ | 60 | 45 | 4 | 1,080 | 2 | 540 |
| Heavy | 55-28 | 10-ton tractor | 24 | 18 |  |  |  |  |
|  |  | 50-ton transporter ${ }^{2}$ | 24 | 18 | 4 | 2,880 | 2 | 1,440 |

[^35]: Tonnage factors are based on average payload capacities for general planning.


Figure 7-1. Transportation brigade.

Temperature Chart for Artic and Subartic Areas

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| ermine ${ }^{\text {e }}$ | ${ }_{60}^{0}$ | － | －-50 | －＋14－ | － 55 | ＋29 | －45 | ＋ |  | ＋198 | － | － | （tio | $\xrightarrow{+14}$ | －+3 |  | ＋30 |  | 边 | ${ }_{4}$ | （10 | － | － | － | － 50 | $\stackrel{\substack{\text {＋24 } \\+1 \\ \text {＋2，}}}{ }$ |  |  |  |  | （12．5 |
| itar | ${ }_{64}^{64}$ | －12 | －50 | ＋99 | －56 | ${ }_{\text {coser }}^{+29}$ | －35 | $\stackrel{+}{+24}$ | － | － | － | － | $\xrightarrow[\substack{+25 \\+25}]{\substack{\text { a }}}$ | $\substack { \text { H4，} \\ \begin{subarray}{c}{4 \\ \hline{ \text { H4，} \\ \begin{subarray} { c } { 4 \\ \hline } } \end{subarray}$ | 边 |  | ＋ist |  | ＋115 | ＋is | ${ }_{\text {－}}^{-25}$ |  | － 30 |  | $\begin{gathered} -40 \\ -50 \\ -50 \end{gathered}$ |  |  | （in | cien | \％ | co．90．9 <br> 10.9 <br> 12.0 |
|  |  | 20 | －60 | $\xrightarrow{\substack{\text {＋24 } \\ \text { 20 }}}$ | －60 | ¢12 | － 60 | $\stackrel{+}{+9}$ | － | － | － | ＋14 | $\xrightarrow[\substack{\text {＋12 } \\+25}]{ }$ |  | $\underset{\substack{\text { cis } \\+35}}{\substack{\text { a }}}$ |  | － |  | － | $\xrightarrow{+78}$ | － |  | － | $\xrightarrow{\substack{29 \\+29}}$ | － 60 | － |  | ${ }^{15} 13.3$ cec－m | cis．o． | Ve8．0．0 | citi． |
|  |  | ${ }_{45}^{15}$ | －is |  | － 50 | ＋34 | ${ }_{-45}^{40}$ | ＋39 | ${ }_{-30}^{+130}$ | ${ }_{+39}^{+34}$ | － | ＋ 74 | ${ }_{\text {＋}}^{+2}$ | ＋90 | $\underset{\substack{735 \\+30}}{ }$ | $\xrightarrow{79}$ | ＋23 | $\underset{+}{+94}$ | ＋15 |  | － 5 | $\xrightarrow{+74}$ | －35 |  | $\begin{aligned} & -.60 \\ & -35 \\ & -35 \end{aligned}$ | $\underset{\text { t34 }}{\substack{4.4 \\ 4 \\ 4}}$ | ${ }^{33} \mathbf{3} 5$ | 12．03 | cis |  | （in |
|  | 178 | ${ }^{30}$ | － 4.4 |  | － | ${ }_{+6}^{+19}$ | －35 | ＋9 | － | ＋39 | ${ }_{-15}^{-5}$ | ${ }_{7}+39$ | $\stackrel{+20}{+10}$ | $\underset{\substack{+9 \\+54}}{ }$ | $\xrightarrow[\substack{+30 \\+25}]{\substack{\text { a }}}$ | ${ }_{\substack{4 \\ 7 \\ 7 \\ \hline \\ \hline}}$ | ${ }_{\text {＋}}^{+25}$ | ＋6 | －10 | ＋4． | －30． | ${ }_{1+39}^{+39}$ | －25 |  | －35 | ， | 14．0（mar） | ${ }^{\text {S }}$ | cis | 3．5 | （5i．9 |
| By |  | ${ }^{14}$ | － |  | － | $\stackrel{1}{+24}$ | －35 | $\stackrel{46}{+4}$ | － | ＋+59 | － | ＋ | － | － 59 | $\xrightarrow{+35}$ |  | $\underset{\substack{\text { tis } \\+30}}{ }$ | ＋8 | －15 | ＋+9 | －25 | ＋29． | ${ }_{-35}^{-45}$ | $\stackrel{+24}{+24}$ | － 50 | ＋14 | 51.4 （Jan） | 12.34 （coct | （sion |  | 管1．5 |
|  |  | ${ }^{30}$ | － |  | －－5s |  | －40 | ＋29 | － | $\pm$ | － | ＋ic | $\stackrel{+}{+25}$ | ${ }_{+9}^{+74}$ | $\pm$ | ＋74 | ＋+35 | ${ }_{\text {＋}}^{+19}$ | ＋15 | $\stackrel{+69}{+64}$ | －20 | － | －35 | －39 | －40 | $\stackrel{\text { tras }}{\substack{\text {＋34 }}}$ |  | 49.20 （Jan | S |  | （14．5 |
|  |  | ${ }_{2}^{43}$ | － | － | － |  | － 5 | ＋19 | － | ＋2 | －15 |  | ＋120 | ＋59 | $\stackrel{+30}{+30}$ | ＋ | ${ }_{725}^{+15}$ | ＋ | －${ }^{\circ}$ | ＋4 | －25 |  | － 55 | $\stackrel{\substack{\text {＋29 } \\ \text {＋29 }}}{ }$ | －56 | ＋ | 25：．${ }^{\text {chay }}$（ | \％ | 30．0 | 1．0 | 4．4．0 |
| 边 | 边 | ${ }^{48}$ | －iso |  | － |  |  |  |  | － | $\stackrel{+}{+20}$ | cots | +25 <br> +30 <br> ＋25 |  |  | － | $\xrightarrow[\substack{\text {＋20 } \\+35}]{\substack{\text { a }}}$ |  |  | $\xrightarrow[\substack{+9 \\+9}]{\substack{19}}$ | $\begin{array}{r}\text {－20 } \\ +5 \\ +5 \\ \hline\end{array}$ | $\substack {+59 \\ \begin{subarray}{c}{+5{ + 5 9 \\ \begin{subarray} { c } { + 5 } } \end{subarray}$ | － 40 |  | － 50 | $\underset{4}{+9}$ |  | ${ }_{\text {cosem }}^{15.55}$ | cois 50.0 | 9．5．5 | Sis．5． |
|  | ${ }_{74}^{65}$ | ${ }^{37}$ | －25 | ＋ | －10 | $\stackrel{+39}{+9{ }^{+19}}$ | ${ }_{-35}$ | $\pm$ | ${ }_{-20}$ | ＋54 | ＋15 | $\pm$ | $\stackrel{+}{+35}$ | $\pm$ | ＋30 | $\xrightarrow{+14}$ | ＋ | ＋59 | 25 | ＋ | $\pm$ | ＋99 | $\bigcirc$ | ＋54 | － 20 | ＋4．4． |  |  |  |  |  |
| ， |  | ${ }_{15}^{46}$ | － | $\underset{\substack{+36 \\+39}}{ }$ | － |  | －30 | $\stackrel{\text {＋19 }}{+18}$ | － | ＋29 | －$+1{ }^{\text {c }}$ | － | ＋155 | － | － | ＋ | ＋20 |  |  | $\pm$ | －20 |  | － | $\xrightarrow{+29}$ | － | － |  |  |  |  | ¢ |
| coin | 6 | $\underset{\substack{10 \\ 25 \\ 43}}{\substack{\text { a }}}$ | － |  | － |  | －40 | ＋ |  | － |  | － | $\begin{aligned} & +350 \\ & +30 \\ & +20 \end{aligned}$ | － | $\begin{aligned} & +\begin{array}{l} +35 \\ +25 \\ +25 \end{array} \end{aligned}$ | ＋ | ＋+20 | ＋ | ＋25 |  | －10 | $\pm$ |  | ${ }_{\text {＋}}^{49}$ | － 40 | ${ }_{+29}$ |  | 边 |  |  | 18．0 |
| Toor |  | ${ }^{25}$ | － | ＋ | 隹－35 | $\xrightarrow{+34}$ | －30 | ＋ | －15 | ${ }_{4}+3$ | ＋ | 4 | ＋25 | ＋4． | ${ }_{+25}^{+25}$ | ＋ | $\stackrel{\substack{\text {＋25 } \\+20}}{ }$ | ＋ | ＋30 | $\stackrel{+9}{+9}$ | ＋10 | $\xrightarrow{+54}$ | ${ }_{-25}$ |  | ${ }_{-20}$ | $\underset{\substack { \text { tic } \\ \begin{subarray}{c}{4 \\ \hline{ \text { tic } \\ \begin{subarray} { c } { 4 \\ \hline } } \\{\hline}\end{subarray}}{ }$ | 43.3 （ mar ） | 7．38（（sep－Apr） |  |  | 80．0 |
|  |  | － | － 40 | $\underset{49}{79}$ |  |  | － | cois |  | cis | － | － | ＋ | $\underset{\substack{\text {＋} \\+9 \\ \hline}}{\substack{4}}$ | － | － | ＋ |  | － | ＋24 | －10 | － | － | cois | －35 | cis | ${ }_{10}^{10.6}$ | itis |  |  | cois |
| Seeravic－． | ${ }^{62}$ | ${ }_{4}^{132}$ | －25 | ＋39 | － | $\stackrel{+89}{+98}$ | －30 |  | －20 | $\xrightarrow{4}$ | ${ }_{+15}$ | cict | ＋ |  | $\underset{\substack{+3 \\+30}}{\substack{\text { a }}}$ |  |  | ＋59 |  |  | $\xrightarrow[\substack{20 \\+15 \\ \text {＋10 }}]{ }$ | $\xrightarrow{\substack{4.4 \\ 4 \\ 4 \\ 4}}$ | －36 |  | － |  | － |  |  |  |  |
|  | ${ }_{65}^{64}$ | $\stackrel{8}{16}$ | － | ${ }_{\text {c }}^{+54}$ |  | $\left.\right\|_{\substack{\text {＋54 }}} ^{+59}$ | ＋s | ＋49 | $\stackrel{+15}{+15}$ | $\pm 4$ | $\stackrel{+15}{+20}$ | $\xrightarrow{+84}$ | ＋30 | $\stackrel{+}{+7}$ | （40 | $\underset{\substack{+6 \\+74}}{\substack{ \\\hline}}$ | ＋ | ${ }_{+74}^{+64}$ | ＋30 | $\stackrel{+64}{+79}$ | ＋15 | $\xrightarrow[\substack{+59 \\ 54}]{ }$ | ＋10 | ${ }_{+59}^{+59}$ | ＋10 | ＋+54 | 4．0．（mar） | $14.08($ Oct－May $)$ |  |  | cois $\begin{aligned} & 30.0 \\ & 20.0\end{aligned}$ |

## Section II. CAPABILITIES OF TRANSPORTATION MEDIUMS

## 7-5. Tonnage Requirements and Transportation Capabilities

For methods used to determine tonnage requirements, see FM 101-10. The figures given below are approximate and are to be used as guides only.

| Medium | Tone per day |  | Adequate to maintain |
| :---: | :---: | :---: | :---: |
|  | STON | LTON |  |
| Highway: ${ }^{\prime}$ |  |  |  |
| Gravel | 3,400 |  | 2 divisions |
| Medium condition | 5,800 |  | 4 divisions |
| First-class | 8,400 |  | 7 divisions |
| Railway, each way: |  |  |  |
| Single track | 4,000 | 3,570 | 3 divisions |
| Double track | 12,000 | 10,700 | 9 divisions |
| Gasoline pipeline: ${ }^{2}$ |  |  |  |
| 6 -inch | 2,000 | 1,790 | 5 to 8 divisions |
| 4 -inch | 930 | 830 | 3 divisions |
| Water terminal discharge rate: ${ }^{8}$ |  |  |  |
| Average cargo ship | 720 | 643 | $1 / 2$ division |
| Across beach: |  |  |  |
| Per 1,000 yards of beach | 1,680 | 1,500 | 1 division plus |

[^36]
## 7-6. Animals

a. Dogs.
(1) Trained dogs may be used individually or in teams to transport cargo in arctic and subarctic areas. They also have limited use in temperature zones to carry messages and small packages of mail, usually in regions inaccessible to other means of transport. Dogs should be permitted to rest 10 minutes in each hour and should not be worked continuously for more than 16 hours per day. For planning purposes, towed loads should not exceed 100 pounds per dog although the heavier breeds are capable of loads of 200 pounds per dog on a flat surface with good traction. The Eskimo dog, or husky, is the one most commonly used in arctic and subarctic regions.

The German shepherd usually is used in temperate zones. The figures below are for normal operating conditions and vary widely under extremes of weather and terrain.
(2) On packed snow with good traction, an individual dog in a sled team has the following cargo-carrying capabilities. On soft snow, load and speed must be reduced 50 percent.

| , | Pounds of load per dog ${ }^{3}$ | Distance in hour ${ }^{2}$ |  |
| :---: | :---: | :---: | :---: |
|  |  | Km | miles |
| Flat | 50 | 9.6 | 6 |
| Hilly | 50 | 4.8 | 3 |
| Mountainous | 50 | 1.6 | 1 |

(3) On hard surfaces with good traction, an individual dog has the following capabilities for carrying cargo packs, messages, and mail.

| Terrain | Pounds of load per dog |  |  | $K$ | Distance in hour |  | Messagcs or mail |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Cargo pack | Messagcs or mail |  |  |  |  |  |
|  |  |  |  | Mi | Km | Mi |  |
| Flat | 35 |  | percent |  | 3.2 | 2 | 24 | 15 |
| Hilly | 30 |  | of dog's | 3.2 | 2 | 16 | 10 |
| Mountainous | 25 |  | weight | 1.6 | 1 | 8 | 5 |

[^37]b. Pack Mules.
(1) Height: 59 to 62 inches.
(2) Weight: 1,000 to 1,200 pounds.
(3) Rate of march: 3.5 to 4 miles ( 5.6 to 6.4 kilometers) per hour.
(4) Capacity: 200 to 250 pounds.
(5) Movement of casualties: 1 litter or 2 sitting casualties.
(6) Forage: 10 pounds of oats and 14 pounds of hay per day. May be reduced for short periods up to 10 days without impairing capacity.
(7) Water: 10 gallons per day.
(8) Noneffective rate: 3.2 percent.
(9) Average daily distance:
(a) Mountains terrain- 12 miles (19 kilometers).
(b) Rolling or flat terrain-24 miles (39 kilometers).
(10) Gradeability :
(a) Rate of ascent- 1,650 vertical feet ( 503 meters) per hour.
(b) Rate of descent-1,000 vertical feet ( 305 meters) per hour.

## c. Transportability.

## Vehicle

Capacity (horscs or mules)
Trailer, 2-horse van .-.-.-.... 2
Truck, $11 / 2$-ton, cargo ......... 2
Truck, $2 \frac{1}{2}$-ton, cargo ...-.... 4
Semitrailer, 6-ton, combina-
tion animal and cargo ..... 8
Railroad stock car, 40-foot . . 25, approximately Railroad stock car, 36-foot _ - 20 to 22, approximately Airplane, cargo transport .... 4 to 6*
d. Horse-Drawn Carts. Capable of traveling 20 miles ( 32 kilometers) per day drawing a payload of 1,000 pounds.

## 7-7. Human Bearers

For planning purposes, the following may be assumed.
a. Average Cargo Loads.
(1) Male bearer- 80 pounds.
(2) Female bearer- 30 to 35 pounds.
b. Personnel Loads. 8 to 12 bearers per litter team.
c. Rate of March. For average conditions on level terrain- 12 miles per day. To estimate the time needed to cover a given distance in hilly or mountainous areas, use the following relationship. For these conditions, cargo loads shown in $a$ above, should be reduced from 20 to 30 percent, depending upon steepness of the terrain.

$$
T=t+a+d
$$

where:

$$
\begin{aligned}
& T=\text { total time required } \\
& t=\text { time required to march a given map } \\
& \quad \text { distance } \\
& a=\frac{\text { total ascent in feet during march }}{1,000} \\
& d= \text { total descent in feet during march } \\
& 1,500
\end{aligned}
$$

*May be transported at altitudes up to 18,000 feet with no ill effects.
d. Overloading and Speed-Up. Overloading and speeding up operations increase the sick rate and cause desertion.
e. Noneffective Rate. Approximately 30 percent.
f. Supervision. Close supervision is required to prevent pilferage.

## Section III. DIMENSIONS AND WEIGHT DATA

## 7-8. Unit Equipment

TB 55-46 provides staff command and field organizations with validated dimensions, weight, and cube of Army vehicles and equipment for standard reference use in planning and in the submission of movement require-
ments to transportation agencies. The data presented are inaccordance with the requirements of MILSTAMP (DOD Reg 4500.32R) for uniform and standard transportation data applicable to all cargo movements in the Department of Defense transportation system.

## 7-9. Packaged Missiles and Other Special Ammunition

| Weapon |  | Container dimensiona (in.) |  |  | $\begin{gathered} \left.\left.C_{(c u b f}^{u}\right)_{f t}\right) \end{gathered}$ | Gross weight <br> (b) | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Container and contents | Length | Width | Height |  |  |  |
| Hawk | Complete round | 216 | 28 | 42 |  | 3,270 |  |
|  | Guidance section | 90 | 29 | 34 |  | 715 | Data applicable only when guidance section is shipped separately. |
|  | Igniter, rocket motor | $291 / 4$ | 193/16 | 1811/32 | 5.96 | 155 | Packed 24 in wooden box. |
|  | Safety and arming device, GM XM32E4 and XM326 | $281 / 6$ | 141/16 | $1025 / 32$ | 2.46 | 72.3 | Packed 8 in wooden box. |
|  | Igniter electrical power unit .-- | $171 / 8$ | $123 / 16$ | $1031 / 32$ | 1.32 | 35 | Packed 24 in wooden box. |
|  | Propellant grain, EPU -----. | $241 / 8$ | $1515 / 16$ | 14 7/32 | 3.16 | 65.6 | Packed 24 in wooden box. |
|  | Propellant grain, inert EPU .-. | $241 / 8$ | $1515 / 16$ | 14 7/32 | 3.16 | 65.6 | Packed 24 in wooden box. |
|  | Explosive release device ------ | $311 / 8$ | 23 9/16 | $103 / 32$ | 4.32 | 54.5 | Packed 24 in wooden box. |
|  | Accumulator, hydraulic, pneumatic (squib activated) | 20 | 20 | 29 | 6.50 | 88 | Packed 1 to metal drum. |
|  | Guidance section -------------- | 90 | 29 | 34 | 51.35 | 715 | Metal shipping container. Data applicable only when guidance section is shipped separately. |
| Nike-Ajax | Warhead, M2 | $151 / 4$ | 77/8 | 10 | 1.7 | 35.42 | Wooden box (2 per box). |
|  | Warhead, M3 | $281 / 4$ | $131 / 2$ | $163 / 8$ | 3.6 | 212 | Wooden box (1 per box). |
|  | Warhead, M4 | 26 5/8 | 123/4 | $161 / 8$ | 3.2 | 153 | Wooden box (1 per box). |
|  | Body, guided missile: M2 or M2E1 | 266 | $381 / 4$ | 41 | 240.4 | 2,495 | Reusable metal container (1 per metal container M326). |
|  | Fin, rocket motor, M12------- | $421 / 4$ | $403 / 4$ | $123 / 4$ | 12.6 | 166 | Wooden box ( 3 per box). |
|  | Fin, control and stabilizer ---- | $761 / 4$ | 22 1/8 | 27 | 26.5 | 220 | Wooden crate ( 4 M9 fins and |
|  | Rocket motor, M5, packed in container M13 or M13A1 w/thrust structure, M2 and igniter M24 or M65 or M69 | 177 | 251/4 | $311 / 2$ | 81.5 | 1,883 | 4 M10 fins per crate). Wooden crate. |
|  | Igniter, rocket motor, M24 or M65 or M69 | $251 / 8$ | $161 / 4$ | 171/8 | 4.0 | 202 | Wooden box (18 per box). |
|  | Antenna: frequency band pass.- | 42 3/8 | $111 / 4$ | $203 / 4$ | 5.7 | 81 | Wooden box. |
|  | Battery: BB401/U | 19 5/16 | 13 | 10 5/8 | 1.5 | 65 | Wooden box (4 per box). |
|  | Delay line ----------------- | 18 | 141/2 | 8 | 1.2 | 41 | Wooden box. |
|  | Explosive harness assembly guided missile | 243/4 | 15 | $81 / 4$ | 1.7 | 36.5 | Wooden box (10 per box). |
| Nike-Hercules | Body section, guided missile, fore and aft | 223 1/2 | $543 / 4$ | 61 1/2 | 435.5 | 4,606 | Reusable container, metal, M410. |
|  | Warhead section, GMHE, M135 with warhead M17 (T45) or M17A1 (T45E1) | $991 / 4$ | 54 3/8 | 61 1/2 | 192.1 | 3,170 | Reusable container, metal. |



Battery (thermal), BA605/U -Battery and switch assembly for rocket motor, M26, 318 mm rocket, M51

Charge spotting M93 for warhead "practice," M8, 318mm rocket, M51 $\qquad$
Explosive harness assembly, M90 and 318 mm rocket, M51
Fuze, rocket, MT, M421
(T-2075E1), 318 mm rocket,
$\qquad$
Igniter, rocket motor, M57 for 318mm rocket, M51 -------Primer assembly, warhead, M8 Igniter, rocket motor, M57

Warhead section, XM477 .....

Rocket motor, M26 for 318 mm rocket, M51
$\qquad$
Honest John
Rocket motor, 762 mm , M3
 fins, M17 .---------------
Rocket motor, 762 mm , M66A1 w/4 fins, M17
 Rocket motor, 762 mm , M6 w/ igniter ----------------------
Rocket motor, 762 mm , M7 series $\qquad$

| $297 / 8$ | $1011 / 16$ | $927 / 32$ | 1.7 | 40 | Wooden box (12 per box). |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $213 / 4$ | $151 / 4$ | $155 / 8$ | 3.0 | 100 | Wooden box (20 per box). |
| $251 / 4$ | 19 15/16 | 11 | 3.3 | 115 | Wooden box (20 per box). |
| $457 / 18$ | $31 / 2$ | $31 / 2$ | . 32 | 54 | Metal case (1 per case). |
| 39 | $261 / 16$ | $103 / 32$ | 6.0 | 85 | Wooden box (100 per box). |
| 49 5/8 | $61 / 6$ | $625 / 32$ | 1.2 | 23.1 | Wooden box (1 per box). |
| $503 / 16$ | $101 / 2$ | $115 / 32$ | 2.9 | 88 | Wooden box (4 per box). |
| 100 | $281 / 2$ | $341 / 2$ | 59.60 | 948 | Packed in reusable metal container, M8 and M8E1. |
| 141 | 39 | 45 | 143.83 | 2,120 | Packed in reusable metal container, M948. |
| 239 1/2 | 41 1/2 | 49 | 281.85 | 6,538 | Wooden crate. |
| 235 | 42 1/8 | 49 | 269.26 | 5,883 | Wooden crate. |
| $1981 / 16$ | 41 5/8 | $473 / 8$ | 206.05 | 4,801 | Wooden crate. |
| 205 | 34 | 38 | 153 | 4,740 | Wooden box. |
| 19 1/2 | 10 1/8 | 12 5/8 | 1.4 | 66 | Wooden box packed 8 per lumber sheathed container. |
| $145 / 8$ | $131 / 16$ | 19 | 2.10 | 55.70 | Wooden box packed 4 per lumber sheathed container. |
| 146 | 49 5/8 | $561 / 2$ | 236.9 | 1,922 | Wooden crate. |
| 146 | 49 5/8 | $561 / 2$ | 236.9 | 3,410 | Wooden crate. |
| 605/8 | $163 / 4$ | $497 / 8$ | 29.31 | 345 | Wooden box. |



| Sergeant (Cont) | Body section, guided missile X.M38 w/warhead (training) . - | $1461 / 2$ | 41 | $503 / 4$ | 175 | 3,000 | Reusable steel container, XM481. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Rocket motor --------------- | 220 1/8 | 47 1/8 | 481/8 | 288.9 | 8,890 | Reusable steel container, XM486. |
|  | Body section (guidance) AN/ DJW-8 | $1071 / 4$ | $471 / 8$ | 473/8 | 138.56 | 2,170 | Reusable steel container, XM487. |
|  | $\begin{aligned} & \text { Control surface assembly, } \\ & \text { XM94 } \end{aligned}$ | $551 / 2$ | $381 / 8$ | 125/8 | $151 / 8$ | 172 | Reusable aluminum container, XM123E1. |
| Pershing | Warhead section w/ or w/o inert or empty warhead | 168 | $511 / 2$ | 53 | 260 | 2,596 | Packed in reusable metal container XM483. |
|  | Guidance control section, GM --- | 90 | 65 | 72 | 235 | 2,532 | Packed in reusable metal container, XM474. |
|  | First stage rocket motor, GM .-- | 145 | 65 | 70 | 381.8 | 9,193 | Packed in reusable metal container, XM475. |
|  | Second stage rocket motor, GM - - | 145 | 65 | 70 | 381.8 | 7,365 | Packed in reusable metal container, XM476. |
|  | Case venting | 50 | 7 | 12 | 2.4 | 32 | Packed in reusable metal container, 2 each per container. |
| SS11 | Complete round | 40 | 28 | $241 / 2$ | 6 | 157 | Wooden crate. |
| SS11/B1 | Complete round | 36 | 191/4 | 203/4 | 8.3 10.4 | 110 | Fiberglass container. <br> Shipping and storage con- |
| Redeye | 3 complete rounds | $551 / 4$ | $211 / 4$ | 201/4 | 10.4 | 144 | tainer, GM system XM547 (tripak). |
| Shillelagh | Complete round | 51 | $143 / 4$ | $143 / 4$ | 6.4 | 709 | Metal container. |
| Entac .-. | Complete round | 31 | 15 | $153 / 8$ | 4.1 | 112 | Wooden container. <br> Wooden box (weight is classi- |
| Davy Crockett . | Complete round .-----.-.-.-.-- | $373 / 4$ | 16 | 16 | 5.6 | --- | fied). |
| XM454 projectile. | Complete round | 57 | 22 | 20 | 14.5 | 220 |  |

## 7-10. Materials Handling Equipment

The items of materials handling equipment listed below are those normally used by terminal service personnel. For the most part, these items are authorized by TOE or TA. The straddle trucks listed in $f$ below normally are
not transportation TOE or TA items, but may be obtained by special authorization when needed. For more complete information, see TM 10-1619.
a. Forklift Trucks. (Gasoline power, pneumatic tires.)

| Capacity$(l b)$ | $\begin{gathered} \text { Life } \\ \text { height } \\ \text { (in.) } \end{gathered}$ | $\begin{aligned} & \text { Free } \\ & \text { lift } \\ & \text { (in.) } \end{aligned}$ | Fork <br> length (in.) | Load center (in. from heel) | Weight (lb) | Dimensions (in.) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Height | Length | Width |
| 3,500 | 144 | ---- | -- | 24 | 6,770 | 108 | 120 | 78 |
| 4,000 | 144 | 22 | 40 | 24 | 7,660 | 95 | 104 | 45 |
| 6,000 | 168 | $63 / 4$ | 40 | 24 | 10,375 | 115 | 113 | 68 |
| 10,000 | 210 | 2 | 48 | 24 | 14,145 | 150 | 136 | 77 |
| 15,000 | 210 | $21 / 2$ | 48 | 24 | 18,330 | 150 | 152 | 96 |

b. Rough-Terrain Forklifts.

| Capacity (lb) | $\begin{aligned} & \text { Lift } \\ & \text { (in.) } \end{aligned}$ | Fork length (in.) | Gradcability (percent) | Turning radius (ft) | Lift tilt (degrees) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | Forward | Back | Left-right |
| 6,000 | 144 | 48 | 45 | 15 | 45 | 30 | 10 |
| 10,000 | 144 | 60 | 45 | 17 | 45 | 30 | 10 |

c. Warehouse Tractors. (Gasoline power, pneumatic tires.)

| Drawbar |  |  |  |  | ions (in.) |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| pull | Towing capacity (tone) | Loaded speed $(\mathrm{mph})$ | $\begin{gathered} \text { Weight } \\ \text { (lb) } \end{gathered}$ | Height | Length | Width |
| 4,000 | 90 | 12 | 5,220 | 57 | 111 | 66 |
| 7,500 | 200 | 9.47 | 12,386 | 72 | 130 | 96 |

d. Warehouse Cranes. (Gasoline power, pneumatic tires.)

| Capacity <br> $(l b)$ | Sluing range | Loaded speed <br> $(m p h)$ | Weight |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 10,000 | $180^{\circ}$ | 15 | $(l b)$ | Didth | Lenensions (in.) |  |
| 10,000 | $180^{\circ}$ | 12 | 20,800 | 95 | 295 | Height |
|  |  |  | 20,000 | 260 | 94 |  |

e. Warehouse Trailers.

| $\begin{gathered} \text { Capacity } \\ (l b) \end{gathered}$ | Tires |  | Construction | $\begin{gathered} \text { Length } \\ \text { (in.) } \end{gathered}$ | Width (in.) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 4,000 | Steel or rubber | Wood | -- | 72 | 36 |
| 4,000 | Steel or rubber | Wood | ------ | 84 | 36 |
| 4,000 | Steel or rubber | Wood |  | 84 | 48 |
| 6,000 | Pneumatic | Wood |  | 108 | 48 |
| 20,000 | Solid rubber | Steel |  | 144 | 72 |

f. Straddle Trucks. (Gasoline power, pneumatic tires, four-wheel steering.)

|  |  |  | Dimensions (in.) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Capacity <br> (lb) | Loaded speed <br> $($ mph $)$ | Weight <br> (lb) | Height | Length | Width |
| 30,000 | 35 | 12,500 | 114 | 187 | 92 |
| 30,000 | 35 | 13,250 | 123 | 187 | 92 |
| 30,000 | 35 | 13,000 | 124 | 188 | 105 |
| 30,000 | 35 | 14,800 | 159 | 192 | 96 |

g. Crawler and Truck-Mounted Cranes. The chart below gives ratings and clearances and can be used to determine lifting capacity for different boom lengths and positions. The actual lifting capacity of any particular crane, for a given boom length and position, can be found on the vehicle nameplate or in the vehicle technical manual. The letters used in the chart indicate the following:


## 7-1.1. Telephone Poles



Transverse breaking loads (lb)



Western and northern cedars are furnished butt-treated; pine is treated full length. To estimate required shipping space, use the following formula.
$R=$ Radius (horizontal distance between end of boom and center of rotating table) in feet
$A=$ Angle in degrees that boom makes with the horizontal
$C=$ Lifting capacity in pounds
$D=$ Distance in feet and inches between top of boom and ground
$\frac{\text { Average weight (lb) } \times \text { constant }}{40}=$ measurement tons
Values of the constants are: Cedar-0.052
Pine-0.026

## Section IV. COLD WEATHER DATA

## 7-12. Sled Train

a. Power Vehicle Specifications.


## b. Sled Specifications. ${ }^{1}$

| Characteristics | 1-ton recon sled |  | $\begin{gathered} \boldsymbol{\varepsilon} / 2-\operatorname{ton} \\ \text { farm } \text { sled } \end{gathered}$ | $\begin{gathered} \text { 10-ton } \\ \text { steel }{ }_{3} \text { skis } \end{gathered}$ | 10-ton ATACO Micarta skis | $\begin{gathered} \text { Fuel } \\ \text { transporter } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1952 | 1953 |  |  |  |  |
| Gross weight (lb) | 1,225 | 1,390 | 1,375 | 7,000 | 7,000 | 10,271 |
| Cubic feet | 75 | 128 | 282 | 1,367 | 1,460 | 403.92 |
| Dimensions: |  |  |  |  |  |  |
| Length | $10^{\prime} 9^{\prime \prime}$ | $13^{\prime} 101 / 2^{\prime \prime}$ | $15^{\prime} 8^{\prime \prime}$ | 22' $\mathbf{4}^{\prime \prime}$ w/o | $22^{\prime} 4^{\prime \prime}$ | $24^{\prime}$ |
| Width | $5^{\prime}$ | $7^{\prime} 11 / 2^{\prime \prime}$ | $7^{\prime} 2^{\prime \prime}$ | $8^{\prime} 6^{\prime \prime}$ | $8^{\prime} 6^{\prime \prime}$ | $10^{\prime}$ |
| Height | $1^{\prime} 5^{\prime \prime}$ | $1^{\prime} 4 \%^{\prime \prime}$ | $2^{\prime} 6^{\prime \prime}$ | $\begin{aligned} & 7^{\prime} 3^{\prime \prime} \text { to top } \\ & \text { of stakes } \end{aligned}$ | $7^{\prime \prime} 8^{\prime \prime}$ to top | $4^{\prime} 6^{\prime \prime}$ |
| Capacity | 2,000 lb | 2,000 lb | $21 / 2$ tons | 10 tons | 10 tons | 3,021 gal. |

[^38]c. Wanigan Specifications. A wanigan is a small house, normally constructed of plywood, lumber, and insulating material; usually
mounted on runners; and transported in trac-tor-drawn sled trains. Interior designs vary; it may be used as a kitchen, shop, bunkhouse, etc.

| Characteristics | Command. | $\underset{M 5 \Omega}{\substack{\text { Passenger. }}}$ | Passenger, M54 | $\underset{M 55}{C_{o m m a n d}}$ | $\underset{M 5 s}{C r e w .}$ | Crew mess. M54 | $\underset{M 55}{\text { Crew, }}$ | $\begin{gathered} M e 88 \\ M 55 \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Weight, empty (lb) - | $\begin{aligned} & 10,500 \\ & \text { (est) } \end{aligned}$ | $\begin{aligned} & 10,500 \\ & \text { (est) } \end{aligned}$ | $\begin{aligned} & 11,400 \\ & \text { (est) } \end{aligned}$ | 15,000 | $\begin{gathered} 16,000 \\ \text { (est) } \end{gathered}$ | 18,000 | 19,000 | 19,000 |
| Cubic feet | 1,560 | 1,560 | 1,870 | 2,600 | 3,310 | 2,868 | 3,790 | 3,790 |
| Dimensions: |  |  |  |  |  |  |  |  |
| Length | $20^{\prime}$ | $20^{\prime}$ | $24^{\prime}$ | $26^{\prime}$ | $35^{\prime}$ | $45^{\prime}$ | $38^{\prime}$ | $38^{\prime}$ |
| Width | $10^{\prime}$ | $10^{\prime}$ | $10^{\prime}$ | $12^{\prime}$ | $8^{\prime} 7$ ' | $8^{\prime} 6^{\prime \prime}$ | $12^{\prime}$ | $12^{\prime}$ |
| Height -------- | 7' ${ }^{\prime \prime}$ | 7' ${ }^{\prime \prime}$ | $8^{\prime} 6^{\prime \prime}$ | $10^{\prime} 3^{\prime \prime}$ | $7^{\prime \prime} 8^{\prime \prime}$ | $7^{\prime} 6^{\prime \prime}$ | $10^{\prime} 3^{\prime \prime}$ | $10^{\prime \prime} 3^{\prime \prime}$ |
| Number of persons accommodated |  | 10 | 12 |  |  | 16 |  | 18 |
| Fuel used .-.------ | Diesel oil | Diesel oil | Diesel oil | Diesel oil | Diesel | Coal | Diesel | Diesel |

## d. Other Data.

(1) Fuel consumption per day.
(a) Coal stove for heating.

1. 20 pounds of coal or 12 Presto logs of summer operations ( $10^{\circ} \mathrm{F}$. or above).
2. 50 pounds of coal or 30 Presto logs for winter operations (below $10^{\circ} \mathrm{F}$.).
(b) Coal stove for cooking.
3. 50 pounds of coal, or
4. 30 Presto logs.
(c) Generator fuel consumption.
5. 5-kw generators burn approximately 20 gallons of gasoline in continuous operations.
6. $30-\mathrm{kw}$ generators burn 30 gallons of diesel fuel oil (VVF 800).
7. $45-\mathrm{kw}$ generators consume 35 gallons of diesel fuel oil (VVF 800).
(d) Yukon stove for heating. Burns 5 gallons of gasoline in a 10-12 hour period while heating the 10 -man arctic tent in temperatures of $0^{\circ} \mathrm{F}$. and lower. This stove will also burn wood or coal.
(e) Starting motors or pumps. Based on an average of 1 hour of operation per day, are rated at 0.2 gallon of gasoline.
(2) Lubrication consumption.
(a) Engine oil consumption of large, general-purpose tractors is rated at 2 gallons per day. The rate is considered equal for OE $30-10-5$. The consumption rate for a light vehicle is 0.006 gallon per mile.
(b) The rate of gear oil consumption is 0.45 gallon per mile for a large, general-purpose tractor; 0.006 gallon per mile for a light vehicle.
(c) GAA is used as an all-purpose grease (also used for water pumps, etc.). Consumption rate is 0.005 pound per mile.
(d) Consumption rates for generators, starting motors, and pumps are based on operations listed in (1) (c) and (e) above.
(3) Antifreeze. Each vehicle will have its initial antifreeze put in before embarking on a cold-weather operation (para 7-14).

## 7-13. Load-Bearing Capacity of Iee

The strength of ice varies with the structure of the ice, the purity of the water from which it is formed, the cycle of formation (freezing, thawing, and refreezing), temperature, snow cover, water currents, and whether or not the ice is water supported. Although the sustaining capacity of ice cannot be determined accurately, experience and tests provide the working capacity figures given below for good quality freshwater ice.

| Load | Ice thicleness in CM ${ }^{1}$ |  | Distance in meters between units ${ }^{2}$ |
| :---: | :---: | :---: | :---: |
|  | Riok | Normal |  |
| Single soldier on skis - | 4 | 5 | 5 |
| File of soldiers 2-pace interval | 8 | 10 |  |
| Vehicles: |  |  |  |
| Truck, 1/4T | 15 | 20 | 15 |
| Truck, $2 / 4$ T | 20 | 25 | 20 |
| Truck, 21/2T | 35 | 40 | 25 |
| Truck, 5T | 45 | 55 | 60 |


| Load | Ice thickness in CM ${ }^{1}$ |  | Distance in meters between units ${ }^{9}$ |
| :---: | :---: | :---: | :---: |
|  | Risk | Normal |  |
| Tractor and trailer loaded, ST $\qquad$ | 80 | 90 | 80 |
| M116 ----------- | 30 | 35 | 15 |
| M113 | 40 | 45 | 25 |
| D7 tractor | 45 | 50 | 40 |
| D8 tractor | 50 | 60 | 50 |
| Crane, 20T _..-....- | 55 | 60 | 70 |
| Grader ------------ | 35 | 40 | 50 |
| Tank M41 | 50 | 65 | 60 |
| SP M52 | 55 | 65 | 50 |
| APC M59 --_----- | 45 | 55 | 50 |
| Tractor M8A2 | 55 | 65 | 70 |
| Aircraft: |  |  |  |
| UH-1A | 20 | 25 |  |
| OH-13 | 15 | 18 |  |
| CH-21 | 30 | 35 |  |
| CH-37 | 45 | 50 |  |
| O-1A | 15 | 20 |  |
| U-6A | 20 | 25 |  |
| U-8D | 20 | 25 |  |
| U-1A | 25 | 30 |  |
| ${ }^{1}$ Multiply by .3937 to obtain inches. <br> ${ }^{2}$ Multiply by 3.2808 to obtain feet. |  |  |  |

## 7-14. Guide for Preparation of Antifreeze Solutions

| Lowest |  |  |  | Denatured alcohol |
| :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \text { expected } \\ \text { ambient } \\ \text { temperature } \\ \mathbf{(}^{\circ} \text { F.) } \end{gathered}$ | Arctic $\underset{\substack{\text { grade } \\ 800 \\ \text { antifreeze } \\ \hline}}{ }$ <br>  | $\begin{gathered} \text { Pints per } \\ \text { goluon of } \\ \text { coolant } \\ \text { capacity } 2 \end{gathered}$ |  |  |
| +20 | Freezing point of $-90^{\circ}$ F. --------- | 11/2 | 1.022 | $11 / 2$ |
| +10 |  | 2 | 1.036 | 21/4 |
| 0 | Issued ready for use and must not be mixed with any other liquid .- | 23/4 | 1.047 | 2\%/4 |
| -10 | , | 31/4 | 1.055 | 31/4 |
| -20 |  | 31/2 | 1.062 | 31/2 |
| -30 |  | 4 | 1.067 | 41/2 |
| -40 |  | $41 / 4$ | 1.073 | \% |
| -50 |  | 41/2 | ---- |  |
| -60 |  | $4 \% /$ | ---- |  |

I Used as temporary emergency expedient when neither arctic grade antifreeze nor ethylene-glycol antifreeze is available.
2 Includes heaters, etc.

## 7-15. Temperature, Snow Cover, and Precipitation in Arctic and Sub-Arctic Areas

The temperature chart below may be used as a guide for preliminary planning of operations in the areas shown, keeping in mind that seasonal storms may cause some of the figures to vary for short periods of time. For windchill factors, see figure 7-2. The planner should obtain further information concerning the particular area and should allow appropriate safety factors when planning for individual clothing, winterization of equipment, etc. Temperatures in the chart are not averages,
but are the high and low extremes for each month for each place shown. The figures showing snow cover indicate expected snow depths and should not be confused with snowfall, since packing and partial melting reduce residual quantities. Mean annual precipitation includes snowfall and rain, with the total represented as inches of water (1 inch of water equals about 1 foot of snow). Generally speaking, most of the precipitation above $70^{\circ}$ latitude is rain. This rule should be used with discretion, however, since other factors (longitude, sea currents, air currents, etc.) affect the type and quantity of precipitation.

| TIME | RS Of day in local mean time |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | previous day |  |  |  |  |  |  |  |  |  |  |  |  |  |  | same day |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | NEXT DAY |  |  |  |  |  |  |  |  |  |  |  |
| - (z) | 12 | 13 |  | 141 | 15 | 16 | 17 | 18 |  | 9 | 20 | 21 | 22 | 22 | 23 | -0 | O1 | 02 | 03 | 04 | 05 | 06 | 07 | OB | 09 | 10 | 11 |  | 213 | 3 | 14 | 15 | 16 | 17 | 18 | 19 | 0 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 9 | 10 | 11 |
| -1 (A) | 13 | 14 |  | 15 | 16 | 17 | 18 | 19 | 920 | 20 | 21 | 22 | 23 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | OB | 09 | 10 | 11 | 12 | 213 | 3 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | O8 | 9 | 10 | 11 | 12 |
| -2 (8) | 14 | 15 |  | 16 | 17 | 18 | 19 | 20 | 021 | 21 | 22 | 23 |  | -0 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | O8 | 09 | 10 | 11 | 12 | 13 | 314 | 1415 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 |
| -3 (c) | 15 | 16 |  | 17 | 18 | 19 | 20 | 21 | 22 | 222 | 23 | 00 |  | 10 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 415 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | O8 | 09 | 10 | 11 | 12 | 13 | 14 |
| -4 (0) | 16 | 17 | 1 | 18 | 19 | 20 | 21 | 22 | 23 | 23 | 00 | 01 |  | $\mathrm{O}_{2}$ | 03 | 04 | 05: | 06 | 07 | OB | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 516 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 |
| -5 (E) | 17 | 18 | 81 | 19 | 20 | 21 | 22 | 23 | 2300 | 00 | 01 | 02 | 03 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 617 | 7 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | OB | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| -6 (F) | 18 | 9 | 12 | 202 | 21 | 22 | 23 | 00 | 0 | 01 | 02 | 03 |  | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 718 | - | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| -7 (6) | 19 | 20 | 2 | 21 |  | 23 | 00 | 01 | 102 | 02 | 03 | 04 |  | 050 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 819 | 192 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| -8(H) | 20 | 21 |  | 22 | 23 | 00 | O1 | 02 | 20 | 03 | 04 | 05 |  | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 92 | 20.2 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | $\bigcirc 8$ | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| -9 (1) | 21 | 22 |  | 23 |  | 01 | 02 | 03 | 3 3, 04 | 04 | 05 | 06 |  | 07. | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 02 | 212 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| -10 (k) | 22 | 23 |  | 00 | 01 | 02 | 03 | 04 | 0405 | 05 | 06 | 07 | -8 | -8 | 09 | 10 |  | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |  | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| -11 | 23 | 00 |  | $\bigcirc$ | 02 | 03 | 04 | 05 | 506 | 06 | 07 | 08 |  | ${ }^{1} 10$ | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 22 | 230 | 000 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| -12 (m) | 00 | 01 |  | 020 | 03 | 040 | 05 | 06 | 607 | 07 | 08 | 09 | 10 | 0 -1 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |  | 19 | 20 | 21 | 22 | 23 |  | 0 | 0 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| +1 (N) | 11 | 12 |  | 13 | 14 | 15 | 16 | 17 | 718 | 18 | 19 | 20 | 21 | 212 | 22 | 23 | 00 | 01 | 02 | :03 | 04 |  | 06 | 07 | 08 | 09 | 10 | 011 | 112 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | -8 | 09 | 10 |
| +2 | 10 | 11 |  | 12 | 13 | 14 | 15 |  |  | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 |  | 05 | 06 | 07 | O8 | os | 910 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | O8 | 09 |
|  | 09 | 10 |  | 11 | 12 | 13 | 14 | 15 | $5: 16$ | 16 | 17 | 18 | 19 | 92 | 20 | 21 |  | 23 | 00 | 01 | 02 |  | 04 | 05 | 06 | 07 | 08 | 8 O9 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 |
|  | 08 | 09 | 910 | 10 | 11 | 12 | 13 | 14 | 4 : 15 | 15 | 16 | 17 | 18 | 819 | 19 | 20 | 21 | 22 | 23 | 00 | 01 |  | 030 | 04 | 05 | 06 | 07 |  | 8 O | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 |
|  | 07 | 08 |  | 091 | 10 | 11 | 12 | 13 | 314 | 14 | 15 | 16 | 17 | 718 | 18 | 19 | 20 | 21 | 22 | 23 | $\infty$ |  | 02 | 03 | 04 | 05 | 06 |  | 07 | -8 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 |
|  | 06 | 07 |  | 08 | 09 | 10 | 11 | 12 | 213 | 131 | 14 | 15 | 16 | 6.1 | 17 | 18 | 19 | 20 | 121 | 22 | 23 |  | 01 | 02 | 03 | 04 | 05 | 506 | 06 | 07 | $\bigcirc 8$ | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | $\bigcirc$ | 01 | 02 | 03 | 04 | 05 |
|  | 05 | 06 |  | 07 | 08 | 09 | 10 | 11 | 112 | 12 | 13 | 14 | 15 | 516 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 4 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 |
| +8 (u) | 04 | 05 |  | 06 | 07 | 08 | 09 | 10 | 011 | 11 | 12 | 13 |  | $4{ }^{15}$ | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 |  | $4{ }^{\circ}$ | 050 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | OI | 02 | 03 |
|  | 03 | 04 |  | 05 | 06 | 07 | 08 | 09 | 910 | 10 | 11 | 12 | 13 | 31 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 203 | 304 | 040 | 05 | 06 | 07 | O8 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 |
| +10 ( w ) | 02 | 03 |  | 04 | 05 | $06 \cdot$ | 07 | O8 | 8 os | 091 | 10 | 11 | 12 | 213 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 20 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 |
| +11 (x) | 01 | 02 |  | 03 | 04 | 05 | 06 | 07 | 7 O8 | 08 | 09 | 10 | 1 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | $\bigcirc$ | $\bigcirc 1$ | 10 | 020 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 |
| +12(Y) | 00 | 1 | $\bigcirc$ | 02 | 03 | 04 | 05 | 06 | 607 | 07 | 08 | 09 | 10 | $\bigcirc 1$ | 11 | $!2$ | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 30 | $\bigcirc$ | 10 | 02 | 03 | 04 | 05 | 06 | $\bigcirc 7$ | $\bigcirc$ | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|  | Ar |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | same day |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

## THE WINDCHILL FACTOR

TEMPERATURE FAHRENHEIT


Figure 7-2. The windchill factor.

## 7-16. Storage Batteries

$a$. The electrolyte in acid-type storage batteries normally is composed of sulphuric acid and pure water. The proportion of these two substances determines the specific gravity of the electrolyte, and the specific gravity, in turn, determines the state of charge of the battery. When the battery discharges, water is formed, causing a reduction in specific gravity. When the battery charges, sulphuric acid is formed, causing an increase in specific gravity. When the ratio of acid to water is such that the specific gravity is 1.275 to 1.300 at $80^{\circ} \mathrm{F}$., the battery is fully charged. The proportions of acid to water shown below are used to make electrolytes of various specific gravities at $80^{\circ} \mathrm{F}$. Freezing points of the resulting electrolytes are also shown.

Parta concentrated sulphuric
acid to one part of water

| acid to one part of water |  |
| :---: | :---: |
| By volume | By weight |
| 0.232 | 0.416 |
| 0.250 | 0.545 |
| 0.294 | 0.527 |
| 0.364 | 0.667 |

$\begin{gathered}\text { Specific } \\ \text { pravity }\end{gathered}$

1.200
1.210
1.240
1.280
Approximate Approximate
freezing point
on
$-16$
$-25$
$-51$
b. Extreme cold of arctic and subarctic areas has an adverse effect on storage batteries. At $-30^{\circ} \mathrm{F}$ the available energy from a battery is only about 10 percent of what it would be at $80^{\circ} \mathrm{F}$. For efficient operation, battery temperatures should be kept from dropping below $+30^{\circ} \mathrm{F}$. Normally this is accomplished through the use of winterization kits. Also, the specific gravity must be kept in the 1.275 to 1.300 range, when corrected to a temperature of $+80^{\circ} \mathrm{F}$. Specific gravity changes about 0.002 for each $5^{\circ}$ temperature change below or above $80^{\circ}$. Specific gravities and approxi-
mate state of charge for various temperatures are given below.

| Temperature <br> F. | Specific oravity <br> (corrected for temperature) | Approxicate atate <br> of charge (percent) |
| :---: | :---: | :---: |
| -80 | 1.000 (water) | Fully discharged |
| -80 | 1.130 | Discharged |
| -75 | $1.213-1.238$ | 46 |
| -70 | $1.215-1.240$ | 48 |
| -65 | $1.217-1.242$ | 50 |
| -60 | $1.219-1.244$ | 52 |
| -55 | $1.221-1.246$ | 54 |
| -50 | $1.223-1.248$ | 56 |
| -45 | $1.225-1.250$ | 58 |
| -40 | $1.227-1.252$ | 60 |
| -35 | $1.229-1.254$ | 62 |


| Temperature <br> ${ }_{F}$. | Specific gravity <br> (corrected for temperature) |
| :---: | :---: |
| -30 | $1.231-1.256$ |
| -25 | $1.233-1.258$ |
| -20 | $1.235-1.260$ |
| -15 | $1.237-1.262$ |
| -5 | $1.239-1.264$ |
| -5 | $1.241-1.266$ |
| 0 | $1.243-1.268$ |
| +5 | $1.245-1.270$ |
| +10 | $1.247-1.272$ |
| +15 | $1.249-1.274$ |
| +20 | $1.251-1.276$ |
| +25 | $1.253-1.278$ |
| +30 | $1.255-1.280$ |
| +80 | $1.275-1.300$ |

63
64
65
68
70
73
75
77
79
80
82
84
85
$-\quad 100$
1.275-1.300 100

## Section V. CARGO CONTAINERS, PALLETS, AND MARKINGS

## 7-17. Reusable Metal Shipping Box and Container Inserts

(fig. 7-3)
Figure 7-3 illustrates two reusable metal shipping boxes (cargo transporters). To facilitate handling and loading small articles, insert containers may be used with the cargo transporter. The insert container is a cardboard box with a maximum capacity of 1,000 pounds when strapped to a wooden pallet. Six insert containers fit into the standard cargo transporter (type 2) and four in the half-size (type 1). Container inserts may be used to consolidate small TOE items, thus eliminating multiple handling and much protective packaging. If units are to be moved by air, the inserts may be used as the shipping containers; cargo transporters are not necessary.

## 7-18. General-Purpose Pallet (fig. 7-4)

The general-purpose pallet is a four-way-entry, wooden pallet, 48 inches long, 40 inches wide, and about $51 / 4$ inches high. It is used primarily for shipping palletized cargo. It may be loaded and shipped from shipper to consignee without the cargo being rehandled. The four-way-entry feature permits easy entrance of the forks of forklift trucks.

## 7-19. Sled Pallet <br> (fig. 7-5)

The sled pallet consists of a heavy, timbered platform ( 4 by 6 feet) and runners ( 4 inches by 6 inches by 6 feet), upon which 3,000 pounds of supplies and equipment may be secured with steel bands. The pallet alone weighs 200 pounds. Cables attached to the runners permit towing. Sled pallets may be moved through any surf or over any beach which may be crossed by LVTPs, wheeled landing vehicles, or similar craft. Rations, water, fuel in 5 -gallon containers, and ammunition are the most suitable supplies for pallet loading.

## 7-20. Shipment Marking

a. General. Address markings identify the consignee, the destination of the shipment, and other pertinent information required for shipment identification purposes. For detailed marking procedures, shipping symbols, and area designators, see MIL-STD-129D, AR 725-50, and Joint Military Standard Transportation and Movement Procedures (MILSTAMP). Terms are defined as follows:
(1) In-the-clear address. A narrative description of the shipping address code.
(2) Shipping address code. Six-position alphameric code which depicts the in-the-clear address.

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BOX, METAL, SHIPPING, REUSABLE (CARGO TRANSPORTER)


Figure 7-3. Characteristics and security of cargo transporters.

(2.) SIDE

(4.) END

Figure 7-4. Dimensions of general-purpose pallet.


Figure 7-5. Sled pallet dimensions.
(3) Required delivery date ( $R D D$ ). A numeric calendar date indicating when material is required by the consignee.
(4) Port designator. Three-position alphameric code used to identify worldwide water ports used in the transportation of DOD material.
(5) Project code. Three-position alphameric code used to identify a specific contingency plan, movement, etc.
b. Domestic Shipment Address. Domestic addresses shall be specified by the cognizant activity. The domestic address shall be composed as follows:
(1) Example.

SC 040072050169
TP 2213
Rossford Ordnance Depot, Toledo, Ohio
Richmond, Virginia
1 of 4; wt: 75 lbs ; cu: 8 ft
(2) Explanation.

Line 1. Transportation control number
Line 2. Transportation priority number (when applicable), and required priority Julian delivery date as applicable
Line 3. Name and address of consignor in the clear (when applicable, coded)
Line 4. TO: Name and address of consignee in the clear (when applicable, coded)
Line 5. Piece number, total pieces, weight and cube (this piece)
c. Oversea Address Marking. The oversea address is the most conspicuous marking on the container and is as large as available space and stencil limitations permit.
(1) Example.

TCN AK650062070120XXX
RDD 280 PROV HAA TP4
A33HRV ATLANTA ARMY DEPOT, GA.
1MJ NORFOLK (NSC) VA.
JK4 LAPALLICE (LAROCHELLE) FR.
AK6500 BRACONNE ARMY DEP, BRACONNE, FRANCE
1 of 98 WT $200 \mathrm{CU} 40^{\prime \prime}$
(2) Explanation.

Line 1. Transportation Control Number (TCN)

Line 2. Required delivery date 280 , project code (when specified), transportation priority
Line 3. Consignor's coded and in-the-clear addresses
Line 4. Port of embarkation (coded and in-the-clear)
Line 5. Port of debarkation (coded and in-the-clear)
Line 6. Ultimate consignee's coded and in-the-clear addresses
Line 7. Piece number, total pieces, weight (this piece), cube (this piece)
d. Domestic Address. Domestic address for oversea shipments is marked as outlined in MIL-STD-129D. Composition of domestic address is as follows:
(1) FROM: (Name and address of consignor)
(2) TO: (Terminal and Address)
(3) Air movement designator when applicable
e. Dangerous Cargo. Surface shipment of ammunition, explosives, and other dangerous cargo must be packaged, marked, and labeled as required by the Department of Transportation and U.S. Coast Guard regulations. Where DA instructions conflict with those of DOT or USCG, the DOT and USCG regulations take precedence. Dangerous cargo shipped by military aircraft will be packaged, marked, and labeled as required by TM 58-250. Shipment by commercial aircraft will be in accordance with Federal Aviation Agency regulations.
f. Labels. Shippers must not use labels which by their size, shape, or color may readily be confused with the standard caution labels prescribed by the ICC.

## Section VI. COMMUNICATIONS-ELECTRONICS

## 7-21. Joint Nomenclature Systems

a. Type Designation Systems. Two joint type designation systems have been established, the Joint Electronics Type Designation

System (MIL-STD-196) and the Joint Photographic Type designation System (MIL-STD155). AN/ at the beginning of a term indicates that the item is electronic and an end item.

For details on the nomenclature for the components of electronic end items and for photographic equipment, whether end item or component, see BS 700-20.
b. Electronic End Items. All U.S. Army, Navy, Air Force, and Marine Corps communi-cations-electronics end items (except photographic) may be identified using the joint nomenclature chart shown in $d$ below.
c. Example. The chart describes the installation; the type of equipment; the purpose of the equipment, and the model number. For example, in the designation AN/VRC-12, AN indicates the joint system, V-ground vehicular, R-radio, C-communication (receiving and transmitting), and 12-the model number of that piece of equipment.
d. Interpretation.


A—Airborne (installed and A—Invisible light, heat radia- A—Auxiliary assemblies (not operated in aircraft) tion complete operating sets)
B-Underwater mobile, sub- B-Pigeon (inactivated, do not B-Bombing marine use)
C—Air-transportable (inac- C-Carrier (wire)
C-Communications (receiv-
ing and transmitting)
tivated, do not use)
D-Pilotless carrier
F-Fixed
G-Ground, general ground use
(includes two or more ground installations)
K-Amphibious
M-Mobile (installed as operating unit in a vehicle which has no function other than transporting the equipment)
P-Pack or portable (animal or man)
S-Water, surface craft
T-Ground, transportable
U-General utility (includes two or more general installation classes, airborne, shipboard, and ground)
V-Ground, vehicular (installed in vehicle designed for carrying electronic equipment, etc., such as tanks)
W-Water surface and underwater
functions other than W-Armament (peculiar to W-Remote control

D—Radiac D-Direction finder
E—Nupac E—Ejection and/or release
F-Photographic G-Gun or searchlight direct-
G-Telegraphic or teletype (wire)
Iaddress L-Searchlight control (inacti-
J-Electro-mechanical or inertial wire
K -Telemetering
L-Countermeasures (inacti- N-Navigational aids (includvated, do not use) ing altimeters, beacons,
M—Meterorological depth sounding, approach
N -Sound in air and landing, compasses,
P -Radar radar beacons)
Q—Sonar and under water P-Reproducing (photosound graphic and sound)
R-Radio Q-Special or combination of types
R -Receiving
S-Detecting and/or range of bearing
T-Transmitting
to W-Remote control armament not otherwise X -Identification and covered) recognition
X-Facsimile or television
Y-Data processing

## 7-22. Radio Sets and Auxiliary Equipment

a. Characteristics of Selected FM Radio Sets.

| Radio est | Nomenclature Revr | Xmtr | $\begin{gathered} \text { Freq } \\ (M H z) \end{gathered}$ | Planning <br>  | Emission | Tuning | No. of channels | Power required | $\begin{gathered} \text { Power } \\ \text { output } \\ \text { (watte) } \end{gathered}$ | Weight <br> Installed in vehicle | (lb) <br> Portable |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| AN/GRC 3 | RT-66 | RF-66 | 20.0-27.9 | 16 or 24 | Voice | Continuous (2 preset) | 80 | 12 or 24 | 2 or 16 | 276 |  |
|  | RT-70 | RF-70 | 47.0-58.4 | 1.6 | Voice | Continuous (2 preset) | 115 | 12 or 24 | 0.5 | 276 |  |
|  | RT-108 | RF-70 | 20.0-27.9 | 1.6 | Voice | Continuous (2 preset) | 80 | 12 or 24 | 0.5 | 276 |  |
| AN/PRC-6 | RT-196 | RT-196 | 47.0-55.4 | 1.6 | Voice | 1 preset | 43 | BA-270/U | 0.25 |  | 6.5 |
| AN/PRC-8 | RT-174 | RF-174 | 20.0-27.9 | 5 or 8 | Voice | Continuous | 80 | BA-279/U | 1.0 |  | 26.1 |
| AN/PRR-9 | PRR-9 | RF-174 | 47.0-57.0 | 0.46 or 1.6 | Voice/MCW | 1/2 preset | 201 | BA-505 | .001/.0045 |  | 0.45 |
| AN/PRT-4 | PRR-9 | PRT-4 | 47.0-57.0 | 0.46 or 1.6 | Voice/MCW | 1/2 preset | 201 | 2BA-399 | .001/.0045 |  | 0.90 |
| AN/PRC-25 | RT-505 | RT-505 | 30.0-75.95 | 5, 8 or 30 | Voice | Detent | 920 | BA-386 | $\begin{aligned} & 1.5,2.0 \text { or } \\ & 2.5 \end{aligned}$ |  | 26 |
| *AN/PRC-80 | RT-505 | RT-505 | 30.0-75.95 | 5,8 or 30 | Voice | Detent <br> (2 presets) | 920 | AM4306 | $\begin{aligned} & 1.5,2.0 \text { or } \\ & 2.5 \end{aligned}$ |  | 35 |
| AN/VRC-12 | RT-246 | RT-246 | 30.8-75.95 | 24 or 32 | Voice | Detent (10 presets) | 920 | 24 | 3 or 35 | 160 |  |
|  | R-442 | RT-246 | 30.0-75.95 | 24 or 32 | Voice | Detent | 920 | 24 |  | 160 |  |
| AN/VRC-24 | OA-2648 | 0A-2648 | 225.0-399.9 | Approx. <br> $50 \mathrm{~km} \mathbf{w} /$ <br> aircraft <br> at $1000^{\prime}$ | Voice | Continuous (20 presets) | 1,750 | 24 | 1.5 | 115 |  |
| AN/VRC-43 | RT-246 | RT-246 | 30.0-75.95 | 24 or 32 | Voice | Detent <br> (10 presets) | 920 | 24 | 3 or 35 | 120 |  |
| AN/VRC-44 | RT-246 | RT-246 | 30.0-75.95 | 24 or 32 | Voice | Detent <br> (10 presets) | 920 | 24 | 3 or 35 | 198 |  |
|  | R-442 | RT-246 | 30.0-75.95 | 24 or 32 | Voice | Detent | 920 | 24 |  | 198 |  |
| AN/VRC-45 | RT-246 | RT-246 | 30.0-75.95 | 24 or 32 | Voice | Detent (10 presets) | 920 | 24 | 3 or 35 | 226 |  |
| AN/VRC-46 | RT-524 | RT-524 | 30.0-75.95 | 24 or 32 | Voice | Detent | 920 | 24 | 3 or 35 | 115 |  |
| AN/VRC-47 | RT-524 | RT-524 | 30.0-75.95 | 24 or 32 | Voice | Detent | 920 | 24 | 3 or 35 | 132 |  |
|  | R-442 | RT-524 | 30.0-75.95 | 24 or 32 | Voice | Detent | 920 | 24 | 3 or 35 | 132 |  |
| AN/VRC-48 | RT-524 | RT-524 | 30.0-75.95 | 24 or 32 | Voice | Detent | 920 | 24 | 3 or 35 | 191 |  |
|  | R-442 | RT-524 | 30.0-75.95 | 24 or 32 | Voice | Detent | 920 | 24 | 3 or 35 | 191 |  |
| AN/VRC-49 | RT-524 | RT-524 | 30.0-75.95 | 24 or 32 | Voice | Detent | 920 | 24 | 3 or 35 | 212 |  |
| AN/VRC-53 | RT-505 | RT-505 | 30.0-75.95 | 5, 8 or 30 | Voice | Detent | 920 | 24 | 2 or 25 | 69 |  |
| AN/GRC-125 | RF-505 | RT-505 | 30.0-75.95 | 8 or 30 | Voice | Detent <br> (2 presets) | 920 | BA-386 or <br> AM4306; <br> 24 V DC <br> veh | 25 or 2.5 | 81.5 | 26 |

[^39]
## b. Characteristics of Selected AM Radios (Except Aircraft).


c. Characteristics of Selected Aircraft Radios (FM and AM).

| Radio set ${ }^{\text {N }}$ | $\begin{gathered} \text { nenclature } \\ R c v r \end{gathered}$ | Xmtr | $\begin{gathered} \text { Freq } \\ (M H z) \end{gathered}$ | Planning range ( km ) | Emission | $\begin{aligned} & \text { Tuning } \\ & (V D C) \end{aligned}$ | Power required | Power output (watta) | Weight (lb) installed in aircraft |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| FM sets* ${ }^{\text {\% }}$ |  |  |  |  |  |  |  |  |  |
| AN/ARC-44 | RT-294 | RT-294 | 24.0-51.9 | 80 | Voice | Continuous | 27.5, 8 amps | 8 | 28.4 |
| AN/ARC-54 | RT-348 | RT-348 | 30.0-69.95 | 46 | Voice | Continuous | 27.5, 7.4 amps | 10 | 28.4 30 |
| AM sets* |  |  |  |  |  | Continuous | 27.5, 7.4 amps | 10 | 30 |
| AN/ARC-51 | RF-702 | RF-702 | 225-399.9 | 48 | Voice | Continuous (monitors | 27.5, 10 amps | 10 | 33.5 |
| AN/ARC-55 | RT-349 | RT-349 | 225-399.9 | 48 | Voice | 243 MHz ) <br> Continuous (monitors | 27.5, 10 amps | 9 | 63 |
| AN/ARC-102 | RT-698 | RT-698 | 2.0-29.9 | Line of sight <br> voice or CW | Voice CW | 243 MHz ) <br> Continuous | $\begin{aligned} & 27.5 \mathrm{~V} \text { DC, or } 115 \\ & \text { V AC, } 400 \mathrm{hps} \end{aligned}$ | 400 | 61 |
| AN/ARC-4 | RT-159 | RT-159 | 120-130 | 16 | Voice, | 2 normal | BA-264 | . 035 | 5.8 |
| AN/ARC-10 | RT-278 | RT-278 | 238.0-263.0 | 48 | MCW, CW Voice, CW, MCW | presets <br> Fixed | 16 V dry battery | 0.2 | $\begin{gathered} \text { (portable) } \\ 3.1 \\ \text { (portable) } \end{gathered}$ |

- May also be used in ground installations and ground to air.
d. Selected Radio Control and Other Auxiliary Equipment.

| Nomenclature |  | Equipment used with these sets | Purpose | Planning range ( km ) | $\begin{gathered} \text { Weight (lb) } \\ 21.85 \end{gathered}$ | $\begin{aligned} & \quad \text { Power required } \\ & 4 \text { BA-30 } \\ & 1 \text { BA-414 } \end{aligned}$ | Other accessories required |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Radio equipment | Control group |  |  |  |  |  |  |
| AN/GRA-6 - | FM radio ---- | $\begin{aligned} & \text { AN/GRC-19 } \\ & \text { AN/PRC-8 } \\ & \text { AN/PRC-9 } \\ & \text { AN/PRC-10 } \end{aligned}$ | Local and remote control of one or two radio sets. | 3.2 |  |  | Wire (WD-1/TT). |
| AN/GRA-39 -- | FM radio --.- | AN/PRC-25 <br> AN/VRC-12 <br> AN/VRC-43 <br> thru <br> AN/VRC-49 | Remote control of one radio set. | 3.2 | 24.375 | $12 \mathrm{BA}-30$ | Wire (WD-2/TT). |
| AN/GSA-7 --- | FM radio-wire integration. | AN/PRC-25 <br> AN/VRC-12 <br> AN/VRC-43 <br> thru <br> AN/VRC-49 | Radio/wire integration or automatic relay (using 2 sets). | 16 | 50.3 | 22-30 V DC (vehicular) 115 V $A C$ or 230 V AC, $50 / 400 \mathrm{hps}$ fixed. | When used with VRC-12 family, requires cable assembly 7474/u (fixed). |
| RC-282 ------- | FM radio antenna group. | Tactical FM radio sets | Stationary ground plane antenna (20 76 MHz ). | 21/2 times normal for quarter w/whip. | 48 | -- | (fixed). |

## e. Field Wire and Field Cable Data.

| T'upe or model | Cubic feet | $\begin{gathered} \text { Weight } \\ (l b) \end{gathered}$ | Short | Measurement tons |
| :---: | :---: | :---: | :---: | :---: |
| Wire, WD-1 ( )/TT or Spool, DR-8A, 1,320 ft (402.3m) | 0.374 | 14 | 0.007 | 0.0093 |
| Wire, WD-1 ( )/TT or Dispenser, MX-306/G, 2,640 ft ( 804.6 m ) | 0.669 | 26 | 0.013 | 0.0167 |
| Wire, WD-1( )/TT or Reel, RL-159( )/U, 1 mile ( 1.6 km ) | 1.50 | 66 | 0.033 | 0.0375 |
| Wire, WD-1 ( )/TT or Reel, DR-5, $21 / 2$ mile ( 4 km ) | 3.859 | 154 | 0.077 | 0.0964 |
| Wire, WD-1( )/TT alone $1 \mathrm{mile}(1.6 \mathrm{~km}$ ) |  | 48 | 0.240 |  |
| Telephone Cable Assembly, CX-4566/G (26 pr) or Reel, RC-435/U, 250 ft (76.2m) | 2.197 | 68 | 0.340 | 0.0549 |
| Telephone Cable Assembly, CX-1606/G (spiral 4) or Reel, DR-15B, $1,320 \mathrm{ft}$ (402.3m) | $3.960$ | 137 | 0.0685 |  |

## Section VII. POL CONTAINERS AND PIPELINES

## 7-23. Pipeline Estimates

a. Rate of Discharge. The quantity of fluid passing through a pipe in a unit of time is termed the capacity or rate of discharge of the pipe and may be determined from the equation

$$
\mathbf{Q}=\mathbf{A} \times \mathbf{V}
$$

where
$Q=\begin{gathered}\text { rate of discharge in cubic feet per } \\ \text { second }\end{gathered}$
$A=\begin{gathered}\text { cross-sectional area of the pipe in } \\ \text { square feet }\end{gathered}$
$V=\begin{gathered}\text { mean velocity of fluid in feet per } \\ \text { second }\end{gathered}$
(1) If the rate of discharge is given in terms of U.S. gallons, these may be converted to cubic feet by multiplying the given number of gallons by 0.13368 . Cubic feet may be converted to U.S. gallons by multiplying the number of cubic feet by 7.4805 .
(2) The cross-sectional area of the pipe in square feet is determined by using the equation

$$
A=0.7854 D^{3}
$$

where
$A=$ cross-sectional area of the pipe in square feet
$D=$ inside diameter of the pipe in feet
(3) The mean velocity of a fluid varies according to the size, hydraulic gradient, and physical condition of the pipe through which
it flows. Economical pipeline velocities are ordinarily in the range of 3.5 to 5.5 feet per second.
b. Example. Determine the rate of discharge of an 8 -inch pipeline in which gasoline is flowing at a velocity of 3 miles per hour.
$D=8 / 12$ or 0.67 foot
$A=0.7854 \times(0.67)^{2}=0.3525$ square foot
$3 \mathrm{mph}=\frac{3 \mathrm{mph} \times 5,280 \text { feet per mile }}{60 \text { minutes per hour }}$
$=264$ feet per minute
264 feet per minute $\times 0.3525$ square foot $=93.1$ cubic feet per minute
93.1 cubic feet per minute $\times 7.4805$ gallons per cubic foot $=696.43$ gallons per minute.
c. Increasing Capacity. The volume of liquid which can be transported through a given pipeline may be increased by longer operation and/or increased pressure. These methods may be used individually or in combination; however, they should be used only on a short-term basis. If increased capacity is desired over a considerable period of time, it is usually better to construct an additional pipeline.
(1) Hours of operation. Normal capacity of a pipeline is based on an operating time of 20 hours per day.
(2) Differential pressure. Increasing the differential pressure of all pumping stations increases the capacity of a given pipeline. To increase the differential pressure of a pumping station, increase the differential pressure on
each pump in the pumping station and/or the number of pumps operating in series at the pumping station.
d. Capacity of Standard Military Lightweight Steel Tubing.

| Inside diameter of line (in.) | Normal design capacity (bbl per hr) | Emergency capacity (bbl per hr) | Safe working pressure (psi) | $\begin{aligned} & \text { Maximum } \\ & \text { working } \\ & \text { pressure (psi) } \end{aligned}$ | $\begin{aligned} & \text { Gallons } \\ & \text { per day* } \end{aligned}$ | Short tons per day |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 4.35 | 355 | 393 | 600 | 750 | 294,000 | 930 |
| 6.415 | 785 | 1,000 | 600 | 750 | 630,000 | 2,000 |
| 8.415 | 1,355 | 1,730 | 500 | 600 | 1,135,000 | 3,500 |
| 12.481 | 7,150 | 11,400 | 400 | 530 | 6,000,000 | 18,000 |

*Computed for an average of all products at normal design capacity. using a 20 -hour operating day.
e. Capacity of Pipes and Cylindrical Conduits. The formula below is used to determine the number of gallons per 12 inches of pipe or cylindrical conduit length. Measurements are in inches.
$\underset{\substack{\text { Gallons } \\ \text { per foot } \\ \text { of length }}}{\text { ( }}=\frac{\text { (3.1416) (pipe or conduit radius) })^{(12)}}{231}$

$$
=\frac{(9.4248)(\text { diameter })^{2}}{231}=(.0408)(\text { diameter })^{2}
$$

The table in paragraph 7-28(1)(b) is applicable here if the vertical cylindrical tank is considered to be in a horizontal position, for then the gallons per foot of liquid depth in the table have the same meaning as gallons per foot of length for full pipes and cylindrical conduits on the ground. To obtain gallons per minute, multiply velocity of flow in feet per minute by the figure shown.
f. Proper Sizes for Pipes. To determine the proper diameter of a pipe for gases and liquids, use the formula in (2) below. Determine the weight of the fluid (in pounds per cubic foot) and the weight of the fluid to flow in the pipe (in thousands of pounds per hour). Then use logarithmic computations to solve the fractional powers of $F$ and $d$ (para 7-49). Weights indicated below are for normal atmospheric pressure ( 14.7 psi ) and a temperature of $60^{\circ} \mathrm{F}$. Variations in pressure and temperature cause the figures for gases to vary considerably, but, for the purposes of this subparagraph, changes in temperature can be disregarded. The actual pressure in the line is the principal determining factor for fluid density, since the unit of volume remains constant. Pressure changes for gases can be compen-
sated for by multiplying $\frac{P}{14.7}$ by the unit weights shown below. In this formula, $P$ is the actual pressure in the line.
(1) Weights of liquids and gases.

| Fluid in pipeline | Pounde por ou ft |
| :---: | :---: |
| Liquids: |  |
| Aviation gasoline | 44.1 |
| 91A gasoline | 45.7 |
| Kerosene | 50.8 |
| Diesel oil | 52.3 |
| Lubricating oil | 56.8 |
| Water, fresh | 62.4 |
| Water, sea | 64.0 |
| Gases: |  |
| Air | 0.07658 |
| Ammonia | 0.04509 |
| Benzene | 0.20640 |
| Butane | 0.15350 |
| Carbon dioxide | 0.11637 |
| Chlorine | 0.18750 |
| Ethylene | 0.07410 |
| Helium | 0.01058 |
| Hydrogen | 0.00530 |
| Methane | 0.04234 |
| Natural gas | 0.05140 |
| Oxygen | 0.08463 |
| Propane | 0.11645 |
| Steam | 0.04761 |

(2) Formula.

$$
D=2.2 \times \frac{F^{0.45}}{d^{0.51}}
$$

$D=$ diameter of pipe in inches
$F=$ calculated flow for the pipeline in thousands of pounds per hour.
$d=$ density of the fluid to flow in the pipe in pounds per cubic foot
g. Data for Steel Pipe. The figures shown below can be used by the transportation plan-
ner for loading and transporting pipe and for computing volumes and weights of the fluid transported in pipes over a specified period of time. The figures in column 2 are expressed in feet so they can be squared and multiplied by 3.1416 to obtain the unit capacity shown in column 3. Inside radii in column 2 vary for the common pipe sizes, depending upon the amount of pressure the line is to carry. (A smaller diameter indicates a heavier pipe, capable of greater pressure.) To arrive at the total cubic feet per second, multiply the figures in column 3 by the actual flow in feet per second in the line. Convert to U.S. gallons per second by multiplying by 7.481 , or to U.S. gallons per minute by multiplying 448.86. Pressure and, therefore, velocity can be built up to the rated capacity of the pipe and pumping system. Data in columns 4 and 5 can be used by the planner for the loading and transporting of steel pipe.

|  |  | Capacity in cubic feet per second (velocity) of 1 ft per sec | $\begin{gathered} \text { Weight of of } \\ 100 \text { ft of } \\ \text { pipe } \\ \text { (li) } \end{gathered}$ | Outside diameter of pipe (ft) 5 |
| :---: | :---: | :---: | :---: | :---: |
| 1/8 | . 01120 | . 000395 | 26.3 | . 0337 |
| 1/8 | . 00896 | . 000243 | 33.6 | . 0337 |
| 1/4 | . 01516 | . 000720 | 45.2 | . 0450 |
| $1 / 4$ | . 01266 | . 000504 | 56.7 | . 0450 |
| \%/8 | . 02054 | . 001330 | 59.8 | . 0562 |
| 3/8 | . 01760 | . 000974 | 77.7 | . 0562 |
| 1/2 | . 0259 | . 00211 | 89.3 | . 0700 |
| 1/2 | . 0227 | . 00162 | 114.5 | . 0700 |
| 1/2 | . 0194 | . 00118 | 137.6 | . 0700 |
| $3 / 4$ | . 0344 | . 00372 | 118.7 | . 0875 |
| 3/4 | . 0309 | . 00300 | 155.4 | . 0875 |
| 3/4 | . 0256 | . 00206 | 203.7 | . 0875 |
| 1 | . 0437 | . 00598 | 176.4 | . 1095 |
| 1 | . 0398 | . 00497 | 227.9 | . 1095 |
| 1 | . 0340 | . 00363 | 299.3 | . 1095 |
| 11/4 | . 0575 | . 01038 | 239.4 | . 1385 |
| 11/4 | . 0533 | . 00892 | 315.0 | . 1385 |
| $11 / 4$ | . 0483 | . 00733 | 395.9 | . 1385 |
| $11 / 2$ | . 0671 | . 01410 | 285.6 | . 1582 |
| 11/2 | . 0625 | . 01225 | 382.2 | . 1582 |
| 11/2 | . 0558 | . 00977 | 510.3 | . 1582 |
| 2 | . 0862 | . 0233 | 384.3 | . 1980 |
| 2 | . 0808 | . 0205 | 528.2 | . 1980 |
| 2 | . 0704 | . 0156 | 782.3 | . 1980 |
| $21 / 2$ | . 1030 | . 0333 | 609.0 | . 2395 |
| 21/2 | . 0967 | . 0294 | 805.4 | . 2395 |
| 21/2 | . 0886 | . 0246 | 1,050 | . 2395 |
| 3 | . 1280 | . 0514 | 795.9 | . 2915 |
| 3 | . 1210 | . 0460 | 1,082 | . 2915 |

[^40]| Common pipe (in.) (ine 1 | $\begin{gathered} \text { Actual } \\ \text { inside } \\ \text { radius } \\ \text { (ft) } \\ \hline \end{gathered}$ | Capacity in cubic feet per second at a flow 1 ft per sec $s$ | Weight of 100 ft of pipe (lb) | Outside of pipe $(f t)$ 5 |
| :---: | :---: | :---: | :---: | :---: |
| 3 | . 1097 | . 0379 | 1,502 | . 2915 |
| $31 / 2$ | . 1480 | . 0688 | 956.6 | . 333 |
| $31 / 2$ | . 1405 | . 0621 | 1,313 | . 333 |
| 4 | . 1680 | . 0886 | 1,134 | . 375 |
| 4 | . 1596 | . 0801 | 1,575 | . 375 |
| 4 | . 1510 | . 0716 | 1,995 | . 375 |
| 4 | . 1435 | . 0647 | 2,370 | . 375 |
| 5 | . 2102 | . 1390 | 1,544 | . 463 |
| 5 | . 2002 | . 1263 | 2,184 | . 463 |
| 5 | . 1896 | . 1130 | 2,846 | . 463 |
| 5 | . 1795 | . 1013 | 3,465 | . 463 |
| 6 | . 2524 | . 2000 | 1,995 | . 552 |
| 6 | . 2400 | . 1810 | 3,003 | . 552 |
| 6 | . 2290 | . 1650 | 3,822 | . 552 |
| 6 | . 2163 | . 1470 | 4,757 | . 552 |
| 8 | . 3390 | . 3605 | 2,352 | . 719 |
| 8 | . 3361 | . 3550 | 9,594 | . 719 |
| 8 | . 3325 | . 3470 | 3,003 | . 719 |
| 8 | . 3251 | . 3320 | 3,749 | . 719 |
| 8 | . 3180 | . 3178 | 4,557 | . 719 |
| 8 | . 3100 | . 3020 | 5,385 | . 719 |
| 8 | . 2995 | . 2820 | 6,374 | . 719 |
| 8 | . 2915 | . 2673 | 7,119 | . 719 |
| 8 | . 2832 | . 2525 | 7,844 | . 719 |
| 10 | . 4270 | . 5730 | 2,951 | . 896 |
| 10 | . 4230 | . 5625 | 3,602 | . 896 |
| 10 | . 4180 | . 5500 | 4,253 | . 896 |
| 10 | . 4060 | . 5170 | 5,754 | . 896 |
| 10 | . 3980 | . 4970 | 6,762 | . 896 |
| 10 | . 3872 | . 4710 | 8,085 | . 896 |
| 10 | . 3770 | . 4460 | 9,366 | . 896 |
| 10 | . 3650 | . 4185 | 11,025 | . 896 |
| 10 | . 3540 | . 3930 | 12,180 | . 896 |
| 12 | . 5110 | . 8190 | 3,507 | 1.062 |
| 12 | . 5040 | . 7980 | 4,599 | 1.062 |
| 12 | . 4980 | . 7790 | 5,628 | 1.062 |
| 12 | . 4840 | . 7365 | 7,686 | 1.062 |
| 12 | . 4720 | . 7060 | 9,303 | 1.062 |
| 12 | . 4615 | . 6680 | 11,340 | 1.062 |
| 12 | . 4480 | . 6310 | 13,230 | 1.062 |
| 12 | . 4380 | . 6030 | 14,700 | 1.062 |
| 12 | . 4225 | . 5610 | 16,905 | 1.062 |
| 14 | . 5625 | . 9950 | 3,864 | 1.167 |
| 14 | . 5575 | . 9790 | 4,799 | 1.167 |
| 14 | . 5520 | . 9575 | 5,733 | 1.167 |
| 14 | . 5470 | . 9400 | 6,647 | 1.167 |
| 14 | . 5340 | . 8950 | 8,925 | 1.167 |
| 14 | . 5210 | . 8520 | 11,235 | 1.167 |
| 14 | . 5060 | . 8030 | 13,755 | 1.167 |
| 14 | . 4940 | . 7675 | 15,435 | 1.167 |
| 14 | . 4790 | . 7220 | 17,955 | 1.167 |
| 14 | . 4670 | . 6850 | 20,350 | 1.167 |
| 16 | . 6460 | 1.310 | 4,421 | 1.333 |
| 16 | . 6420 | 1.293 | 5,492 | 1.333 |


| Common Size (in.) ${ }^{\text { }}$ 1 | $\begin{gathered} \text { Actual } \\ \text { inside } \\ \text { radius } \\ \text { (ft) } \\ \mathbf{g}) \end{gathered}$ | Capacity in cubic feet per second (velocity) of $1 \mathrm{ft} \boldsymbol{p} \boldsymbol{p}$ | Weight of pipe pipe | Outside diameter of pipe (ft) |
| :---: | :---: | :---: | :---: | :---: |
| 16 | . 6350 | 1.265 | 6,573 | 1.333 |
| 16 | . 6250 | 1.227 | 8,694 | 1.333 |
| 16 | . 6120 | 1.176 | 11,340 | 1.333 |
| 16 | . 5970 | 1.120 | 14,385 | 1.333 |
| 16 | . 5810 | 1.058 | 17,325 | 1.333 |
| 16 | . 5650 | 1.002 | 20,265 | 1.333 |
| 16 | . 5470 | . 940 | 23,520 | 1.333 |
| 16 | . 5365 | . 902 | 25,305 | 1.333 |
| 18 | . 7290 | 1.667 | 4,977 | 1.500 |
| 18 | . 7240 | 1.648 | 6,695 | 1.500 |
| 18 | . 7140 | 1.602 | 8,610 | 1.500 |
| 18 | . 7025 | 1.550 | 11,025 | 1.500 |
| 18 | . 6905 | 1.497 | 13,965 | 1.500 |
| 18 | . 6725 | 1.420 | 17,955 | 1.500 |
| 18 | . 6530 | 1.341 | 21,840 | 1.500 |
| 18 | . 6380 | 1,280 | 25,095 | 1.500 |
| 18 | . 6200 | 1.208 | 28,875 | 1.500 |
| 18 | . 6035 | 1.145 | 31,920 | 1.500 |
| 20 | . 8130 | 2.074 | 5,544 | 1.665 |
| 20 | . 8025 | 2.025 | 8,253 | 1.665 |
| 20 | . 7910 | 1.965 | 11,025 | 1.665 |
| 20 | . 7835 | 1.931 | 12,915 | 1.665 |
| 20 | . 7660 | 1.840 | 17,535 | 1.665 |
| 20 | . 7480 | 1.757 | 21,945 | 1.665 |
| 20 | . 7290 | 1.670 | 26,355 | 1.665 |
| 20 | . 7080 | 1.573 | 31,385 | 1.665 |
| 20 | . 6875 | 1.484 | 35,910 | 1.665 |
| 20 | . 6725 | 1.420 | 39,270 | 1.665 |
| 24 | . 9795 | 3.015 | 6,668 | 2.000 |
| 24 | . 9680 | 2.945 | 9,944 | 2.000 |
| 24 | . 9520 | 2.845 | 14,805 | 2.000 |
| 24 | . 9440 | 2.803 | 17,955 | 2.000 |
| 24 | . 9230 | 2.673 | 24,255 | 2.000 |
| 24 | . 8990 | 2.532 | 31,185 | 2.000 |
| 24 | . 8750 | 2.408 | 37,905 | 2.000 |
| 24 | . 8540 | 2.290 | 43,680 | 2.000 |
| 24 | . 8285 | 2.155 | 50,820 | 2.000 |
| 24 | . 8080 | 2.052 | 56,280 | 2.000 |
| 30 | 1.225 | 4.720 | 10,395 | 2.500 |
| 30 | 1.207 | 4.575 | 16,590 | 2.500 |
| 30 | 1.198 | 4.510 | 20,685 | 2.500 |

- Does not necessarily indicate that the pipe is actually this sizc.


## 7-24. Volume of Liquid in Tanks

a. General. Transportation planners and
users frequently need weight and cube data for liquids. After a volume of liquid has been determined, the weight may be found by multiplying the total volume in gallons by the weight of 1 gallon of the liquid. (Unit weights for various liquids are to be found in para $7-23 f(1))$. It is assumed that the cylindrical and elliptical tanks discussed below have flat ends. (If a tank does not have flat ends, then the curvature of the ends must be determined, and the volume contained in the ends added to the volumes shown below. However, in such cases, it is usually more advantageous to calibrate the tank, which entails the drawing off or adding of measured amounts of the liquid and measuring the change in liquid depth in the tank.) In the charts below, single and/or double interpolation should be used to determine values between those shown. Values shown are close approximations for $60^{\circ} \mathrm{F}$. and can be used for practical purposes. Variations in conditions, especially temperature, cause the values to vary. If exact quantities are desired, the formulas shown must be used in conjunction with temperature coefficients of expansion and contraction for the liquids and containers. Presentation of detailed computations for varying conditions is not within the scope of this manual, but approximate computations for POL products under various temperatures are shown in $f$ below. Unless otherwise specified, dimensions are in inches.
b. Cylindrical Tanks.
(1) Vertical.
(a) Formula. The volume of liquid in a vertical cylindrical tank may be computed by using the formula shown below.

Gallons per foot of liquid depth
$=\frac{(3.1416) \quad(\text { radius of tank })^{2} \text { (12) }}{231}$ $=\frac{(9.4248)(\text { diameter of tank })^{2}}{231}$
(.0408) (diameter) ${ }^{2}$
(b) Table. Gallons per foot of liquid depth are shown for vertical cylindrical tanks of various diameters.

| Diameter (in.) | $\underset{\text { par }}{\text { Gallons }}$ | Diameter (in.) | $\begin{aligned} & \text { Gallons } \\ & \text { per } f t \end{aligned}$ | Diameter (in.) | Gallons per ft |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 0.0408 | 54 | 118.9 | 107 | 467.5 |
| 2 | 0.163 | 55 | 123.3 | 108 | 477.5 |
| 3 | 0.367 | 56 | 127.9 | 109 | 486.0 |
| 4 | 0.653 | 57 | 132.8 | 110 | 495.0 |
| 5 | 1.02 | 58 | 137.4 | 111 | 503.0 |
| 6 | 1.47 | 59 | 142.2 | 112 | 512.5 |
| 7 | 2.00 | 60 | 147.1 | 113 | 522.0 |
| 8 | 2.61 | 61 | 152.1 | 114 | 532.5 |
| 9 | 3.30 | 62 | 157.0 | 115 | 541.0 |
| 10 | 4.08 | 63 | 162.0 | 116 | 551.0 |
| 11 | 4.93 | 64 | 167.5 | 117 | 560.0 |
| 12 | 5.87 | 65 | 172.5 | 118 | 570.0 |
| 13 | 6.89 | 66 | 177.7 | 119 | 580.0 |
| 14 | 8.00 | 67 | 183.3 | 120 | 589.0 |
| 15 | 9.17 | 68 | 188.3 | 121 | 597.0 |
| - 16 | 10.44 | 69 | 194.5 | 122 | 607.0 |
| 17 | 11.78 | 70 | 200.0 | 123 | 617.0 |
| 18 | 13.22 | 71 | 206.0 | 124 | 627.0 |
| 19 | 14.72 | 72 | 211.9 | 125 | 637.0 |
| 20 | 16.31 | 73 | 217.5 | 126 | 648.0 |
| 21 | 18.00 | 74 | 223.6 | 127 | 658.0 |
| 22 | 19.75 | 75 | 229.8 | 128 | 668.0 |
| 23 | 21.60 | 76 | 236.0 | 129 | 679.0 |
| 24 | 23.50 | 77 | 242.2 | 130 | 689.0 |
| 25 | 25.50 | 78 | 248.7 | 131 | 698.0 |
| 26 | 27.56 | 79 | 255.0 | 132 | 710.0 |
| 27 | 29.79 | 80 | 261.2 | 133 | 722.0 |
| 28 | 32.00 | 81 | 268.0 | 134 | 733.0 |
| 29 | 34.33 | 82 | 274.8 | 135 | 743.0 |
| 30 | 36.65 | 83 | 281.0 | 136 | 754.0 |
| 31 | 39.20 | 84 | 288.0 | 137 | 766.0 |
| 32 | 41.80 | 85 | 295.3 | 138 | 777.0 |
| 33 | 44.40 | 86 | 302.0 | 139 | 788.0 |
| 34 | 47.20 | 87 | 309.0 | 140 | 800.1 |
| 35 | 49.90 | 88 | 316.8 | 141 | 811.0 |
| 36 | 52.80 | 89 | 323.5 | 142 | 822.0 |
| 37 | 55.80 | 90 | 331.0 | 143 | 833.0 |
| 38 | 58.90 | 91 | 338.0 | 144 | 846.0 |
| 39 | 62.00 | 92 | 346.0 | 145 | 858.0 |
| 40 | 65.30 | 93 | 353.6 | 146 | 871.0 |
| 41 | 68.60 | 94 | 361.0 | 147 | 882.0 |
| 42 | 71.90 | 95 | 369.0 | 148 | 893.0 |
| 43 | 75.40 | 96 | 377.0 | 149 | 906.0 |
| 44 | 79.00 | 97 | 384.5 | 150 | 917.0 |
| 45 | 82.60 | 98 | 392.5 | 151 | 930.0 |
| 46 | 86.30 | 99 | 401.0 | 152 | 942.0 |
| 47 | 90.10 | 100 | 408.5 | 153 | 955.0 |
| 48 | 93.90 | 101 | 417.0 | 154 | 968.0 |
| 49 | 97.90 | 102 | 426.0 | 155 | 979.0 |
| 50 | 102.0 | 103 | 434.0 | 156 | 993.0 |
| 51 | 106.0 | 104 | 442.5 | 157 | 1,005 |
| 52 | 110.1 | 105 | 451.0 | 158 | 1,018 |
| 53 | 114.6 | 106 | 459.0 | 159 | 1,031 |

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| Diameter <br> (in.) <br> 160 | $\begin{aligned} & \text { Gallons } \\ & \text { per } f t \end{aligned}$ | Diameter (in.) | Gallons per ft | Diameter (in.) | Gallons per ft |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 160 | 1,044 | 218 | 1,940 | 276 | 3,110 |
| 161 | 1,058 | 219 | 1,957 | 277 | 3,125 |
| 162 | 1,070 | 220 | 1,975 | 278 | 3,150 |
| 163 | 1,082 | 221 | 1,991 | 279 | 3,180 |
| 164 | 1,096 | 222 | 2,010 | 280 | 3,200 |
| 165 | 1,110 | 223 | 2,025 | 281 | 3,220 |
| 166 | 1,122 1,137 | 224 | 2,050 | 282 | 3,244 |
| 168 | 1,157 | 225 | 2,065 | 283 | 3,265 |
| 169 | 1,165 | 227 | 2,083 | 284 | 3,288 |
| 170 | 1,178 | 228 | 2,100 | 285 | 3,310 |
| 171 | 1,193 | 229 | 2,120 | 286 | 3,335 |
| 172 | 1,205 | 230 | 2,160 | 288 | 3,360 3,382 |
| 173 | 1,219 | 231 | 2,179 | 289 | 3,382 3,408 |
| 174 | 1,235 | 232 | 2,193 | 289 | 3,408 |
| 175 | 1,247 | 233 | 2,212 | 291 | 3,433 |
| 176 | 1,263 | 234 | 2,233 | 291 | 3,455 |
| 177 | 1,278 | 235 | 2,250 | 292 | 3,475 |
| 178 | 1,293 | 236 | 2,250 | 293 | 3,498 $\mathbf{3 , 5 2 9}$ |
| 179 | 1,309 | 237 | 2,291 | 295 | 3,529 $\mathbf{3 , 5 5 0}$ |
| 180 | 1,322 | 238 | 2,310 | 296 | 3,550 3,572 |
| 181 | 1,336 | 239 | 2,330 | 296 | 3,572 $\mathbf{3 , 5 9 5}$ |
| 182 | 1,347 | 240 | 2,350 | 298 | 3,595 $\mathbf{3} 620$ |
| 183 | 1,365 | 241 | 2,370 | 298 | 3,620 |
| 184 | 1,380 | 242 | 2,389 | 299 | 3,648 |
| 185 | 1,395 | 243 | 2,409 | 301 | 3,665 3,690 |
| 186 | 1,411 | 244 | 2,429 | 301 | 3,690 |
| 187 | 1,425 | 245 | 2,449 | 302 | 3,720 $\mathbf{3 , 7 4 8}$ |
| 188 | 1,442 | 246 | 2,469 | 303 | 3,748 $\mathbf{3 , 7 7 0}$ |
| 189 | 1,459 | 247 | 2,489 | 305 | 3,800 |
| 190 | 1,472 | 248 | 2,509 | 306 | 3,820 |
| 192 | 1,486 1,504 | 249 | 2,530 | 307 | 3,850 |
| 193 | 1,620 | 250 | 2,550 | 308 | 3,880 |
| 194 | 1,537 | 252 | 2,571 | 309 | 3,900 |
| 195 | 1,553 | 253 | 2,590 $\mathbf{2 , 6 1 0}$ | 310 | 3,920 |
| 196 | 1,566 | 254 | 2,610 | 311 | 3,950 |
| 197 | 1,580 | 255 | 2,650 | 312 313 | 3,970 |
| 198 | 1,600 | 256 | 2,650 | 313 314 | 4,000 4,030 |
| 199 | 1,618 | 257 | +2,672 | 314 315 | 4,030 4,050 |
| 200 | 1,631 | 258 | 2,717 | 316 | 4,050 4,080 |
| 201 | 1,648 | 259 | 2,734 | 316 317 | 4,080 4,110 |
| 202 | 1,666 | 260 | 2,756 | 317 318 | 4,110 4,130 |
| 203 | 1,680 | 261 | 2,756 $\mathbf{2 , 7 8 0}$ | 318 319 | 4,130 4,160 |
| 204 | 1,697 | 262 | 2,800 $\mathbf{2 , 8 0 0}$ | 319 320 | 4,160 4,180 |
| 205 | 1,714 | 263 | 2,819 | 320 321 | 4,180 4,210 |
| 206 | 1,733 1,748 | 264 | 2,844 | 322 | 4,230 |
| 208 | 1,766 | 265 | 2,862 | 323 | 4,260 |
| 209 | 1,781 | 267 | 2,890 $\mathbf{2} 909$ | 324 | 4,280 |
| 210 | 1,800 | 268 | 2,909 | 325 | 4,310 |
| 211 | 1,819 | 269 | 2,930 $\mathbf{2 , 9 5 0}$ | 326 | 4,340 |
| 212 | 1,836 | 270 | 2,950 $\mathbf{2 , 9 7 9}$ | 327 328 | 4,360 |
| 213 | 1,851 | 271 | 2,979 | 328 329 | 4,390 4,420 |
| 214 | 1,870 | 272 | 2,992 3,018 | 329 330 | 4,420 4,440 |
| 215 | 1,884 | 273 | 3,018 | 330 331 | 4,440 4,470 |
| 216 | 1,902 | 274 | 3,061 | 331 332 | 4,470 4,500 |
| 217 | 1,920 | 275 | 3,085 | 333 | 4,530 |


| Diameter (in.) | $\begin{gathered} \text { Gallons } \\ \text { per } f t \end{gathered}$ | Diameter (in.) | Gallone per ft | Diameter (in.) | Gallons per ft |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 334 | 4,550 | 455 | 8,450 | 770 | 24,220 |
| 335 | 4,580 | 460 | 8,630 | 780 | 24,870 |
| 336 | 4,610 | 465 | 8,830 | 790 | 25,500 |
| 337 | 4,630 | 470 | 9,010 | 800 | 26,120 |
| 338 | 4,670 | 475 | 9,200 | 810 | 26,800 |
| 339 | 4,690 | 480 | 9,390 | 820 | 27,480 |
| 340 | 4,720 | 485 | 9,600 | 830 | 28,100 |
| 341 | 4,740 | 490 | 9,790 | 840 | 28,800 |
| 342 | 4,770 | 495 | 10,000 | 850 | 29,530 |
| 343 | 4,800 | 500 | 10,200 | 860 | 30,200 |
| 344 | 4,830 | 505 | 10,400 | 870 | 30,900 |
| 345 | 4,860 | 510 | 10,600 | 880 | 31,680 |
| 346 | 4,890 | 515 | 10,810 | 890 | 32,350 |
| 347 | 4,920 | 520 | 11,010 | 900 | 33,100 |
| 348 | 4,950 | 525 | 11,240 | 910 | 33,800 |
| 349 | 4,980 | 530 | 11,460 | 920 | 34,600 |
| 350 | 4,990 | 535 | 11,670 | 930 | 35,360 |
| 351 | 5,030 | 540 | 11,890 | 940 | 36,100 |
| 352 | 5,060 | 545 | 12,100 | 950 | 36,900 |
| 353 | 5,080 | 550 | 12,330 | 960 | 37,700 |
| 354 | 5,110 | 555 | 12,560 | 970 | 38,450 |
| 355 | 5,150 | 560 | 12,790 | 980 | 39,250 |
| 356 | 5,180 | 565 | 13,090 | 990 | 40,100 |
| 357 | 5,210 | 570 | 13,280 | 1,000 | 40,850 |
| 358 | 5,240 | 575 | 13,500 | 1,010 | 41,700 |
| 359 | 5,270 | 580 | 13,750 | 1,020 | 42,600 |
| 360 | 5,280 | 585 | 13,980 | 1,030 | 43,400 |
| 365 | 5,440 | 590 | 14,220 | 1,040 | 44,250 |
| 370 | 5,580 | 600 | 14,700 | 1,050 | 45,100 |
| 375 | 5,740 | 610 | 15,210 | 1,060 | 45,900 |
| 380 | 5,890 | 620 | 15,700 | 1,070 | 46,750 |
| 385 | 6,060 | 630 | 16,200 | 1,080 | 47,750 |
| 390 | 6,200 | 640 | 16,750 | 1,090 | 48,600 |
| 395 | 6,370 | 650 | 17,250 | 1,100 | 49,500 |
| 400 | 6,530 | 660 | 17,770 | 1,110 | 50,300 |
| 405 | 6,700 | 670 | 18,330 | 1,120 | 51,250 |
| 410 | 6,860 | 680 | 18,880 | 1,130 | 52,200 |
| 415 | 7,030 | 690 | 19,450 | 1,140 | 53,250 |
| 420 | 7,190 | 700 | 20,000 | 1,150 | 54,100 |
| 425 | 7,380 | 710 | 20,600 | 1,160 | 55,100 |
| 430 | 7,540 | 720 | 21,190 | 1,170 | 56,000 |
| 435 | 7,730 | 730 | 21,750 | 1,180 | 57,000 |
| 440 | 7,900 | 740 | 22,360 | 1,190 | 58,000 |
| 445 | 8,080 | 750 | 22,980 | 1,200 | 58,900 |
| 450 | 8,260 | 760 | 23,600 |  |  |

(2) Horizontal.
(a) When the capacity of a horizontal cylindrical tank is known, the quantity in the

Part of tank depth filled
Part of tank capacity filled tank may be approximated by using the scale below.

| .80 | .860 |
| :--- | :--- |
| .75 | .804 |
| .70 | .740 |
| .65 | .687 |
| .60 | .626 |
| .55 | .563 |
| .50 | .500 |
| .45 | .437 |
| .40 | .374 |
| .35 | .313 |
| .30 | .252 |

Part of tank depth filled

| .25 | .196 |
| :--- | :--- |
| .20 | .140 |
| .15 | .096 |
| .10 | .052 |
| .05 | .026 |

Example. A horizontal tank is 80 inches in diameter. Depth of liquid in tank is 20 inches. Full tank capacity is $\mathbf{8 , 0 0 0}$ gallons. Find the number of gallons actually in tank.
$\frac{20}{80}=0.25$ (part of tank depth filled)
0.25 (part of tank depth filled) $=0.196$ (part of tank capacity filled)
$0.196 \times 8,000=1,568$ gallons in tank
(b) When the capacity of a horizontal cylindrical tank is not known, the volume of liquid may be computed as shown below.
$L=$ length of tank
$l=$ depth of liquid in tank
$r=$ radius of tank
$h=$ distance from top of tank to surface of liquid

| l/D | Tank less Quantity to multiply $D$ by to obtain | half full $l / D$ | Quantity to multiply $D$ by to obtain a |
| :---: | :---: | :---: | :---: |
| . 01 | 0.200 | . 26 | 1.070 |
| . 02 | 0.284 | . 27 | 1.093 |
| . 03 | 0.348 | . 28 | 1.115 |
| . 04 | 0.403 | . 29 | 1.137 |
| . 05 | 0.451 | . 30 | 1.159 |
| . 06 | 0.495 | . 31 | 1.181 |
| . 07 | 0.536 | . 32 | 1.203 |
| . 08 | 0.574 | . 33 | 1.224 |
| . 09 | 0.609 | . 34 | 1.245 |
| . 10 | 0.644 | . 35 | 1.266 |
| . 11 | 0.676 | . 36 | 1.287 |
| . 12 | 0.708 | . 37 | 1.308 |
| . 13 | 0.738 | . 38 | 1.328 |
| . 14 | 0.767 | . 39 | 1.349 |
| . 15 | 0.795 | . 40 | 1.369 |
| . 16 | 0.823 | . 41 | 1.390 |
| . 17 | 0.850 | . 42 | 1.410 |
| . 18 | 0.876 | . 43 | 1.430 |
| . 19 | 0.902 | . 44 | 1.451 |
| . 20 | 0.927 | . 45 | 1.471 |
| . 21 | 0.952 | . 46 | 1.491 |
| . 22 | 0.976 | . 47 | 1.511 |
| . 23 | 1.000 | . 48 | 1.531 |
| . 24 | 1.024 | . 49 | 1.551 |
| . 25 | 1.047 | . 50 | 1.571 |

(d) The volume of liquid in flat-end horizontal cylindrical tanks of various sizes is given below. Quantities are in U.S. gallons for each liquid depth shown per foot of tank
$D=$ diameter of tank
$a=$ cross-sectional length of "wet arc" formed by liquid, measured on lower part of tank
$a^{\prime}=$ cross-sectional length of "dry arc" above liquid, measured on upper part of tank

1. When tank is less than half full:

Volume (gal.) $=\left[\begin{array}{lll}\frac{a r}{2}-(r-1) & \sqrt{2 r l-1^{2}}\end{array}\right] \times \frac{L}{231}$
2. When tank is half full:

$$
\text { Volume (gal.) }=\frac{r^{2} L}{147}
$$

3. When $\operatorname{tank}$ is more than half full: Volume (gal.)

$$
=\left[3.1416 r^{2}-a^{\prime} r+(r-h) \sqrt{2 r h-h^{2}}\right] \times \frac{L}{231}
$$

(c) When it is not practical to measure $a$ and $a^{\prime}$ in the formulas above (because of buried tanks, etc.), the lengths of these arcs can be computed by determining $l / D$ and $h / D$ ratios, and using the table below.

|  | Tank more than half full <br> Quantity to | to <br> multiply $D$ <br> Quantity to |
| :---: | :---: | :---: | :---: |
| multiply |  |  |

length. Therefore, in the formulas shown in (b) above, the ratio $L / 231$ becomes a constant of 0.0519 . To obtain liquid volume, multiply the figure from the chart by the tank length (feet and fractions).

Depth of liquid in tank (in.)

|  | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 | 39 | 42 | 45 | 48 | 51 | 54 | 57 | 60 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 9 | . 95 | 2.34 | 3.30 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 12 | 1.15 | 2.95 | 4.73 | 5.9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 15 | 1.30 | 3.41 | 5.67 | 7.6 | 9.18 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 18 | 1.45 | 3.85 | 6.61 | 9.4 | 11.8 | 13.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 21 | 1.58 | 4.24 | 7.37 | 10.5 | 13.5 | 16.0 | 18.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 24 | 1.70 | 4.61 | 8.10 | 11.8 | 15.5 | 18.9 | 21.8 | 23.5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 27 | 1.78 | 4.86 | 8.70 | 12.8 | 17.0 | 21.0 | 24.7 | 27.5 | 29.8 |  |  |  |  |  |  |  |  |  |  |  |
| 30 | 1.91 | 5.23 | 9.30 | 13.7 | 18.4 | 23.0 | 27.5 | 31.5 | 34.8 | 36.8 |  |  |  |  |  |  |  |  |  |  |
| 33 | 1.99 | 5.43 | 9.80 | 14.5 | 19.6 | 24.8 | 29.8 | 34.5 | 38.7 | 41.9 | 44.4 |  |  |  |  |  |  |  |  |  |
| 36 | 2.12 | 5.80 | 10.3 | 15.4 | 20.9 | 26.4 | 32.0 | 37.5 | 42.5 | 47.1 | 50.8 | 52.9 |  |  |  |  |  |  |  |  |
| 39 | 2.20 | 5.94 | 10.8 | 16.2 | 22.0 | 28.0 | 34.0 | 40.0 | 45.7 | 51.1 | 55.8 | 59.3 | 62.2 |  |  |  |  |  |  |  |
| 42 | 2.28 | 6.31 | 11.3 | 17.0 | 23.1 | 29.5 | 36.0 | 42.5 | 48.9 | 55.0 | 60.7 | 65.7 | 69.7 | 72.0 |  |  |  |  |  |  |
| 45 | 2.35 | 6.43 | 11.8 | 17.7 | 24.1 | 30.9 | 37.8 | 44.8 | 51.7 | 58.4 | 64.8 | 70.7 | 75.9 | 79.6 | 82.7 |  |  |  |  |  |
| 48 | 2.45 | 6.78 | 12.2 | 18.4 | 25.1 | 32.2 | 39.5 | 47.0 | 54.5 | 61.8 | 68.9 | 75.6 | 81.8 | 87.2 | 91.6 | 94.0 |  |  |  |  |
| 51 | 2.54 | 6.89 | 12.6 | 19.1 | 26.1 | 33.5 | 41.2 | 49.0 | 57.0 | 64.8 | 72.6 | 80.0 | 86.9 | 93.3 | 98.8 | 102.9 | 106.3 |  |  |  |
| 54 | 2.61 | 7.23 | 13.0 | 19.7 | 27.0 | 34.7 | 42.8 | 51.1 | 59.5 | 67.9 | 76.2 | 84.3 | 92.0 | 99.3 | 105.9 | 111.8 | 116.4 | 119.0 |  |  |
| 57 | 2.68 | 7.43 | 13.4 | 20.3 | 27.9 | 35.9 | 44.1 | 53.0 | 61.8 | 70.7 | 79.5 | 88.2 | 96.6 | 104.6 | 112.1 | 118.9 | 124.8 | 129.2 | 132.8 |  |
| 60 | 2.76 | 7.64 | 13.8 | 20.9 | 28.7 | 37.1 | 45.8 | 54.9 | 64.1 | 73.5 | 82.8 | 92.0 | 101.1 | 109.8 | 118.2 | 126.0 | 133.1 | 139.3 | 144.1 | 146.9 |
| 63 | 2.82 | 7.84 | 14.2 | 21.5 | 29.5 | 38.2 | 47.3 | 56.7 | 66.3 | 76.0 | 85.9 | 95.5 | 105.2 | 114.6 | 123.7 | 132.3 | 140.2 | 147.5 | 153.7 | 158.3 |
| 66 | 2.89 | 8.05 | 14.6 | 22.1 | 30.4 | 39.3 | 48.7 | 58.4 | 68.4 | 78.6 | 88.9 | 99.1 | 109.3 | 119.3 | 129.1 | 138.5 | 147.4 | 155.7 | 163.2 | 169.7 |
| 69 | 2.95 | 8.23 | 14.9 | 22.5 | 31.2 | 40.2 | 50.0 | 60.1 | 70.5 | 81.0 | 91.7 | 102.6 | 113.2 | 123.7 | 134.1 | 144.2 | 153.8 | 163.0 | 171.4 | 179.1 |
| 72 | 3.02 | 8.42 | 15.3 | 23.2 | 31.9 | 41.4 | 51.3 | 61.7 | 72.5 | 83.4 | 94.5 | 105.8 | 117.0 | 128.1 | 139.1 | 149.8 | 160.2 | 170.2 | 179.6 | 188.4 |
| 75 | 3.08 | 8.60 | 15.6 | 23.5 | 32.7 | 42.4 | 52.6 | 63.3 | 74.4 | 85.7 | 97.2 | 108.9 | 120.5 | 132.2 | 143.7 | 155.1 | 166.1 | 176.8 | 187.0 | 196.7 |
| 78 | 3.15 | 8.78 | 15.9 | 24.2 | 33.4 | 43.3 | 53.9 | 64.9 | 76.3 | 88.0 | 99.9 | 112.0 | 124.1 | 136.3 | 148.3 | 160.3 | 172.0 | 183.4 | 194.4 | 204.9 |
| 81 | 3.20 | 8.95 | 16.2 | 24.7 | 34.2 | 44.3 | 55.1 | 66.5 | 78.1 | 90.2 | 102.4 | 115.0 | 127.5 | 140.2 | 152.7 | 165.2 | 177.5 | 189.5 | 201.2 | 212.4 |
| 84 | 3.25 | 9.12 | 16.6 | 25.2 | 34.9 | 45.2 | 56.3 | 67.9 | 79.9 | 92.3 | 105.0 | 117.9 | 130.9 | 144.0 | 157.0 | 170.0 | 182.9 | 195.6 | 208.0 | 220.0 |
| 87 | 3.34 | 9.29 | 16.9 | 25.7 | 35.6 | 46.2 | 57.5 | 69.4 | 81.7 | 94.3 | 107.4 | 120.7 | 134.1 | 147.6 | 161.2 | 174.7 | 188.0 | 201.3 | 214.4 | 227.0 |
| 90 | 3.43 | 9.45 | 17.2 | 26.2 | 36.2 | 47.1 | 58.6 | 70.8 | 83.4 | 96.4 | 109.8 | 123.5 | 137.3 | 151.2 | 165.3 | 179.3 | 193.2 | 207.0 | 220.7 | 234.1 |
| 93 | 3.47 | 9.61 | 17.5 | 26.7 | 36.9 | 48.0 | 59.7 | 72.2 | 85.1 | 98.4 | 111.6 | 126.1 | 140.3 | 154.7 | 169.2 | 183.7 | 198.1 | 212.5 | 226.7 | 240.6 |
| 96 | 3.50 | 9.78 | 17.8 | 27.1 | 37.5 | 48.8 | 60.8 | 73.5 | 86.7 | 100.4 | 114.4 | 128.8 | 143.4 | 158.2 | 173.1 | 188.0 | 203.0 | 217.9 | 232.6 | 247.2 |
| 99 | 3.56 | 9.89 | 18.1 | 27.6 | 38.3 | 49.7 | 61.9 | 74.8 | 88.3 | 102.3 | 116.7 | 131.4 | 146.4 | 161.5 | 176.8 | 192.2 | 207.7 | 223.0 | 238.3 | 253.5 |
| 102 | 3.61 | 10.1 | 18.4 | 28.0 | 39.0 | 50.5 | 63.0 | 76.2 | 89.9 | 104.2 | 118.9 | 133.9 | 149.3 | 164.8 | 180.5 | 196.4 | 212.3 | 228.1 | 244.0 | 259.7 |
| 105 | 3.66 | 10.3 | 18.6 | 28.5 | 39.5 | 51.3 | 64.0 | 77.5 | 91.5 | 106.1 | 121.1 | 136.4 | 152.1 | 168.0 | 184.1 | 200.4 | 216.7 | 233.1 | 249.4 | 265.6 |
| 108 | 3.71 | 10.4 | 18.9 | 28.9 | 40.0 | 52.1 | 65.1 | 78.7 | 93.0 | 107.9 | 123.2 | 138.9 | 154.9 | 171.2 | 187.7 | 204.4 | 221.1 | 238.0 | 254.8 | 271.5 |
| 111 | 3.77 | 10.6 | 19.2 | 29.4 | 40.6 | 52.9 | 66.1 | 79.9 | 94.5 | 109.6 | 125.2 | 141.3 | 157.6 | 174.3 | 191.2 | 208.2 | 225.4 | 242.9 | 259.9 | 277.0 |
| 114 | 3.82 | 10.7 | 19.5 | 29.8 | 41.1 | 53.7 | 67.1 | 81.2 | 96.0 | 111.4 | 127.3 | 143.7 | 160.4 | 177.4 | 194.7 | 212.1 | 229.7 | 247.8 | 265.0 | 283.3 |
| 117 | 3.87 | 10.9 | 19.7 | 30.2 | 41.6 | 54.0 | 67.9 | 82.4 | 97.6 | 113.2 | 129.5 | 145.8 | 162.9 | 180.3 | 198.8 | 215.8 | 233.8 | 252.3 | 270.0 | 288.5 |
| 120 | 3.92 | 11.0 | 19.8 | 30.6 | 42.0 | 54.2 | 68.7 | 83.6 | 99.2 | 114.9 | 131.8 | 148.0 | 165.5 | 183.2 | 203.0 | 219.5 | 238.0 | 256.8 | 274.9 | 294.0 |

Depth of liquid in tank (in.)

|  | 63 | 66 | 69 | 72 | 75 | 78 | 81 | 84 | 87 | 90 | 93 | 96 | 99 | 102 | 105 | 108 | 111 | 114 | 117 | 120 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 12 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 18 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 21 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 24 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 27 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 30 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 33 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 36 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 39 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 42 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 45 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 48 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| ¢ 51 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| E 54 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| $\begin{aligned} & 57 \\ & 60 \end{aligned}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 63 | 162.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 䕀 66 | 174.8 | 177.7 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| - 69 | 185.6 | 190.4 | 194.6 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 72 | 196.3 | 203.1 | 208.5 | 211.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| - 75 | 205.6 | 213.6 | 220.4 | 225.5 | 230.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 78 | 214.8 | 224.0 | 232.3 | 239.5 | 245.1 | 248.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 81 | 223.2 | 233.4 | 242.7 | 251.1 | 258.2 | 263.5 | 268.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 84 | 231.6 | 242.7 | 253.1 | 262.7 | 271.3 | 278.8 | 284.6 | 287.9 |  |  |  |  |  |  |  |  |  |  |  |  |
| 87 | 239.4 | 251.2 | 262.5 | 273.1 | 282.8 | 291.6 | 299.0 | 303.9 | 308.7 |  |  |  |  |  |  |  |  |  |  |  |
| 90 | 247.1 | 259.7 | 271.9 | 283.4 | 294.3 | 304.3 | 313.3 | 321.0 | 327.1 | 330.5 |  |  |  |  |  |  |  |  |  |  |
| 93 | 254.4 | 267.7 | 280.6 | 292.9 | 304.8 | 315.8 | 327.9 | 335.0 | 342.6 | 343.4 | 352.9 |  |  |  |  |  |  |  |  |  |
| 96 | 261.6 | 275.6 | 289.3 | 302.5 | 315.2 | 327.2 | 338.5 | 348.9 | 358.2 | 366.2 | 372.5 | 376.0 |  |  |  |  |  |  |  |  |
| 99 | 268.4 | 283.1 | 297.5 | 311.4 | 324.8 | 337.8 | 350.0 | 361.4 | 371.9 | 381.4 | 389.3 | 395.2 | 399.5 |  |  |  |  |  |  |  |
| 102 | 275.2 | 290.6 | 305.6 | 320.3 | 334.5 | 348.3 | 361.5 | 374.0 | 385.5 | 396.5 | 406.1 | 414.4 | 420.1 | 424.5 |  |  |  |  |  |  |
| 105 | 281.7 | 297.6 | 313.3 | 328.7 | 343.6 | 358.2 | 372.2 | 385.6 | 398.2 | 410.1 | 421.0 | 430.7 | 437.1 | 445.0 | 449.5 |  |  |  |  |  |
| 108 | 288.2 | 304.7 | 321.0 | 337.0 | 352.7 | 368.0 | 382.9 | 397.2 | 410.8 | 423.7 | 435.9 | 447.0 | 454.0 | 465.5 | 470.0 | 475.9 |  |  |  |  |
| 111 | 294.4 | 311.5 | 328.4 | 345.0 | 361.3 | 377.4 | 392.9 | 407.6 | 422.4 | 436.4 | 449.0 | 461.5 | 471.0 | 482.8 | 490.5 | 497.4 | 502.6 |  |  |  |
| 114 | 300.6 | 318.3 | 335.8 | 353.0 | 369.9 | 386.7 | 402.9 | 418.0 | 434.0 | 449.0 | 462.0 | 476.0 | 488.0 | 500.0 | 511.0 | 519.0 | 526.0 | 531.0 |  |  |
| 117 | 306.3 | 324.2 | 342.4 | 360.0 | 377.9 | 394.9 | 411.9 | 428.3 | 444.0 | 460.5 | 474.8 | 489.8 | 503.0 | 516.0 | 527.0 | 537.5 | 546.5 | 553.6 | 558.0 |  |
| 120 | 312.0 | 330.0 | 349.0 | 367.0 | 386.0 | 403.0 | 421.0 | 438.5 | 454.0 | 472.0 | 487.5 | 503.5 | 518.0 | 532.0 | 543.0 | 556.0 | 567.0 | 576.2 | 580.0 | 588.0 |

c. Rectangular Tanks. The chart below gives liquid volumes for each foot of liquid depth in rectangular tanks of various sizes. To obtain total liquid volume, multiply the figure shown by liquid depth (feet and fractions). Figures in the chart were obtained from the following formula:

Volume (gal.) $=\frac{L w l}{231}$
Where

$$
\begin{aligned}
& L=\text { length of tank in inches } \\
& w=\text { width of tank in inches } \\
& l=\text { depth of liquid in inches }
\end{aligned}
$$

Length of tank (in.)

|  | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 38 | 86 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 12 | 7.48 | 9.35 | 11.23 | 13.10 | 14.95 | 16.85 | 18.70 | 20.58 | 22.46 |
| 15 | 9.36 | 11.68 | 14.02 | 16.36 | 18.72 | 21.00 | 23.33 | 25.70 | 28.02 |
| 18 | 11.23 | 14.02 | 16.83 | 19.65 | 22.44 | 25.25 | 28.05 | 30.90 | 33.66 |
| 21 | 13.10 | 16.36 | 19.65 | 22.90 | 26.18 | 29.50 | 32.70 | 36.00 | 39.30 |
| 24 | 14.95 | 18.72 | 22.44 | 26.18 | 29.97 | 33.70 | 37.40 | 41.20 | 44.80 |
| 27 | 16.85 | 21.00 | 25.25 | 29.50 | 33.70 | 37.90 | 42.10 | 46.30 | 50.50 |
| 30 | 18.70 | 23.33 | 28.05 | 32.70 | 37.40 | 42.10 | 46.80 | 51.50 | 56.10 |
| 33 | 20.58 | 25.70 | 30.90 | 36.00 | 41.20 | 46.30 | 51.50 | 56.60 | 61.80 |
| 36 | 22.46 | 28.02 | 33.66 | 39.30 | 44.80 | 50.50 | 56.10 | 61.80 | 67.30 |
| 39 | 24.30 | 30.40 | 36.50 | 42.60 | 48.70 | 54.70 | 60.80 | 66.90 | 72.90 |
| 42 | 26.19 | 32.70 | 39.24 | 45.80 | 52.30 | 58.90 | 65.50 | 72.00 | 78.50 |
| 45 | 28.05 | 35.10 | 42.10 | 49.10 | 56.10 | 63.10 | 70.20 | 77.20 | 84.20 |
| 48 | 29.93 | 37.40 | 44.90 | 52.30 | 59.80 | 67.30 | 74.80 | 82.30 | 89.80 |
| 51 | 31.75 | 39.71 | 47.70 | 55.70 | 63.60 | 71.50 | 79.60 | 87.50 | 95.40 |
| 54 | 33.70 | 42.10 | 50.50 | 58.80 | 67.30 | 75.70 | 84.10 | 92.60 | 101.00 |
| 57 | 35.50 | 44.40 | 53.25 | 62.20 | 71.00 | 80.00 | 88.80 | 97.70 | 106.60 |
| 60 | 37.40 | 46.75 | 56.10 | 65.40 | 74.80 | 84.10 | 93.50 | 102.90 | 112.20 |
| 63 | 39.30 | 49.10 | 58.90 | 68.70 | 78.40 | 88.40 | 98.20 | 108.00 | 117.70 |
| 66 | 41.10 | 51.40 | 61.70 | 72.00 | 82.30 | 92.50 | 102.80 | 113.30 | 123.40 |
| 69 | 43.10 | 53.70 | 64.50 | 75.20 | 85.90 | 96.80 | 107.40 | 118.40 | 129.00 |
| 72 | 44.90 | 56.10 | 67.30 | 78.50 | 89.70 | 100.90 | 112.20 | 123.50 | 134.60 |
| 75 | 46.75 | 58.40 | 70.10 | 81.80 | 93.40 | 105.10 | 117.00 | 128.60 | 140.10 |
| 78 | 48.60 | 60.75 | 72.90 | 85.10 | 97.20 | 109.30 | 121.60 | 133.70 | 145.90 |
| 81 | 50.50 | 68.10 | 75.70 | 88.30 | 100.80 | 113.50 | 126.30 | 139.00 | 151.40 |
| 84 | 52.40 | 65.50 | 78.60 | 91.60 | 104.60 | 117.60 | 131.00 | 144.00 | 157.10 |
| 87 | 54.20 | 67.80 | 81.30 | 94.80 | 108.30 | 122.00 | 135.60 | 149.20 | 162.60 |
| 90 | 56.10 | 70.20 | 84.20 | 98.20 | 112.20 | 126.10 | 140.30 | 154.50 | 168.30 |
| 93 | 58.00 | 72.45 | 86.90 | 101.40 | 115.70 | 130.40 | 145.00 | 159.50 | 174.00 |
| 96 | 59.80 | 74.80 | 89.80 | 104.50 | 119.60 | 134.50 | 149.60 | 164.50 | 179.50 |
| 99 | 61.70 | 77.20 | 92.60 | 108.00 | 123.50 | 138.90 | 154.40 | 169.70 | 185.20 |
| 102 | 63.60 | 79.60 | 95.50 | 111.20 | 127.20 | 143.00 | 158.90 | 174.50 | 190.70 |
| 105 | 65.40 | 81.90 | 98.30 | 114.50 | 131.00 | 147.30 | 163.60 | 179.60 | 196.40 |
| 108 | 67.30 | 84.20 | 101.20 | 117.80 | 134.60 | 151.50 | 168.30 | 184.90 | 202.00 |
| 111 | 69.20 | 86.60 | 103.90 | 121.00 | 138.30 | 155.50 | 173.00 | 190.00 | 205.20 |
| 114 | 71.00 | 88.90 | 106.70 | 124.40 | 142.10 | 159.80 | 177.70 | 195.00 | 213.20 |
| 117 | 72.80 | 91.30 | 109.50 | 127.50 | 145.90 | 164.00 | 182.40 | 200.50 | 219.00 |
| 120 | 74.75 | 93.60 | 112.40 | 130.80 | 149.60 | 168.20 | 187.00 | 205.30 | 224.40 |

Length of tank (in.)

|  | 39 | 42 | 45 | 48 | 51 | 54 | 57 | 60 | 63 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 12 | 24.30 | 26.19 | 28.05 | 29.93 | 31.75 | 33.70 | 35.50 | 37.40 | 39.30 |
| 15 | 30.40 | 32.70 | 35.10 | 37.40 | 39.71 | 42.10 | 44.40 | 46.75 | 49.10 |
| 18 | 36.50 | 39.24 | 42.10 | 44.90 | 47.70 | 50.50 | 53.25 | 56.10 | 58.90 |
| 21 | 42.60 | 45.80 | 49.10 | 52.30 | 55.70 | 58.80 | 62.20 | 65.40 | 68.70 |
| 24 | 48.70 | 52.30 | 56.10 | 59.80 | 63.60 | 67.30 | 71.00 | 74.80 | 78.40 |
| 27 | 54.70 | 58.90 | 63.10 | 67.30 | 71.50 | 75.70 | 80.00 | 84.10 | 88.40 |
| 30 | 60.80 | 65.50 | 70.20 | 74.80 | 79.60 | 84.10 | 88.80 | 93.50 | 98.20 |
| 33 | 66.90 | 72.00 | 77.20 | 82.30 | 87.50 | 92.60 | 97.70 | 102.90 | 108.00 |
| 36 | 72.90 | 78.50 | 84.20 | 89.80 | 93.40 | 101.00 | 106.60 | 112.20 | 117.70 |
| 39 | 79.00 | 85.10 | 91.10 | 97.20 | 103.30 | 109.40 | 115.50 | 121.60 | 127.60 |
| 42 | 85.10 | 91.60 | 98.10 | 104.70 | 111.20 | 117.80 | 124.40 | 131.00 | 137.40 |
| 45 | 91.10 | 98.10 | 105,20 | 112.20 | 119.20 | 126.20 | 133.20 | 140.20 | 147.20 |
| 48 | 97.20 | 104.70 | 112.20 | 119.70 | 127.20 | 134.60 | 142.00 | 149.50 | 157.00 |
| 51 | 103.30 | 111.20 | 119.20 | 127.20 | 135.00 | 143.00 | 151.00 | 158.90 | 166.80 |
| 54 | 109.40 | 117.80 | 126.20 | 134.60 | 143.00 | 151.50 | 159.90 | 168.30 | 176.60 |
| 57 | 115.50 | 124.40 | 133.20 | 142.00 | 151.00 | 159.90 | 168.80 | 177.50 | 186.50 |
| 60 | 121.60 | 131.00 | 140.20 | 149.50 | 158.90 | 168.30 | 177.50 | 187.00 | 196.40 |
| 63 | 127.60 | 137.40 | 147.20 | 157.00 | 166.80 | 176.60 | 186.50 | 196.40 | 206.00 |
| 66 | 133.90 | 144.00 | 154.10 | 164.60 | 174.60 | 185.10 | 195.50 | 205.50 | 215.80 |
| 69 | 139.80 | 150.50 | 161.20 | 172.00 | 182.60 | 193.50 | 204.50 | 215.00 | 225.30 |
| 72 | 146.00 | 157.10 | 168.10 | 179.50 | 190.50 | 202.00 | 213.00 | 224.30 | 235.20 |
| 75 | 152.00 | 163.50 | 175.20 | 187.00 | 198.50 | 210.30 | 222.00 | 233.30 | 245.00 |
| 78 | 158.00 | 170.20 | 182.20 | 194.50 | 206.40 | 219.00 | 231.00 | 243.00 | 255.00 |
| 81 | 164.10 | 176.60 | 189.30 | 202.00 | 214.50 | 227.00 | 239.90 | 252.30 | 264.90 |
| 84 | 170.20 | 183.30 | 196.30 | 209.40 | 222.50 | 235.60 | 249.00 | 261.60 | 274.90 |
| 87 | 176.40 | 289.80 | 203.30 | 217.00 | 230.50 | 244.00 | 257.80 | 271.00 | 284.60 |
| 90 | 182.50 | 196.40 | 210.30 | 224.40 | 238.50 | 252.50 | 266.90 | 280.50 | 294.10 |
| 93 | 188.50 | 203.00 | 217.20 | 231.90 | 246.10 | 261.00 | 275.20 | 289.80 | 304.00 |
| 96 | 194.40 | 209.50 | 224.40 | 239.40 | 254.10 | 269.30 | 284.00 | 299.30 | 314.00 |
| 99 | 200.50 | 216.00 | 231.50 | 247.00 | 262.10 | 277.80 | 293.00 | 308.80 | 324.00 |
| 102 | 206.50 | 222.50 | 238.50 | 254.30 | 270.00 | 286.00 | 302.00 | 318.00 | 333.20 |
| 105 | 212.50 | 229.00 | 245.30 | 261.50 | 278.00 | 294.50 | 311.00 | 327.20 | 343.20 |
| 108 | 218.60 | 235.60 | 252.70 | 269.30 | 286.00 | 303.00 | 319.80 | 336.60 | 353.00 |
| 111 | 224.80 | 242.00 | 259.80 | 276.60 | 294.00 | 311.00 | 328.80 | 346.00 | 362.90 |
| 114 | 230.90 | 248.70 | 266.90 | 284.20 | 302.00 | 319.80 | 337.80 | 355.30 | 372.90 |
| 117 | 237.00 | 255.00 | 273.90 | 291.50 | 310.00 | 328.20 | 346.50 | 365.00 | 382.90 |
| 120 | 242.90 | 261.80 | 280.70 | 299.10 | 318.00 | 336.60 | 355.30 | 374.00 | 392.20 |

Length of tank (in.)

|  | 66 | 69 | 72 | 75 | 78 | 81 | 84 | 87 | 90 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 12 | 41.10 | 43.10 | 44.90 | 46.75 | 48.60 | 50.50 | 52.40 | 54.20 | 56.10 |
| 15 | 51.40 | 53.75 | 56.10 | 58.40 | 60.75 | 63.10 | 65.50 | 67.80 | 70.20 |
| 18 | 61.70 | 64.50 | 67.30 | 70.10 | 72.90 | 75.70 | 78.60 | 81.30 | 84.20 |
| 21 | 72.00 | 75.20 | 78.50 | 81.80 | 85.10 | 88.30 | 91.60 | 94.80 | 98.20 |
| 24 | 82.30 | 85.90 | 89.70 | 93.40 | 97.20 | 100.80 | 104.60 | 108.30 | 112.20 |
| 27 | 92.50 | 96.80 | 100.90 | 105.10 | 109.30 | 113.50 | 117.60 | 122.00 | 126.10 |
| 30 | 102.80 | 107.40 | 112.20 | 117.00 | 121.60 | 126.30 | 131.00 | 135.60 | 140.30 |
| 33 | 113.30 | 118.40 | 123.50 | 128.60 | 133.70 | 139.00 | 144.00 | 149.20 | 154.50 |
| 36 | 123.40 | 129.00 | 134.60 | 140.10 | 145.90 | 151.40 | 157.10 | 162.60 | 168.30 |
| 39 | 133.90 | 139.80 | 146.00 | 152.00 | 158.00 | 164.10 | 170.20 | 176.40 | 182.50 |
| 42 | 144.00 | 150.50 | 157.10 | 163.50 | 170.20 | 176.60 | 183.30 | 189.80 | 196.40 |
| 45 | 154.10 | 161.20 | 168.10 | 175.20 | 182.20 | 189.30 | 196.30 | 203.30 | 210.30 |
| 48 | 164.60 | 172.00 | 179.50 | 187.00 | 194.50 | 202.00 | 209.40 | 217.00 | 224.40 |
| 51 | 174.60 | 182.60 | 190.50 | 198.50 | 206.40 | 214.50 | 222.50 | 230.50 | 238.50 |
| 54 | 185.10 | 193.50 | 202.00 | 210.30 | 219.00 | 227.00 | 235.60 | 244.00 | 252.50 |
| 57 | 195.50 | 204.50 | 213.00 | 222.00 | 231.00 | 239.90 | 249.00 | 257.80 | 266.90 |

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Length of tank (in.)

|  | 66 | 69 | 72 | 75 | 78 | 81 | 84 | 87 | 90 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 60 | 205.50 | 215.00 | 224.30 | 233.30 | 243.00 | 252.30 | 261.60 | 271.00 | 280.50 |
| 63 | 215.80 | 225.30 | 235.20 | 245.00 | 255.00 | 264.90 | 274.90 | 284.60 | 294.10 |
| 66 | 226.30 | 236.80 | 247.00 | 257.00 | 267.40 | 277.90 | 288.00 | 298.00 | 308.60 |
| 69 | 236.80 | 247.40 | 258.00 | 269.00 | 279.80 | 290.40 | 301.50 | 312.00 | 322.80 |
| 72 | 247.00 | 258.00 | 269.30 | 280.40 | 291.60 | 302.90 | 314.20 | 325.00 | 336.50 |
| 75 | 257.00 | 269.00 | 280.40 | 292.20 | 303.90 | 315.80 | 327.00 | 339.00 | 350.40 |
| 78 | 267.40 | 279.80 | 291.60 | 303.90 | 316.00 | 328.00 | 340.30 | 352.80 | 364.70 |
| 81 | 277.90 | 290.40 | 302.90 | 315.80 | 328.00 | 341.00 | 353.50 | 366.00 | 379.00 |
| 84 | 288.00 | 301.50 | 314.20 | 327.00 | 340.30 | 353.50 | 366.50 | 379.90 | 393.00 |
| 87 | 298.00 | 312.00 | 325.00 | 339.00 | 352.80 | 366.00 | 379.90 | 393.00 | 406.80 |
| 90 | 308.60 | 322.80 | 336.50 | 350.40 | 364.70 | 379.00 | 393.00 | 406.80 | 421.00 |
| 93 | 319.00 | 333.00 | 347.50 | 362.00 | 377.00 | 391.50 | 406.00 | 421.00 | 435.00 |
| 96 | 329.00 | 342.10 | 359.00 | 373.90 | 389.00 | 403.50 | 419.00 | 433.50 | 449.00 |
| 99 | 339.30 | 355.00 | 370.70 | 385.80 | . 401.00 | 416.00 | 432.00 | 447.00 | 462.50 |
| 102 | 349.60 | 365.80 | 381.40 | 397.00 | 413.20 | 428.50 | 445.00 | 460.70 | 477.00 |
| 105 | 360.00 | 376.80 | 392.90 | 408.00 | 425.50 | 442.00 | 458.00 | 474.50 | 491.00 |
| 108 | 370.30 | 387.20 | 404.00 | 421.00 | 437.80 | 454.00 | 471.10 | 487.00 | 505.00 |
| 111 | 380.60 | 398.00 | 415.00 | 432.00 | 449.00 | 467.00 | 484.00 | 501.50 | 519.00 |
| 114 | 391.00 | 408.00 | 426.40 | 444.00 | 462.00 | 479.00 | 497.50 | 515.00 | 533.00 |
| 117 | 401.70 | 419.00 | 437.50 | 456.00 | 474.00 | 492.00 | 510.90 | 528.00 | 547.50 |
| 120 | 411.50 | 430.70 | 449.00 | 467.00 | 486.00 | -504.90 | 523.00 | 542.00 | 561.00 |



Length of tank (in.)

|  | 120 | 128 | 126 | 129 | 132 | 185 | 188 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 12 | 74.75 | 76.70 | 78.50 | 80.40 | 82.25 | 84.10 | 86.00 |
| 15 | 93.60 | 95.90 | 98.30 | 100.50 | 103.00 | 105.30 | 107.60 |
| 18 | 112.40 | 115.20 | 118.00 | 120.80 | 123.50 | 126.50 | 129.20 |
| 21 | 130.80 | 134.10 | 137.40 | 140.50 | 143.90 | 147.20 | 150.50 |
| 24 | 149.60 | 153.50 | 157.10 | 160.90 | 164.50 | 168.30 | 172.00 |
| 27 | 168.20 | 172.50 | 176.70 | 180.90 | 185.00 | 189.40 | 193.50 |
| 30 | 187.00 | 191.80 | 196.40 | 201.30 | 205.70 | 210.50 | 215.10 |
| 33 | 205.30 | 210.50 | 215.50 | 220.90 | 226.00 | 231.00 | 236.00 |
| 36 | 224.40 | 230.00 | 235.60 | 241.00 | 246.90 | 252.50 | 258.10 |
| 39 | 242.90 | 249.00 | 255.00 | 261.00 | 267.00 | 273.30 | 279.70 |
| 42 | 261.80 | 268.50 | 274.90 | 281.00 | 288.00 | 294.40 | 301.10 |
| 45 | 280.70 | 287.50 | 294.50 | 302.00 | 308.00 | 315.50 | 322.80 |
| 48 | 299.10 | 304.80 | 314.10 | 321.80 | 329.00 | 336.80 | 344.00 |
| 51 | 318.00 | 325.90 | 333.80 | 341.80 | 349.80 | 357.80 | 365.80 |
| 54 | 336.60 | 345.00 | 353.40 | 362.00 | 370.30 | 378.80 | 387.00 |
| 57 | 355.30 | 364.30 | 373.00 | 382.00 | 391.00 | 400.00 | 409.00 |
| 60 | 374.00 | 383.80 | 392.80 | 402.50 | 411.40 | 421.00 | 430.30 |
| 63 | 392.20 | 402.00 | 412.00 | 422.00 | 432.00 | 441.80 | 451.80 |
| 66 | 411.50 | 421.50 | 432.00 | 442.00 | 452.50 | 463.00 | 473.00 |
| 69 | 430.70 | 441.00 | 452.00 | 462.50 | 473.00 | 484.00 | 495.00 |
| 72 | 449.00 | 460.00 | 471.30 | 482.00 | 493.50 | 505.00 | 516.00 |
| 75 | 467.00 | 479.00 | 491.00 | 502.00 | 514.00 | 526.00 | 537.50 |
| 78 | 486.00 | 498.00 | 510.50 | 522.50 | 535.00 | 547.00 | 559.00 |
| 81 | 504.90 | 517.00 | 530.00 | 542.50 | 555.00 | 567.50 | 580.50 |
| 84 | 523.00 | 537.00 | 549.80 | 562.50 | 576.00 | 589.00 | 602.00 |
| 87 | 542.00 | 556.00 | 569.50 | 582.50 | 597.00 | 610.00 | 623.00 |
| 90 | 561.00 | 575.00 | 589.00 | 603.00 | 617.00 | 631.00 | 645.00 |
| 93 | 579.00 | 593.00 | 607.50 | 622.50 | 637.00 | 652.00 | 666.00 |
| 96 | 598.00 | 614.00 | 628.00 | 644.00 | 658.30 | 674.00 | 688.00 |
| 99 | 617.00 | 632.50 | 648.00 | 663.00 | 679.00 | 694.90 | 711.00 |
| 102 | 636.00 | 652.00 | 667.50 | 684.00 | 699.00 | 715.80 | 732.00 |
| 105 | 654.00 | 671.00 | 687.50 | 703.00 | 719.50 | 736.50 | 752.50 |
| 108 | 673.00 | 690.00 | 707.50 | 723.50 | 741.00 | 757.50 | 774.00 |
| 111 | 691.00 | 709.00 | 726.00 | 743.00 | 760.00 | 777.50 | 795.00 |
| 114 | 711.00 | 729.00 | 747.00 | 764.00 | 782.00 | 800.00 | 818.00 |
| 117 | 729.90 | 748.00 | 766.00 | 784.00 | 802.50 | 820.00 | 839.00 |
| 120 | 747.50 | 767.00 | 785.00 | 804.00 | 823.00 | 842.00 | 866.00 |

d. Elliptical Tanks (Horizontal).
(1) Formula. The full capacity in gallons of horizontal elliptical tanks with flat ends can be computed by the following formula.

$$
\text { Volume }(\mathrm{gal} .)=\frac{.7854 \mathrm{abL}}{231}
$$

Where
$a=$ long axis of elliptical cross-section

| Part of <br> tank depth <br> flled | Part of <br> tank capoc- <br> ity filled | Part of <br> tank depth <br> flled |
| :---: | :---: | :---: |
| 0.01 | 0.0020 | 0.05 |
| 0.02 | 0.0050 | 0.06 |
| 0.03 | 0.0090 | 0.07 |
| 0.04 | 0.0134 | 0.08 |

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$b=$ short axis of elliptical cross-section $L=$ length of tank
(2) Table. For tanks of known capacity; the partial content in gallons for varying liquid depths can be determined by using the scale below. (See $b$ (2) above for example of use.)

| Part of <br> tank capac- <br> ity filled | Part of <br> tank of <br> flledth | Part of <br> tank capac- <br> ity filled |
| :---: | :---: | :---: |
| 0.0187 | 0.09 | 0.0445 |
| 0.0245 | 0.10 | 0.0520 |
| 0.0307 | 0.11 | 0.0598 |
| 0.0374 | 0.12 | 0.0680 |


| Part of <br> tank depth <br> filed | Part of <br> tank capac- <br> ity flled |
| :---: | :---: |
| 0.13 | 0.0764 |
| 0.14 | 0.0850 |
| 0.15 | 0.0940 |
| 0.16 | 0.1032 |
| 0.17 | 0.1127 |
| 0.18 | 0.1224 |
| 0.19 | 0.1323 |
| 0.20 | 0.1423 |
| 0.21 | 0.1526 |
| 0.22 | 0.1632 |
| 0.23 | 0.1740 |
| 0.24 | 0.1850 |
| 0.25 | 0.1961 |
| 0.26 | 0.2073 |
| 0.27 | 0.2186 |
| 0.28 | 0.2300 |
| 0.29 | 0.2407 |
| 0.30 | 0.2531 |
| 0.31 | 0.2648 |
| 0.32 | 0.2766 |
| 0.33 | 0.2884 |
| 0.34 | 0.3003 |
| 0.35 | 0.3119 |
| 0.36 | 0.3244 |
| 0.37 | 0.3366 |
| 0.38 | 0.3490 |
| 0.39 | 0.3614 |
| 0.40 | 0.3739 |
| 0.41 | 0.3864 |
| 0.42 | 0.3989 |
|  |  |


| Part of |
| :---: |
| tank |
| fileped |

0.43
0.44
0.45
0.46
0.47
0.48
0.49
0.50
0.51
0.52
0.53
0.54
0.55
0.56
0.57
0.58
0.59
0.60
0.61
0.62
0.63
0.64
0.65
0.66
0.67
0.68
0.69
0.70
0.71
0.72
e. Spherical Tanks. The chart ((4) below) may be used to determine the liquid volume in spherical tanks for various depths of the liquid. Also shown are three formulas which may be used instead of the table. When more precise computations are desired, use the formulas which do not require figures from the chart. Volumes are shown in cubic inches; cubic inches are divided by 231 to obtain gallons. In this subparagraph, the words "sphere" and "tank" have the same meaning, and the letters used represent the following:

$$
\begin{aligned}
d= & \text { dept of liquid or height of seg- } \\
& \text { ment of sphere formed by liquid } \\
& \text { (when tank is less than half full) } \\
= & \text { distance from top of sphere to surface } \\
& \text { of liquid (when tank is more than } \\
& \text { half full) } \\
C= & \text { a value for different } d / D \text { relation- } \\
& \text { ships which represents the volume of }
\end{aligned}
$$

| Part of <br> tank capac- <br> ity filled | Part of <br> tank depth <br> filed | Part of <br> tank capoc- <br> ity <br> filled |
| :---: | :---: | :---: |
| 0.4114 | 0.73 | 0.7814 |
| 0.4240 | 0.74 | 0.7927 |
| 0.4366 | 0.75 | 0.8039 |
| 0.4492 | 0.76 | 0.8150 |
| 0.4619 | 0.77 | 0.8260 |
| 0.4745 | 0.78 | 0.8368 |
| 0.4873 | 0.79 | 0.8474 |
| 0.5000 | 0.80 | 0.8577 |
| 0.5127 | 0.81 | 0.8677 |
| 0.5255 | 0.82 | 0.8776 |
| 0.5381 | 0.83 | 0.8873 |
| 0.5508 | 0.84 | 0.8968 |
| 0.5634 | 0.85 | 0.9060 |
| 0.5760 | 0.86 | 0.9150 |
| 0.5886 | 0.87 | 0.9236 |
| 0.6011 | 0.88 | 0.9320 |
| 0.6136 | 0.89 | 0.9402 |
| 0.6261 | 0.90 | 0.9480 |
| 0.6386 | 0.91 | 0.9555 |
| 0.6510 | 0.92 | 0.9626 |
| 0.6634 | 0.93 | 0.9693 |
| 0.6756 | 0.94 | 0.9755 |
| 0.6881 | 0.95 | 0.9813 |
| 0.6997 | 0.96 | 0.9866 |
| 0.7116 | 0.97 | 0.9910 |
| 0.7234 | 0.98 | 0.9950 |
| 0.7352 | 0.99 | 0.9980 |
| 0.7469 | 1.00 | 1.0000 |
| 0.7593 |  |  |
| 0.7700 |  |  |

the sphere segment divided by the cube of the sphere's diameter
$D=$ diameter of tank
(1) When tank is less than half full:
(a) To find the volume of the liquid, form the ratio $d / D$ and find the value of $C$ in the table. Then Volume of liquid $=D^{3} C$
(b) Alternate method: (chart not required) Volume of liquid $=.5236 \mathrm{~d}^{2}(3 D-2 d)$
(2) When tank is half full:

Volume of liquid $=.2618 D^{3}$ (chart not required)
(3) When tank is more than half full:
(a) Since the ratio $d / D$ (if $d$ is considered the depth of liquid) becomes greater than 0.50 , the table no longer applies. Therefore, the chart should be used to determine the volume of the unfilled portion. Subtract this from the total volume of the tank (.5236D ${ }^{3}$ ) to obtain the volume of the filled portion. In this
case, $d$ becomes the distance from the top of tank to the surface of liquid. To find the volume of the unfilled portion, form the ratio $d / D$ and find the value of $C$ in the chart. The unfilled portion is then $D^{3} C$, and the volume of the filled portion can be determined as follows:

$$
\begin{aligned}
\text { Volume of liquid } & =.5236 D^{3}-D^{3} C \\
& =D^{3}(.5236-C)
\end{aligned}
$$

| $d / D$ | $C$ | $d / D$ | $C$ | $d / D$ | $C$ | $d / D$ | $C$ |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :---: |
| 0.01 | 0.0002 | 0.11 | 0.0176 | 0.21 | 0.0596 | 0.31 | 0.1198 | 0.0 | 0.41 |
| 0.02 | 0.0006 | 0.12 | 0.0208 | 0.22 | 0.0649 | 0.32 | 0.1265 | 0.42 | 0.1995 |
| 0.03 | 0.0014 | 0.13 | 0.0242 | 0.23 | 0.0704 | 0.33 | 0.1334 | 0.43 | 0.2072 |
| 0.04 | 0.0024 | 0.14 | 0.0279 | 0.24 | 0.0760 | 0.34 | 0.1404 | 0.44 | 0.2149 |
| 0.05 | 0.0038 | 0.15 | 0.0318 | 0.25 | 0.0818 | 0.35 | 0.1475 | 0.45 | 0.2227 |
| 0.06 | 0.0054 | .0 .16 | 0.0359 | 0.26 | 0.0878 | 0.36 | 0.1547 |  | 0.46 |
| 0.07 | 0.0073 | 0.17 | 0.0403 | 0.27 | 0.0939 | 0.37 | 0.1620 | 0.47 | 0.2383 |
| 0.08 | 0.0095 | 0.18 | 0.0448 | 0.28 | 0.1002 | 0.38 | 0.1694 | 0.48 | 0.2461 |
| 0.09 | 0.0120 | 0.19 | 0.0495 | 0.29 | 0.1066 | 0.39 | 0.1768 | 0.49 | 0.2539 |
| 0.10 | 0.0147 | 0.20 | 0.0545 | 0.30 | 0.1131 | 0.40 | 0.1843 | 0.50 | 0.2618 |

f. Temperature Corrections (Approximate) for POL Products.


7-25. Dimensions of Containers

| Nomenclature | $\begin{gathered} \text { Unite } \\ \text { package } \end{gathered}$ | $\begin{gathered} \text { Type } \\ \text { package } \end{gathered}$ | Length | Size of package (im) Width $\stackrel{\text { or }}{\text { diameter }}$ | Height |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Drum: |  |  |  |  |  |
| U.S. 55-gal., 16-gage | 1 | Drum | 0 | $241 / 8$ | 34\% |
| U.S. 55-gal., 18-gage | 1 | Drum | 0 | 245\% | $347 / 8$ |
| Can: |  |  |  |  |  |
| U.S. 5-gal. (gasoline) | 1 | Can | 138/4 | 61/2 | 18\% |
| U.S. 5-gal. (oil) | 2 | Case | 0 | 11 15/16 | 14 3/16 |
| U.S. 5-qt. ( oil) | 6 | Case | 0 | 14 | 10 |
| U.S. 1-qt. (oil) | 12 | Case | 18 | 13 | 6 |
| Pail: |  |  |  |  |  |
| U.S. 25-1b (grease) | 1 | Pail | 0 | 111/2 | 111/2 |

## 7-26. Bulk Capacities



## Section VIII. SUPPLY

## 7-27. Classes of Supply

## Cllass Definition

Articles consumed at an approximately uniform rate, such as rations.

II Articles authorized by established allowances, such as TOE, TA, or special authorizations.
II(A) Aviation supplies and equipment for which allowances for initial issue to organizations are prescribed by appropriate Table of Allowance lists.
III Fuels, lubricants, fuel oils, coal
and
III (A) Aviation fuels and lubricants.

How obtained
From QM class I distributing points. Basis of issue is the daily report of personnel strength and equipment status submitted through channels.
By requisition. Often submitted through channels to Army ACS Logistics.
By requisition. Often submitted through channels to Army ACS Logistics.

Directly from Army logistical command distribution points.

Obtained on credit basis or by exchange of empty for filled containers.

| Class | Definition | Howo obtained |
| :---: | :---: | :---: |
| IV | Supplies and equipment in excess of, or not authorized by, established allowances, not in any other class, or transferred to class IV because special control measures are required. | By requisition. Submitted as for class III items. Depots normally require staff approval before issue. Critical items require authority of superior headquarters. |
| IV (A) | Aircraft, and aircraft equipment, parts, and supplies. | From transportation Army aircraft maintenance and supply units. |
| V | Ammunition, pyrotechnics, land mines, and chemicals. | Normally by credit allocations to troop units, authorizing ammunition supply points. |
| V ( A ) | Aviation ammunition, bombs, rockets, pyrotechnics, and similar expendable accessories. | Normally by credit allocations to troop units, authorizing ammunition supply points. |

## 7-28. Shipping Data on Commonly Transported Items

## a. Rations.

| Type | ContentaPackage or case <br> Weight <br> $(l b)$ |  | Cuft | Ration or packetincluilingpackaging(veightAvo vol(lis) |  | Avg calories |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Field $A^{1}$ |  | --- | ---- | 6.0 | 0.183 | 4,200 |
| Operational $B^{\text {a }}$ | -------- | --- | ---- | 6.0 | 0.127 | 4,400 |
| Small detachment, 5 persons ${ }^{3}$ | 5 rations | 28.5 | 1.1 | 5.8 | 0.2 | 3,600 |
| Combat, indiv ${ }^{\text {c }}$ | 6 rations | 38 | 1.2 | 6.5 | 0.2 | 3,600 |
| Trail, frigid, indiv ${ }^{\text {s }}$ | 8 rations | 34 | 1.6 | 4.0 | 0.2 | 4,400 |
| Supplement, sundries pack (1 pack per 100 men$)^{\circ}$ |  | 47 | 1.9 |  |  |  |
| Indiv, combat, meal type | 4 rations | 24 | ---- | 4.8 | 0.85 | 3,600 |
| Supplement, aid station (205 8-oz drinks) ${ }^{7}$ |  | 20 | 1.1 |  |  |  |
| Survival: |  |  |  |  |  |  |
| Aretic, SA ${ }^{\text {a }}$ | 24 packets | 34 | 0.7 | 1.5 | ---- | 2,000 |
| Tropic, ST ${ }^{\text {® }}$ | 24 packets | 36 | 0.7 | 1.5 | ---- | 1,700 |

[^41]
## b. Ammunition.

| Nomsnclature | $\begin{gathered} \text { Number } \\ \text { per } \\ \text { unit } \end{gathered}$ | Weight (lb) |  | Cubic feet |  | Stowage factor |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Crated | Uncrated | Crated | Uncrated | Crated | Uncrated |
| Block, deml, chain | 16 | 61.1 |  | 1.28 | --- | 44 | ---- |
| Block, deml, $21 / 2$ \#, plastic | 24 | 75 | ---- | 1.60 | ---- | 47 | --- |
| Canister, N2, 37 mm , G | 20 | 102 | --- | 2.04 | ---- | 45 | ---- |
| Cart, AP, cal .30, in cartons | 1,500 | 112 | ---. | 1.5 | ---- | 30 | ---- |
| Cart, AP, cal .30, 8 rd clip | 1,440 | 112 | ---- | 1.5 | ---- | 30 | --- |
| Cart, AP, cal .50, in cartons | 300 | 97 | .- - | 1.5 | . . - | 35 | ---- |
| Cart, AP, cal .50, in cartons | 350 | 112 | --- | 1.5 | - | 30 | --- |


| Nomenclaturc | $\underset{\text { per }}{\text { Number }}$ unit | Weight (lb) |  | Cubic fect |  | Stowage factor |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Crated | Uncrated | Crated | Uncrated | Crated | Uncrated |
| Cart, AP, 3', M78 | 4 | 153 | ---- | 3.22 | --. | 47 | ---- |
| Cart, AP, 7.62mm, in cartons, grade |  |  |  |  |  |  |  |
| MG .-.------.-.--------------- | 1,200 | 86 | ---- | 1.28 | -... | 33 | -.-- |
| Cart, AP, 37mm, M51 | 20 | 104 |  | 2.01 | ---- | 43 | ---- |
| Cart, AP, 37mm, M74 | 20 | 91 | ---- | 1.01 | ---- | 50 | ---- |
| Cart, AP, 75 mm , M72 | 3 | 80 | 66 | 1.51 | . 83 | 28 | 28 |
| Cart, AP, 90 mm , M77 | 4 | 237 | -... | 4.43 | ---- | 42 | -..- |
| Cart, APC, 37 mm , M59 | 25 | 99 | ---- | 2.03 | ---- | 46 | ---- |
| Cart, APC, 75 mm , M61 | 3 | 83 | 70 | 1.84 | 1.03 | 50 | 33 |
| Cart, AP, I\&T, cal .30, 1/b | 1,200 | 101 | - - - | 1.5 | -..- | 33 | ---- |
| Cart, AP, I\&T, cal .50, 1/b | 265 | 103 | ---- | 1.5 | ---- | 33 | ---- |
| Cart, AP\&T, cal .30, w/b | 1,240 | 98 | ---- | 1.5 | ---- | 33 | ---- |
| Cart, AP\&T, cal .30, w/b | 1,250 | 100 | ---- | 1.5 | ---- | 34 | ---- |
| Cart, AP\&T, cal .30, w/b | 1,200 | 107 | ---- | 1.5 |  | 31 | ---- |
| Cart, AP\&T, cal .30, w/b <br> (100 rds) | 1,200 | 92 | ---- | 1.5 | ---- | 37 | --- |
| Cart, AP\&T, cal .30, w/b, 250 rd mg, chest | 1,000 | 77 | --- | . 9 | ---- | 26 |  |
| Cart, B\&T, cal .30, w/b | 1,200 | 93 | ---- | 1.5 | ---- | ? 36 | ---- |
| Cart, B\&T, cal .30, w/b, 250 rd mg , chest | 1,000 | 77 | ---- | . 9 | ---- | 26 | ---- |
| Cart, B\&T, cal .30, web belt | 1,250 | 96 | ---- | 1.5 | ---- | 35 | ---- |
| Cart, B\&T, $7.62 \mathrm{~mm}, 100$ rd belt --- | 800 | ---- | ---- | . 91 | ---- | -.-. | ---- |
| Cart, B\&T, $7.62 \mathrm{~mm}, 210$ rd belt | 840 | ---- | ---- | . 91 | ---- | ---- | ---- |
| Cart, B\&T, $7.62 \mathrm{~mm}, 220$ rd belt --- | 880 | ---- | ---- | . 92 | ---- | ---- | ---- |
| Cart, ball, cal .30 carbine | 3,000 | 100 | ---- | . 85 | ---- | 19 | ---- |
| Cart, ball, cal . 30 carbine | 3,450 | 107 | ---- | . 9 | ---- | 19 | ---- |
| Cart, ball, cal .30, in cartons | 1,500 | 111 | ---- | 1.5 | ---- | 30 | ---- |
| Cart, ball, cal .30, 5 rd clip | 1,440 | 117 | ---- | 1.5 | ---- | 29 | --.-- |
| Cart, ball, cal .30, 5 rd clip | 1,500 | 114 | ---- | 1.5 | ---- | 29 | ---- |
| Cart, ball, cal .30, 8 rd clip | 1,344 | 110 | ---- | 1.5 | ---- | 31 | ---- |
| Cart, ball, cal .45, in cartons | 1,800 | 97 | ---- | . 8 | ---- | 19 | ---- |
| Cart, ball, cal .45, in cartons | 2,000 | 111 | ---- | 1.0 | ---- | 20 | ---- |
| Cart, ball, 7.62 mm , linked, grade MG | 880 | 78 | ---- | . 92 | -... | 26 | .-. - |
| Cart, grenade, cal .30, M3 | 2,000 | 90 | --- - | 1.5 | ---- | 37 | ---- |
| Cart, HE, $3^{\prime \prime}$ | 4 | 153 | --- | 3.22 | ---- | 47 | ---- |
| Cart, HE, 37mm, M54 | 25 | 99 | ---- | 2.03 | ---- | 46 | ---- |
| Cart, HE, 37 mm , M63 | 20 | 91 | ---- | 2.04 | ---- | 50 | ---- |
| Cart, HE, 37mm, MK11 | 60 | 114 | ---- | 1.60 | ---- | 31 | ---- |
| Cart, HE, 40mm, MK1 | 16 | 115 | -- | 1.80 | ---- | 35 | ---- |
| Cart, HE, 60mm, M49A2 | 18 | 103 | 82 | 3.23 | 2.51 | 70 | 69 |
| Cart, HE, 75 mm , M48 w/f M48 | 3 | 80 | 69 | 1.35 | . 92 | 38 | 30 |
| Cart, HE, 75 mm , M48 w/f M54 | 3 | 82 | 68 | 1.84 | 1.03 | 50 | 34 |
| Cart, HE, 81mm, M43A1 | 6 | 72 | 58 | 1.65 | 1.08 | 51 | 42 |
| Cart, HE, 81mm, M56 | 3 | 55 | 42 | 1.33 | . 91 | 54 | 42 |
| Cart, HE, 90 mm , M71 | 4 | 237 | ---- | 4.43 | ---- | 42 | -- |
| Cart, HE, 105 mm , M1 w/f_M48 | 3 | 172 | 154 | 2.37 | 2.06 | 31 | 30 |
| Cart, HE, $105 \mathrm{~mm}, \mathrm{M} 54 \mathrm{w} / \mathrm{f}$ | 3 | 172 | 154 | 2.37 | 2.06 | 31 | 30 |
| Cart, inc, cal $.50{ }^{-}$in cartons | 350 | 108 | --- - | 1.5 | ---- | 31 | --- - |
| Cart, LE, 37 mm , Mkl | 60 | 105 | - | 1.38 | --- | 29 | ---- |
| Cart, Mkl, 75 mm , wo/f | 3 | 72 | 57 | 1.72 | . 86 | 54 | 38 |
| Cart, practice, 37mm, Mk11 | 40 | 90 | --- - | 1.38 | ---- | 34 | -- |
| Cart, practice, 60 mm , M50A2 | 18 | 103 | 82 | 2.23 | 2.51 | 70 | 69 |
| Cart, smoke, 75 mm , WP, Mk2 | 3 | 72 | 57 | 1.72 | . 96 | 54 | 38 |
| Cart, smoke, 75mm, WP, M64 .... | 3 | 82 | 70 | 1.66 | . 92 | 45 | 29 |


| Nomenclature |  | Weight (lb) |  | Cubic feet |  | Stowage factor |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | unit | Crated | Uncrated | Crated | Uncrated | Crated | Uncrated |
| Cart, smoke, 81mm, WP, M57 | 3 | 55 | 45 | 1.65 | . 91 | 67 | 45 |
| Cart, smoke, 105mm, WP, M60 | 3 | 172 | 159 | 2.37 | 2.06 | 31 | 29 |
| Cart, tracer, cal .50, in cartons .-. - | 350 | 111 | ---- | 1.5 | ---- | 30 | ---- |
| Cart, tracer, 7.62 mm , M62 in cartons, grade $\mathbf{R}$ | 400 | 28 | ---- | . 54 | ---- | 43 |  |
| Cart, tracer, $7.62 \mathrm{~mm}, \mathrm{M} 62$ in cartons, grade $\mathbf{R}$ | 960 | 72 | ---- | . 91 | ---- | 28 |  |
| Cart, tracer, 7.62 mm , M62 in cartons, grade $\mathbf{R}$ | 1,040 | 78 |  | 1.28 | ---- | 37 |  |
| Cart, 12-ga, No. 00 buckshot -- | 500 | 62 | ---- | . 768 | -.. - | 28 | ---- |
| Cart, 12-ga, No. $71 / 2$ | 500 | 58 | ---- | . 768 | ---- | 30 | ---- |
| Chg, prop, M1A1 (green bag) 155H ----------------------- | 6 | 67 | 40 | 3.08 | 1.91 | 103 | 107 |
| Chg, prop, M3 (green bag) 155H -- | 6 | 82 | 53 | 3.33 | 2.68 | 91 | 114 |
| Chg, prop, M2 (white bag) 155H -- | 6 | 82 | 73 | 3.26 | 2.63 | 89 | 81 |
| Explosive, cratering, 40 lb --- | 1 | 51 | ---- | 1.21 | --. - | 53 |  |
| Explosive, TNT 1\# B1 | 50 | 67.7 | ---- | 1.11 | ---- | 37 |  |
| Fuze, det, M6A2 | 200 | 64 | -- - - | 2.50 |  | 88 |  |
| Fuze, ing, M10A2 | 200 | 64 | ---- | 2.7 | ---- | 95 | ---- |
| Fuze, PD, M46 | 50 | 51 | ---- | . 89 | ---- | 39 | ---- |
| Fuze, PD, M47 | 50 | 53 | ---- | . 89 | --- - | 38 | ---- |
| Fuze, PD, M51, M51A1, M55, M55A1 | 25 | 83 | ---- | 1.46 | ---- | 39 |  |
| Fuze, PD, MT, M67 | 25 | 78 | ---- | 1.46 | ---- | 42 |  |
| Grenade, AT, M11A1, pret | 50 | 87 | ---- | 3.3 | --- - | 85 |  |
| Grenade, hand, frg, Mk II | 25 | 50 | -- | 1.26 | ---- | 57 | ---- |
| Grenade, hand, off (unfused) | 50 | 50 | ---- | 1.37 | -- - - | 62 | ---- |
| Grenade, hand, tug, Mk, 1A1 | 24 | 47 | ---- | . 97 | --- - | 46 | --- - |
| Grenade, rifle, M9 and M9A1 --- | 10 | 32 | ---- | 1.2 | --- - | 83 |  |
| Grenade, rifle, pret, M11 | 50 | 108 | ---- | 2.8 | . - - | 58 |  |
| Mine, AP, blast, M25 -.-...-....- | 96 | 30 | -- - - | -- | --- - | - |  |
| Mine, AP, fragmentation, M16A1 -- | 4 | 44.8 | --. - | .77 | -.-- | 35 | ---- |
| Mine, AP, sharpnel, directional, M18A1 | 6 | 53 | ---- | 1.74 | ---- | 74 | ---- |
| Mine, AT, blast, metallic, hv, M15 - | 1 | 49 | -- | 1.17 | -. - - | 54 | ---- |
| Mine, AT, blast, nonmetallic, plastic, M19 | 2 | 71.8 | ---- | 1.57 | ---- | 49 | -.-- |
| Mine, AT, shaped charge, metallic, M21 | 4 | 90.8 | --- - | 4.14 | --. | 94 | ---- |
| Primer, DTE, M14, 1-sec delay | 100 | 67 | ---- | 1.01 | ---- | 34 | ---- |
| Primer, perc, Mk11, Mk11A, Mk11A1 | 2,400 | 96 | - | 1.56 | --. - | 36 | ---- |
| Projectile, 8", How | 1 | - - | 200 | -- | ---- | -- | ---- |
| Projectile, 155mm, AP, M112B1 | 1 | 117 | -- | 1.34 | - | 26 | -- |
| Projecile, 155 mm , all other | 1 | --- | 96 | - - - | . 83 | -- | 19 |
| Signal, illumination, ground Mi7 <br> to M22 | 61 | --- | ---- | 1.85 | ---- | -- | --- |
| Signal, pistol, rocket, Mk2, red \& green star | 103 | --- | --- - | 2.57 | -..- | -- | -- |
| Signal, pistol, rocket, Mk2 red \& white | 31 | --- | --- | . 92 | ---- | -- | -- |

## c. Petroleum Products.

| c. Petroleum Proa | Container | No. per | Weight (lb) | Cubic feet | Stowage factor |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Aviation gasoline _--- | 55-gal. drum, 18-gage steel | 1 | 373 | 9.03 | 54 |
|  | $55-\mathrm{gal}$. drum, 16-gage steel | 1 | 389 | 8.8 | 51 |
|  | 55-gal. drum, 18-page light steel | 1 | 364 | 9.2 | 56.5 |
|  | 5 -gal. can, 11-lb can | 1 | 40.5 | . 81 | 44.8 |
| 83 octane gasoline --- | 55-gal. drum, 18-gage steel | 1 | 384 | 9.03 | 52.7 |
|  | 55-gal. drum, 16-gage steel | 1 | 400 | 8.8 | 49.2 |
|  | 55-gal. drum, 18-gage light steel | 1 | 376 | 9.2 | 55 |
|  | 5-gal. can, 11-lb can | 1 | 41.6 | . 81 | 43.6 |
| Kerosene ----------- | 55 -gal. drum, 18-gage steel | 1 | 421 | 9.03 | 48.1 |
|  | $55-\mathrm{gal}$. drum, 16-gage steel | 1 | 437 | 8.8 | 45.1 |
|  | 55-gal. drum, 18-gage light steel | 1 | 351 | 9.2 | 58.8 |
|  | $5-\mathrm{gal}$. can, 11-1b can | 1 | 45 | . 81 | 40.4 |
| Diesel fuel ---------- | 55-gal. drum, 18-gage steel | 1 | 432 | 9.03 | 47 |
|  | 55-gal. drum, 16-gage steel | 1 | 448 | 8.8 | 44.2 |
|  | 55-gal. drum, 18-gage light steel | 1 | 430 | 9.2 | 47.9 |
|  |  | 1 | 46 | . 81 | 39.5 |
| Lubricating oils ----- | 55-gal. drum, 18-gage steel -----------------1-1-1 | 1 | 472 | 9.03 | 42.8 |
|  | 55-gal. drum, 16-gage steel _-----------------1 | 1 | 488 | 8.8 | 40.5 |
|  |  | 1 | 462 | 9.2 | 44.6 |
|  |  | 1 | 49 | . 81 | 37.1 |
|  | Cases of 1-qt. cans, 12 per case (crated) ----- | 12 | 35 | . 88 | 56.6 |
|  | Cases of 1-qt. cans, 24 per case (crated) ----- | 24 | 60 | 1.6 | 60 |
|  | Cases of 5-qt cans, 6 per case (crated) ------ | 6 | 77 | 1.9 | 55.7 |
| Grease |  | 1 | 29 | . 95 | 73.6 |
|  | 5-lb cans, 6 per case (crated) | 6 | 44 | 1.1 | 56 |

## 7-29. Annealed Wire

|  | Diameter | Tensile strength |
| :---: | :---: | :---: |
| Gage No. | (in.) | $(16)$ |
| 7 | $3 / 16$ | 1,100 |
| 8 | $11 / 64$ | 950 |
| 9 | $5 / 32$ | 800 |
| 11 | $1 / 8$ | 500 |

## 7-30. Rods and Bolts

 Diameter (in.)Tensile strength* (lb)
5,200
8,100
11,700
21,100
1
25,800
11/8
32,800
38,600

| $13 / 8$ | 38,600 |
| :--- | :--- |
| $11 / 2$ | 46,900 |

*At root of thread.
7-31. Common Nails


## 7-32. High-Tension Bands



Note: The use of secondhand or reclaimed hightension wire, or common wires for such items specified in the rules and detailed figures is prohibited. (Rules and figures are those contained in AAR open top car loading manual cited in paragraph 4-14.)

## 7-33. Supply-Planning Terms

a. Consumption Rate. The average quantity of an item consumed or expended during a given time interval, expressed in quantities per applicable basis.
b. Day of Supply. That quantity of supplies estimated to be required for 1 day under the conditions of the operation and for the force stated.
c. Replacement Factor. A number expressed as a decimal which, when multiplied by the total projected quantity of an item in use, gives the quantity of that item required to be re-
placed during a given period of time.
d. Slice. An average logistical planning factor used to obtain estimates of requirements for personnel and materiel.

## Section IX. STORAGE AND MAINTENANCE SPACE

## 7-34. Storage

a. Gross Storage Area: Average Ratio of Open to Covered by Classes of Supply.

|  | Ration ofgross storage areaOpenCovered |  |
| :---: | :---: | :---: |
| All classes (except bulk POL) | 5.5 | 1 |
| Classes I, II, III (packaged and solid), and IV $\qquad$ | 4.7 | 1 |
| Classes I, II, III (packaged), and IV | 3 | 1 |
| Class V (including 10 percent of V-A | 12 | 1 |

b. Average Stack Height. Figures given are for use of all services in theaters of operation. For CONUS storage, the figures must be increased 25 percent.
(1) Covered storage- 8 feet ( 2.4 meters).
(2) Open storage- 6 feet ( 1.8 meters).
c. Miscellaneous Data.

## Ammunition storage per mile (1.6

km ) of road ${ }^{1}$ $\qquad$ 1,000 short tons
Ammunition storage per square
mile ${ }^{1}$--------------------------- 5,000 short tons

| $\begin{gathered}\text { Minimum } \\ \text { vehicles }{ }^{2}\end{gathered}$ hardstand for 2,500 | 110,000 square feet |
| :---: | :---: |
| Solid footing for vehicle park for |  |
| 2,500 vehicles _--------------1. | 4,000,000 sq ft |
| Minimum hardstand for artillery and combat vehicles, per item | 350 square feet |

## 7-35. Covered Shop Floor Space

| Maintenance and Supply: | Sq m | Sq ft |
| :---: | :---: | :---: |
| Direct support company | 1,858 | 20,000 |
| Guided missile depot support shop | 1,208 | 13,000 |
| Guided missile direct support shop ----- | 1,208 | 13,000 |
| Guided missile heavy support shop ------------ | 1,208 | 13,000 |
| Tire repair company | 1,486 | 16,000 |
| Transportation: |  |  |
| Heavy truck company | 474 | 5,100 |
| Light truck company | 344 | 3,700 |
| Medium truck company | 520 | 5,600 |
| Railway operating battalion | 2,601 | 28,000 |
| Railway shop battalion | 3,716 | 40,000 |

[^42]
# Section X. FIELD ESTABLISHMENTS AND EXPEDIENTS 

7-36. Tentage

| Type | $\begin{aligned} & \text { Shape } \\ & \text { fof } \\ & \text { floor } \end{aligned}$ | $\begin{gathered} \text { Floor } \\ \text { dimensiona } \\ \text { (in.) } \end{gathered}$ | Size |  |  |  |  | $\begin{gathered} \text { Num- } \\ \text { bera } \\ \text { men } \\ \text { accom- } \\ \text { maO- } \\ \text { dated } \end{gathered}$ | Weight(ib) |  | Totalweigh (lb) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Total | Hei |  | Sur |  |  |  |  |  |
|  |  |  | $\underset{\substack{\text { ground } \\ \text { perimeter } \\ \text { (in.) }}}{ }$ | $\begin{aligned} & \text { Ridge } \\ & \text { (in.) } \end{aligned}$ | $\begin{gathered} \text { Side } \\ \text { soall } \\ \text { (in.) } \end{gathered}$ | $\begin{gathered} \text { face } \\ \text { area } \\ (\mathrm{sq} \mathrm{ft}) \end{gathered}$ | Floor space ( $s q f t$ |  | Tent only | Pins, poles |  |
| Tents: |  |  |  |  |  |  |  |  |  |  |  |
| Arctic, 10-man-- | Hexagon | 210 dia | $630{ }^{\text {e }}$ | 102 | 36 | 316 | 199 | 10 | 68 | 8 | 76 |
| Assembly ------ | Rectangular plus rounded ends | $480 \times 960$ | 2,467 | 252 | 96 | 4,965 | 2,857 | 80 | 1,100 | 655 | 1,755 |
| Balloon inflation. | Rectangle | $159 \times 182$ | 682 | 148 | ( ${ }^{\circ}$ | 885 | 201 | 8 | 110 | 333 | 443 |
| CP, M1942 _--.- | Rectangle | $84 \times 142$ | 452 | 84 | 72 | 328 | 84 | 2 | 112 | 104 | 216 |
| CP, M1945 _._-- | Octagon | $120 \times 247^{\text {\% }}$ | 627 | 108 | 66 | 406 | $172^{\text {r }}$ | 3 | 165 | 92 | 257 |
| Fly, squad | Rectangle | $240 \times 451$ | 1,382 | 144 | 63 | 1,673 | 750 | 15 | 190 | 62 | 252 |
| Fly, ward, hosp. | Rectangle | $240 \times 648$ | 1,776 | 144 | 63 | 2,216 | 1,080 | 27 | 225 | 101 | 326 |
| GP, large ------ | Rectangle | $216 \times 624$ | 1,680 | 144 | 66 | 2,035 | 936 | 21 | 420 | 245 | $665{ }^{\text {n }}$ |
| GP, medium | Rectangle | $192 \times 396$ | 1,176 | 120 | 66 | 915 | 528 | 12 | 255 | 200 | 455 |
| Hexagonal, M1950. | Hexagon | 159 dia | 477 | 102 | 24 | 218 | 113 | 5 | 40 | 8 | 48 |
| Hospital, sectional. | Rectangle | $216 \times 636^{\text {k }}$ | 1,704 | 144 | 72 | 2,170 | $954{ }^{\text {k }}$ | $24^{1}$ | 770 | 327 | 1,097 |
| Hospital, ward.- | Rectangle | $192 \times 600$ | 1,584 | 144 | 54 | 2,162 | 800 | $20^{1}$ | 390 | 259 | 649 |
| Kitchen | Rectangle | $144 \times 216$ | 720 | $144^{\text {m }}$ | 72 | 831 | 216 | 10 | 203 | 217 | 420 |
| Maint, shelter -- | Rectangle | $218 \times 322$ | 1,080 | 164 | 66 | 1,306 | 487 | 11 | 500 | 755 | 1,255 |
| Mountain | Rectangle | $54 \times 82$ | 272 | 43 | 12 | 112 | 31 | 2 | 6 | 4 | 10 |
| Oper, surgical _- | Rectangle | $192 \times 324$ | 1,032 | 144 | 84 | 1,190 | 432 | 10 | 252 | 75 | 327 |
| Oper, surgical, hv. | Rectangle | $216 \times 648$ | 1,728 | 133 | 72 | 2,068 | 972 | 22 | 817 | 876 | 1,693 |
| Pyramidal | Square | $192 \times 192$ | 768 | 144 | 63 | 896 | 256 | 6 | 130 | 94 | 224 |
| Pyramidal, lightweight. | Circle | 132 dia | 414 | 102 | 24 | 182 | 95 | 4 | 37 | 2 | 39 |
| Squad, M1942 -- | Rectangle | $192 \times 384$ | 1,152 | 144 | 54 | 886 | 512 | 12 | 255 | 147 | 402 |
| Squad, M1945 .- | Rectangle | $192 \times 384$ | 1,152 | 144 | 54 | 886 | 512 | 12 | 275 | 150 | 425 |
| Storage - | Rectangle | $214 \times 241$ | 910 | 156 | 63 | 1,008 | 358 | 8 | 200 | 202 | 402 |
| Wall, large ----- | Rectangle | $168 \times 174$ | 684 | 132 | 54 | 570 | 203 | 8 | 130 | 145 | 275 |
| Wall, small | Rectangle | $106 \times 110$ | 432 | 102 | 45 | 284 | 81 | 2 | 55 | 60 | 115 |
| Paulins: ${ }^{\text {r }}$ |  |  |  |  |  |  |  |  |  |  |  |
| Fly, storage |  | $300 \times 245$ | --- | --- | -- | 512 | --- | -- | 85 | 20 | 105 |
| Fly, wall, small. | --------- | $186 \times 110$ | --- | --- | -- | 142 | --- | -- | 23 | 15 | 38 |
| Large |  | $240 \times 480$ | --- | --- | -- | 800 | --- | -- | 250 | --- | 250 |
| Medium |  | $192 \times 384$ | --- | --- | -- | 512 |  |  | 160 |  | 160 |
| Screen, latrine _- | ( ${ }^{\text {a }}$ | $216 \times 108 \times 84^{*}$ | 660 | --- | $72^{\text {t }}$ | 292 | 144 | ( ${ }^{\text {a }}$ | 32 |  | 32 |
| Small ------- | --------- | $144 \times 204$ | --- | --- | -- | 204 | --- | -- | 57 | -- | 57 |

[^43]c. Cubic Measure.

| Cubic centimeters | Cubic decimeters or liters | Cubic inches | Cubic feet ${ }^{1}$ | Cubic yards | U.S. quarts |  | U.S. gallons |  | U.S. bushels | Measurement tons |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | Liquid | Dry | Liquid | Dry |  |  |
| 1.0 | 0.001 | 0.061 | 0.0000353 | 0.0000013 | 0.001056 | 0.000908 | 0.000264 | 0.000227 | 0.000028 | 0.00000088 |
| 1,000.0 | 1.0 | 61.023 | . 0353 | . 00131 | 1.0567 | . 9081 | . 2642 | . 227 | . 0284 | . 000882 |
| 16.39 | . 01639 | 1.0 | . 0005787 | . 0000214 | . 0173 | . 0149 | . 00433 | . 00372 | . 00465 | . 0000144 |
| 28,317.0 | 28.317 | 1,728.0 | 1.0 | . 03704 | 29.922 | 25.714 | 7.481 | 6.4285 | . 80356 | . 025 |
| 764,559.0 | 764.559 | 46,656.0 | 27.0 | 1.0 | 807.896 | 694.279 | 201.974 | 173.57 | 21.696 | . 677 |
| 946.0 | . 9464 | 57.75 | . 03342 | . 00124 | 1.0 | . 8594 | . 25 | . 2148 | . 02686 | . 000837 |
| 1,101.2 | 1.1012 | 67.201 | . 03889 | . 00144 | 1.1636 | 1.0 | . 2909 | . 25 | . 0313 | . 000975 |
| 3,785.4 | 3.7854 | 231.0 | . 13368 | . 00495 | 4.0 | 3.4377 | 1.0 | . 8594 | .1074 | . 00335 |
| 4,404.9 | 4.4049 | 268.803 | . 15556 | . 00576 | 4.6546 | 4.0 | 1.1636 | 1.0 | . 125 | . 00388 |
| 35,239.3 | 35.2393 | 2,150.42 | 1.2445 | . 0461 | 37.237 | 32.0 | 9.3092 | 8.0 | 1.0 | . 0312 |
| 1,130.000.0 | 1,130.0 | 69,120.0 | 40.0 | 1.48 | 1,190.0 | 1,030.0 | 298.0 | 256.0 | 32.2 | 1.0 |

${ }^{1}$ A board foot, used in measurements for lumber, measures $12^{\prime \prime} \times 12^{\prime \prime} \times 1^{\prime \prime}$. Its volume is $1 / 12$ of a cubic foot.
d. Angular Conversions.

| Circle | Radians | Degrees | Minutes | Seconds | Mils | Right angle | Straight line |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1.0 | 6.2832 | 360.0 | 21,600.0 | 1,296,000 | 6,400.0 | 4.0 | 2.0 |
| . 16 | 1.0 | 57.3 | 3,430.0 | 206,000 | 1,018.6 | . 636 | . 318 |
| . 00279 | . 017453 | 1.0 | 60.0 | 3,600 | 17.778 | . 0111 | . 00556 |
| . 0000463 | . 000289 | . 0167 | 1.0 | 60 | . 297 | . 000185 | . 00000925 |
| . 00000078 | . 0000049 | . 00028 | . 0167 | 1 | . 00495 | . 0000003 | . 00000016 |
| . 000157 | . 000982 | . 05625 | 3.375 | 202 | 1.0 | . 000625 | . 000312 |
| . 25 | 1.535 | 90.0 | 5,400.0 | 324,000 | 1,600.0 | 1.0 | . 5 |
| . 50 | 3.07 | 180.0 | 10,800.0 | 648,000 | 3,200.0 | 2.0 | 1.0 |

e. Power.

|  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | Kilogram-meters <br> per sec | Foot-pounds <br> per sec | U.S. |


| Kilograme (kg) | Graine (gr) | Ounces Avoirdupois |  | Pounds Avoirdupois |  | $\underset{(2,000 \mathrm{lb})}{\text { Short }}$ | $\begin{gathered} \text { Tons } \\ \text { Long } \\ (2,240 \mathrm{lb}) \end{gathered}$ | $\begin{gathered} \text { Metric } \\ (1,000 \mathrm{~kg}) \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1.0 | 15,432.4 | 32.1507 | 35.274 | 2.67923 | 2.20462 | 0.001102 | 0.0009842 | 0.001 |
| . 0000648 | 1.0 | . 002083 | . 00012286 | . 0001736 | . 0001429 | . 00000007 | . 00000006 | . 00000006 |
| . 0311 | 480.0 | 1.0 | 1.09714 | . 08333 | . 06857 | . 00003429 | . 00003061 | . 0000311 |
| . 02385 | 437.5 | . 91146 | 1.0 | . 07595 | . 0625 | . 00003125 | . 0000279 | . 00002835 |
| . 37324 | 5,760.0 | 12.0 | 13.1657 | 1.0 | . 82286 | . 0004114 | . 0003674 | . 0003732 |
| . 45359 | 7,000.0 | 14.5833 | 16.0 | 1.21528 | 1.0 | . 0005 | . 0004464 | . 004536 |
| 907.185 | 14,000,000.0 | 29,166.7 | 32,000.0 | 2,430.56 | 2,000.0 | 1.0 | . 89286 | . 90719 |
| 1,016.05 | 15,680,000.0 | 32,666.7 | 35,840.0 | 2,722.22 | 2,240.0 | 1.12 | 1.0 | 1.01605 |
| 1,000.0 | 15,432,356.0 | 32,150.7 | 35,274.0 | 2,679.23 | 2,204.62 | 1.10232 | . 98421 | 1.0 |

Miscellaneous weight relationships:


Apothecaries
1 scruple $=20$ grains
1 ounce $=8$ drams
1 dram $=3$ scruples
Pound
7,000 grains
5,760 grains
5,760 grains

| Storage bulls (cu ft) |  | $\begin{gathered} \text { Total } \\ \text { cubs } \\ \text { packed } \\ \text { (cu ft } \end{gathered}$ | Material | Doors |  | Ventilation |  | Stove pipe heater openinga | Liner | Pitching ${ }^{\text {b }}$ |  | Striking ${ }^{\text {b }}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Tent only | Pins, poles |  |  | No. | $\begin{gathered} \text { Height } \\ \text { (in.) } \end{gathered}$ | $\begin{gathered} \text { No. } \\ \text { of } \\ \text { open- } \\ \text { ings } \end{gathered}$ | $\begin{gathered} \text { No. } \\ \text { of } \\ \text { wini- } \\ \text { dows } \end{gathered}$ |  |  | No. | $\begin{aligned} & \text { Time } \\ & \text { (min) } \end{aligned}$ | No. | $\underset{(\min )}{T i m e}$ |
| 7.1 | 0.2 | 7.3 | 9 oz OD cotton | 2 | 60 | 4 | 0 | 1 | Yes | 6 | 27 | 6 | 15 |
| 23.3 | 16.9 | 40.2 | 9.8 and 12.3 oz duck | 4 | 96 | 4 | $0{ }^{\text {d }}$ | 4 | No | 9 | 90 | 9 | 60 |
| --- | --- | 61.4 | 9.8 oz duck | 2 | 148 | 1 | 4 | 1 | No | 4 | 30 | 4 | 20 |
| 5.0 | 3.7 | 8.7 | 12.3 oz duck | 1 | 72 | 1 | 3 | 1 | Yes | 4 | 20 | 4 | 15 |
| 6.3 | 3.6 | 9.9 | 12.3 oz duck | 1 | 72 | 1 | 3 | 1 | Yes ${ }^{\text {b }}$ | 5 | 20 | 5 | 15 |
| 4.3 | 5.0 | 9.3 | 9 oz duck |  |  |  |  |  |  |  |  |  |  |
| 7.6 | 4.5 | 12.1 | 9 oz duck |  |  |  |  |  |  |  |  |  |  |
| 21.0 | 7.7 | $69.0{ }^{1}$ | 12.3 oz duck | 2 | 72 | 2 | 8 | 3 | Yes | 6 | 75 | 6 | 50 |
| 12.7 | 6.3 | $19.0{ }^{\text {J }}$ | 12.3 oz duck | 2 | 72 | 2 | 6 | 2 | Yes | 4 | 40 | 4 | 30 |
| 3.6 | 0.2 | 3.8 | 9 oz plied yarn and sateen cotton cloth | 1 | 60 | 2 | 0 | 1 | Yes | 5 | 15 | 5 | 10 |
| 31.5 | 12.2 | 43.7 | 12.3 oz duck except floor ( 9.8 oz duck) | 2 | 72 | 2 | 16 | 3 | Yes | 9 | 90 | 9 | 70 |
| 20.5 | 9.6 | 30.1 | 12.3 oz duck | 2 | 54 | 2 | 14 | 3 | Yes | 9 | 90 | 9 | 70 |
| 14.2 | 12.0 | 26.2 | 12.3 oz duck | 1 | 72 | Ventilator Screens ${ }^{\text {n }}$ |  | 0 | No | 5 | 60 | 5 | 45 |
| 26.3 | 58.0 | 84.3 | 12.3, 9.8 and 6 oz duck | 2 | 164 | $2^{\circ}$ | 0 | 4 | No | 10 | 75 | 10 | 60 |
| 0.5 | 0.2 | 0.7 | Lightweight cotton and synthetic fiber | 2 | 27 dia <br> (p) | 2 | 0 | 0 | No | 2 | 10 | 2 | 5 |
| 10.3 | 3.5 | 13.8 | 9.8 and 12.3 oz duck | 2 | 84 | 2 | 8 | 2 | Yes | 4 | 40 | 4 | 30 |
| 38.8 | 23.2 | 62.0 | 9.8 and 12.3 oz duck | 2 | 72 | 2 | 16 | 3 | Yes | 9 | 90 | 9 | 70 |
| 6.2 | 3.6 | 9.8 | 12.3 oz duck | 1 | 63 | 1 | 0 | 1 | No | 5 | 20 | 5 | 15 |
| 2.5 | 0.2 | 2.7 | 12.3 oz duck | 1 | -- | 2 | 0 | 1 | No | 5 | 15 | 5 | 10 |
| 10.9 | 5.9 | 16.8 | 9.8 and 12.3 oz duck | 2 | 54 | 2 | -- | 2 | No | 4 | 40 | 4 | 30 |
| 11.1 | 6.1 | 17.2 | 12.3 oz duck | 2 | 54 | 2 | -- | 2 | Yes | 4 | 40 | 4 | 30 |
| 9.6 | 9.2 | 18.8 | 12.3 oz duck | 2 | 63 | 2 | -- |  | --- | 4 | 40 | 4 | 30 |
| 5.8 | 3.1 | 8.9 | 12.3 and 9.8 oz cotton duck | 2 | 132 | 2 | 0 | (9) | No | 4 | 30 | 4 | 20 |
| 3.4 | 4.1 | 7.5 | 12.3 and 9.8 oz cotton duck | 2 | 102 | 2 | 0 | (9) | No | 4 | 30 | 4 | 20 |
| 2.8 | 0.8 | 3.6 | 9.8 oz duck |  |  |  |  |  |  |  |  |  |  |
| 3.1 | 0.7 | 3.8 | 9.8 oz duck |  |  |  |  |  |  |  |  |  |  |
| 6.7 | --- | 6.7 | 9.8 oz duck |  |  |  |  |  |  |  |  |  |  |
| 4.2 |  | 4.2 | 9.8 oz duck |  |  |  |  |  |  |  |  |  |  |
| 0.8 | --- | 0.8 | 9.7 oz duck | 1 | -- | -- | -- | -- | No | 6 | 20 | 6 | 15 |
| 2.3 | --- | 2.3 | 9.8 oz duck |  |  |  |  |  |  |  |  |  |  |

[^44]
## 7-37. Conversion Factors

a. Linear Measure.

| $\left.\begin{array}{c} \text { U.S. dry measure : } 1 \text { bushel }=4 \text { pecks }=8 \text { gallons }=32 \text { quarts }=64 \text { pints } \\ \text { U.S. liquid measure: } 1 \text { gallon }=4 \text { quarts }=8 \text { pints }=32 \text { gills }=128 \text { fuid onnces }=.83268 \text { imperial gallon } \end{array}\right]$ |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Meters* | Inches | Feet | Yards | Rods | Chains | Statute | ${ }^{\text {Miles }}{ }_{\text {Nautical }}{ }^{\text {¢* }}$ | Kilometers | $\underset{\text { Cableas }}{\text { length }}$ | Fathome |
| 1.0 | 39.37 | 3.28083 | 1.09361 | 0.19884 | 0.04971 | 0.0006214 | 0.0005396 | 0.001 | 0.00454 | 0.546 |
| . 0254 | 1.0 | . 0833 | . 0278 | . 00505 | . 00126 | . 00001578 | . 00001371 | . 0000254 | . 000116 | . 0139 |
| . 3048 | 12.0 | 1.0 | . 3333 | . 0606 | . 0151 | . 0001894 | . 0001645 | . 0003048 | . 00139 | . 167 |
| . 9144 | 36.0 | 3.0 | 1.0 | . 1818 | . 04545 | . 0005682 | . 0004934 | . 0009144 | . 00417 | . 500 |
| 5.0292 | 198.0 | 16.5 | 5.5 | 1.0 | . 25 | . 003125 | . 002714 | . 005029 | . 0228 | 2.76 |
| 20.1168 | 792.0 | 66.0 | 22.0 | 4.0 | 1.0 | . 0125 | . 01085 | . 02012 | . 091 | 11.0 |
| 1,609.35 | 63,360.0 | 5,280.0 | 1,760.0 | 320.0 | 80.0 | 1.0 | . 8684 | 1.6094 | 7.32 | 879.0 |
| 1,853.25 | 72,962.5 | 6,080.2 | 2,026.73 | 368.497 | 92.1243 | 1.15155 | 1.0 | 1.85325 | 8.46 | 1,010.0 |
| 1,000.0 | 39,370.0 | 3,280.83 | 1,093.61 | 198.838 | 49.7096 | . 6214 | . 5396 | 1.0 | 4.56 | 546.0 |
| 219.5 | 8,640.0 | 720.0 | 240.0 | 43.6 | 10.9 | . 1364 | . 1184 | . 2195 | 1.0 | 120.0 |
| 1.829 | 72.0 | 6.0 | 2.0 | . 363 | . 091 | . 00114 | . 00098 | . 00183 | . 00835 | 1.0 |

[^45]b. Surface Measure.

| Square metere | Square inches | Square feat | Square yards | Square rode | Acres | Square miles <br> Hectares | Square <br> (etatute) |  |
| :---: | ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1.0 | $1,550.0$ | 10.764 | 1.196 | 0.03954 | 0.000247 | 0.0001 | 0.000000386 | 0.000001 |

## g. Speed.

| Meters per second | Meters per minute | Feet per second | $\begin{gathered} \text { Peet } \\ \text { per } \\ \text { minute } \end{gathered}$ | $\begin{gathered} \text { Miles } \\ \text { per } \\ \text { hour } \end{gathered}$ | Knote per hour | $\begin{gathered} \text { Kilo- } \\ \text { metcrs } \\ \text { per hour } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1.0 | 60.0 | 3.28083 | 196.8 | 2.23693 | 1.94254 | 3.6 |
| . 0167 | 1.0 | . 055 | 3.3 | . 0376 | . 0324 | . 06 |
| . 30480 | 18.2 | 1.0 | 60.0 | . 68182 | . 59209 | 1.09728 |
| . 00505 | . 303 | . 0167 | 1.0 | . 0113 | . 0097 | . 0182 |
| . 44704 | 26.9 | 1.4667 | 88.0 | 1.0 | . 86839 | 1.60935 |
| . 51479 | 30.9 | 1.68894 | 101.0 | 1.15155 | 1.0 | 1.85325 |
| . $27778{ }^{\circ}$ | 16.7 | . 91134 | 54.7 | . 62137 | . 53959 | 1.0 |

h. Temperature. The chart below shows relationships between fahrenheit and centigrade readings for a temperature range covering most areas of the earth. Figures shown are close approximations that should cover the needs of the transportation planner or operator. To compute temperature conversions out-
side of the range shown, use one of the following formulas:

$$
\begin{aligned}
& { }^{\circ} \mathrm{C}=-\frac{9}{5}\left({ }^{\circ} \mathrm{F}-32\right) \\
& { }^{\circ} \mathrm{F}=\frac{5}{9}\left({ }^{\circ} \mathrm{C}+32\right)
\end{aligned}
$$

| ${ }^{\circ} \boldsymbol{F}$ | ${ }^{\circ} \mathrm{C}$ | ${ }^{\circ} \mathrm{F}$ | ${ }^{\circ} \mathrm{C}$ | ${ }^{\circ} \mathrm{F}$ | ${ }^{\circ} \mathrm{C}$ | ${ }^{\circ} \mathrm{F}$ | ${ }^{\circ} \mathrm{C}$ | ${ }^{\circ} \mathrm{F}$ | ${ }^{\circ} \mathrm{C}$ | ${ }^{\bullet} \boldsymbol{F}$ | ${ }^{\circ} \mathrm{C}$ | ${ }^{\circ} \mathrm{F}$ | ${ }^{\circ} \mathrm{C}$ | ${ }^{\circ} \mathrm{F}$ | ${ }^{\circ} \mathrm{C}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| -66 | -54.4 | -40 | -40.0 | -14 | -25.6 | 12 | -11.1 | 38 | 3.3 | 64 | 17.8 | 90 | 32.2 | 116 | 46.6 |
| -65 | -53.9 | -39 | -39.4 | -13 | -25.0 | 13 | -10.6 | 39 | 3.9 | 65 | 18.3 | 91 | 32.8 | 117 | 47.2 |
| -64 | -53.3 | -38 | -38.9 | -12 | -24.4 | 14 | $-10.0$ | 40 | 4.4 | 66 | 18.9 | 92 | 33.3 | 118 | 47.8 |
| -63 | -52.7 | -37 | $-38.3$ | -11 | -23.9 | 15 | -9.4 | 41 | 5.0 | 67 | 19.4 | 93 | 33.9 | 119 | 48.3 |
| -62 | -52.2 | -36 | -37.8 | -10 | -23.3 | 16 | -8.9 | 42 | 5.6 | 68 | 20.0 | 94 | 34.4 | 120 | 48.9 |
| -61 | -51.6 | -35 | -37.2 | -9 | -22.8 | 17 | -8.3 | 43 | 6.1 | 69 | 20.6 | 95 | 35.0 | 121 | 49.4 |
| -60 | -51.1 | -34 | $-36.7$ | -8 | -22.2 | 18 | -7.8 | 44 | 6.7 | 70 | 21.1 | 96 | 35.6 | 122 | 50.0 |
| -59 | -50.6 | -33 | -36.1 | -7 | -21.7 | 19 | -7.2 | 45 | 7.2 | 71 | 21.7 | 97 | 36.1 | 123 | 50.6 |
| -58 | -50.0 | -32 | $-35.6$ | -6 | -21.1 | 20 | -6.7 | 46 | 7.8 | 72 | 22.2 | 98 | 36.7 | 124 | 51.1 |
| -57 | -49.4 | -31 | -35.0 | -5 | -20.6 | 21 | -6.1 | 47 | 8.3 | 73 | 22.8 | 99 | 37.2 | 125 | 51.7 |
| -56 | -48.9 | -30 | -34.4 | -4 | -20.0 | 22 | -5.6 | 48 | 8.9 | 74 | 23.3 | 100 | 37.8 | 126 | 52.2 |
| -55 | -48.3 | -29 | $-33.9$ | -3 | -19.5 | 23 | -5.0 | 49 | 9.4 | 75 | 23.9 | 101 | 38.3 | 127 | 52.7 |
| -54 | -47.8 | -28 | -33.3 | -2 | $-18.9$ | 24 | -4.4 | 50 | 10.0 | 76 | 24.4 | 102 | 38.9 | 128 | 53.3 |
| -53 | -47.2 | -27 | -32.8 | -1 | -18.3 | 25 | -3.9 | 51 | 10.6 | 77 | 25.0 | 103 | 39.4 | 129 | 53.9 |
| -52 | -46.6 | -26 | $-32.2$ | 0 | $-17.8$ | 26 | -3.3 | 52 | 11.1 | 78 | 25.6 | 104 | 40.0 | 130 | 54.4 |
| -51 | -46.1 | -25 | -31.7 | 1 | $-17.2$ | 27 | -2.8 | 53 | 11.7 | 79 | 26.1 | 105 | 40.6 |  |  |
| -50 | -45.6 | -24 | -31.1 | 2 | -16.7 | 28 | -2.2 | 54 | 12.2 | 80 | 26.7 | 106 | 41.1 |  |  |
| -49 | -45.0 | -23 | -30.6 | 3 | -16.1 | 29 | -1.7 | 55 | 12.8 | 81 | 27.2 | 107 | 41.6 |  |  |
| -48 | -44.4 | -22 | $-30.0$ | 4 | -15.6 | 30 | -1.1 | 56 | 13.3 | 82 | 27.8 | 108 | 42.2 |  |  |
| -47 | -43.9 | -21 | - 29.4 | 5 | -15.0 | 31 | -0.6 | 57 | 13.9 | 83 | 28.3 | 109 | 42.7 |  |  |
| -46 | -43.3 | -20 | -28.9 | 6 | -14.4 | 32 | 0 | 58 | 14.4 | 84 | 28.9 | 110 | 43.3 |  |  |
| -45 | -42.8 | -19 | $-28.3$ | 7 | -13.9 | 33 | 0.6 | 59 | 15.0 | 85 | 29.4 | 111 | 43.9 |  |  |
| -44 | -42.2 | -18 | -27.8 | 8 | $-13.3$ | 34 | 1.1 | 60 | 15.6 | 86 | 30.0 | 112 | 44.4 |  |  |
| -43 | -41.6 | -17 | -27.2 | 9 | $-12.8$ | 35 | 1.7 | 61 | 16.1 | 87 | 30.6 | 113 | 45.0 |  |  |
| -42 | -41.1 | -16 | -26.7 | 10 | -12.2 | 36 | 2.2 | 62 | 16.7 | 88 | 31.1 | 114 | 45.6 |  |  |
| -41 | -40.6 | $\bigcirc 15$ | -26.1 | 11 | -11.7 | 37 | 2.8 | 63 | 17.2 | 89 | 31.7 | 115 | 46.1 |  |  |

i. Simplified Conversion Factors for Quick Computation. The following are accurate to within 2 percent:

Inches to centimeters-Multiply by 10 and divide by 4.
Yards to meters -Multiply by 9 and divide by 10.
Miles to kilometers -Multiply by 8 and divide by 5.
Gallons to liters -Multiply by 4 and subtract $1 / 5$ of the number of gallons.
Pounds to kilograms -Multiply by 5 and divide by 11.
j. Pressure and Density Equivalents.

|  | Pressure equivalents |  |  |  |  | Dcnsity equivalents |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Pounds per sq in. | Short tons per sq ft | Atmospheres | Columns of mercury ( $0^{\circ} \mathrm{C}$ at sea leval) |  | $\begin{gathered} \text { Grams } \\ \text { per cu cm } \end{gathered}$ | $\stackrel{L b}{\text { per } c u \text { in. }}$ | ${ }_{p c r}^{L b}{ }_{f t}$ | Short tons per cu $\boldsymbol{y d}$ | $\begin{aligned} & \text { Lb per } \\ & \text { U.S. } \\ & \text { gal. } \end{aligned}$ |
|  |  |  |  | Mcters | Inches |  |  |  |  |  |
|  | 14.22 | 1.024 | 0.9678 | 0.7356 | 28.96 | 1 | 0.03613 | 62.43 | 0.8428 | 8.345 |
| 0.07031 | 1 | 0.072 | 0.06805 | 0.5171 | 2.036 | 27.68 | 1 | 1,728 | 23.33 | 231 |
| 0.9765 | 13.89 | 1 | 0.9451 | 0.7183 | 28.28 | 0.01602 | 0.000578 | 1 | 0.0135 | 0.1337 |
| 1.0332 | 14.70 | 1.058 | 1 | 0.76 | 29.92 | 1.187 | 0.04287 | 74.07 | 1 | 9.902 |
| 1.3595 | 19.34 | 1.392 | 1.316 | 1 | 39.37 | 0.1198 | 0.004329 | 7.481 | 0.1010 | 1 |
| 0.03453 | 0.4912 | 0.03536 | 0.03342 | 0.02540 | 1 |  |  |  |  |  |

k. Equivalents . .. ... or Masses per Unit Lengths. The chart shown below may ${ }^{1}$ ised for wires, pipes, rails, etc.

| Grams |
| :---: |
| per centimeter |

1.0
0.01
10.0
0.025511
14.8816
4.96054
0.0028185

| Kilograms <br> per kilometer | Kilograms <br> per meter |
| :---: | :--- |
| 100.0 | 0.1 |
| 1.0 | 0.001 |
| $1,000.0$ | 1.0 |
| 2.5511 | 0.0025511 |
| $1,488.16$ | 1.48815 |
| 496.054 | 0.49605 |
| 0.28185 | 0.00028185 |


| Grains |
| :---: |
| per inch |

39.1983
0.391983
391.983
1.0
583.333
194.444
0.11048

$\quad$| Pounds |
| ---: |
| per foot |

0.067197
0.00067197
0.67197
0.00171429
1.0
0.33333
0.00018939

| Pounds <br> per yard | Pounds <br> per mile |
| :--- | :---: |
| 0.201591 | 354.80 |
| 0.000201591 | 3.5480 |
| 2.01591 | $3,548.00$ |
| 0.00514286 | 9.0514 |
| 3.0 | $5,280.0$ |
| 1.0 | $1,760.0$ |
| 0.00056818 | 1.0 |

l. Simplified Conversion Factors (Feet and Inches). The chart below serves as a rapid means of converting inches to feet and inches and vice versa. Inches are shown in the extreme left column and in the spaces immediately above the three sets of double horizontal lines. In the body of the chart, feet and/or feet
and inches are shown (a dash separates feet from inches). For example, to convert 197 inches to feet and inches, find the number below the figure 190 on the top horizontal line and opposite the figure 7 . It is $16-5$, which represents 16 feet and 5 inches.

FM 55-15


| 130 | 140 | 150 | 160 | 170 | 130 | 190 | 200 | 210 | 220 | 280 | 240 | 250 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 10-10 | 11-8 | 12-6 | 13-4 | 14-2 | 15 | 15-10 | 16-8 | 17-6 | 18-4 | 19-2 | 20 | 20-10 |
| 10-11 | 11-9 | 12-7 | 13-5 | 14-3 | 15-1 | 15-11 | 16-9 | 17-7 | 18-5 | 19-3 | 20-1 | 20-11 |
| 11 | 11-10 | 12-8 | 13-6 | 14-4 | 15-2 | 16 | 16-10 | 17-8 | 18-6 | 19-4 | 20-2 | 21 |
| 11-1 | 11-11 | 12-9 | 13-7 | 14-5 | 15-3 | 16-1 | 16-11 | 17-9 | 18-7 | 19-5 | 20-3 | 21-1 |
| 11-2 | 12 | 12-10 | 13-8 | 14-6 | 15-4 | 16-2 | 17 | 17-10 | 18-8 | 19-6 | 20-4 | 21-2 |
| 11-3 | 12-1 | 12-11 | 13-9 | 14-7 | 15-5 | 16-3 | 17-1 | 17-11 | 18-9 | 19-7 | 20-5 | 21-3 |
| 11-4 | 12-2 | 13 | 13-10 | 14-8 | 15-6 | 16-4 | 17-2 | 18 | 18-10 | 19-8 | 20-6 | 21-4 |
| 11-5 | 12-3 | 13-1 | 13-11 | 14-9 | 15-7 | 16-5 | 17-3 | 18-1 | 18-11 | 19-9 | 20-7 | 21-5 |
| 11-6 | 12-4 | 13-2 | 14 | 14-10 | 15-8 | 16-6 | 17-4 | 18-2 | 19 | 19-10 | 20-8 | 21-6 |
| 11-7 | 12-5 | 13-3 | 14-1 | 14-11 | 15-9 | 16-7 | 17-5 | 18-3 | 19-1 | 19-11 | 20-9 | 21-7 |
| 380 | 380 | 400 | 410 | 420 | 480 | 440 | 450 | 460 | 470 | 480 | 490 | 500 |
| 31-8 | 32-6 | 33-4 | 34-2 | 35 | 35-10 | 36-8 | 37-6 | 38-4 | 39-2 | 40 | 40-10 | 41-8 |
| 31-9 | 32-7 | 33-5 | 34-3 | 35-1 | 35-11 | 36-9 | 37-7 | 38-5 | 39-3 | 40-1 | 40-11 | 41-9 |
| 31-10 | 32-8 | 33-6 | 34-4 | 35-2 | 36 | 36-10 | 37-8 | 38-6 | 39-4 | 40-2 | 41 | 41-10 |
| 31-11 | 32-9 | 33-7 | 34-5 | 35-3 | 36-1 | 36-11 | 37-9 | 38-7 | 39-5 | 40-3 | 41-1 | 41-11 |
| 32 | 32-10 | 33-8 | 34-6 | 35-4 | 36-2 | 37 | 37-10 | 38-8 | 39-6 | 40-4 | 41-2 | 42 |
| 32-1 | 32-11 | 33-9 | 34-7 | 35-5 | 36-3 | 37-1 | 37-11 | 38-9 | 39-7 | 40-5 | 41-3 | 42-1 |
| 32-2 | 33 | 33-10 | 34-8 | 35-6 | 36-4 | 37-2 | 38 | 38-10 | 39-8 | 40-6 | 41-4 | 42-2 |
| 32-3 | 33-1 | 33-11 | 34-9 | 35-7 | 36-5 | 37-3 | 38-1 | 38-11 | 39-9 | 40-7 | 41-5 | 42-3 |
| 32-4 | 33-2 | 34 | 34-10 | 35-8 | 36-6 | 37-4 | 38-2 | 39 | 39-10 | 40-8 | 41-6 | 42-4 |
| 32-5 | 33-3 | 34-1 | 34-11 | 35-9 | 36-7 | 37-5 | 38-3 | 39-1 | 39-11 | 40-9 | 41-7 | 42-5 |
| 680 | 640 | 650 | 660 | 670 | 630 | 690 | 700 | 710 | 720 | 780 | 740 | 750 |
| 52-6 | 53-4 | 54-2 | 55 | 55-10 | 56-8 | 57-6 | 58-4 | 59-2 | 60 | 60-10 | 61-8 | 62-6 |
| 52-7 | 53-5 | 54-3 | 55-1 | 55-11 | 56-9 | 57-7 | 58-5 | 59-3 | 60-1 | 60-11 | 61-9 | 62-7 |
| 52-8 | 53-6 | 54-4 | 55-2 | 56 | 56-10 | 57-8 | 58-6 | 59-4 | 60-2 | 61 | 61-10 | 62-8 |
| 52-9 | 53-7 | 54-5 | 55-3 | 56-1 | 56-11 | 57-9 | 58-7 | 59-5 | 60-3 | 61-1 | 61-11 | 62-9 |
| 52-10 | 53-8 | 54-6 | 55-4 | 56-2 | 57 | 57-10 | 58-8 | 59-6 | 60-4 | 61-2 | 62 | 62-10 |
| 52-11 | 53-9 | 54-7 | 55-5 | 56-3 | 57-1 | 57-11 | 58-9 | 59-7 | 60-5 | 61-3 | 62-1 | 62-11 |
| 53 | 53-10 | 54-8 | 55-6 | 56-4 | 57-2 | 58 | 58-10 | 59-8 | 60-6 | 61-4 | 62-2 | 63 |
| 53-1 | 53-11 | 54-9 | 55-7 | 56-5 | 57-3 | 58-1 | 58-11 | 59-9 | 60-7 | 61-5 | 62-3 | 63-1 |
| 53-2 | 54 | 54-10 | 55-8 | 56-6 | 57-4 | 58-2 | 59 | 59-10 | 60-8 | 61-6 | 62-4 | 63-2 |
| 53-3 | 54-1 | 54-11 | 55-9 | 56-7 | 57-5 | 58-3 | 59-1 | 59-11 | 60-9 | 61-7 | 62-5 | 63-3 |

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Figure 7-6. Scale for converting gallons of fuel and lubricants to tons.

7-38. Conversion of Fuel and Lubricants From Gallons to Tons
The scale in figure 7-16 is approximate and
should be used only for rapid computation. For this reason, weights given per unit of volume are slightly heavier than average.

## 7-39. Petroleum Conversion Factors

(Conversion factors give average, not exact figures.)

| Multiply | $B y$ | To obtain |
| :---: | :---: | :---: |
| Gallons, gasoline | 0.0027 | Long tons. |
| Gallons, gasoline | . 0026 | Metric tons. |
| Gallons, gasoline | 6.103 | Pounds. |
| Gallons, gasoline | . 0031 | Short tons. |
| Gallons, oil | 7.434 | Pounds. |
| Long tons | 367.21 | Gallons, gasoline. |
| Measurement tons | 1.086 | Short tons, gasoline. |
| Measurement tons | 1.4285 | Short tons, gasoline in drums. |
| Measurement tons | 1.0 | Short tons, grease. |
| Measurement tons | 1.11 | Short tons, oil. |
| Measurement tons | 1.2048 | Short tons, oil in drums. |
| Metric tons | 373.10 | Gallons, gasoline. |
| Pounds | . 1639 | Gallons, gasoline. |
| Pounds | . 1345 | Gallons, oil. |
| Short tons | 327.8 | Gallons, gasoline. |
| Short tons, gasoline | . 9195 | Measurement tons. |
| Short tons, gasoline in drums | . 7 | Measurement tons. |
| Short tons, grease | 1.0 | Measurement tons. |
| Short tons, oil | . 90 | Measurement tons. |
| Short tons, oil in drums | . 83 | Measurement tons. |

## 7-40. Map-Distance Conversion

a. Table.

| Map distance | Ground distance | Representative fraction (RF) |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  |
| One inch .... | Inches | 25,000 | 50,000 | 75,000 | 100,000 | 200,000 | 250,000 | 500,000 | 1,000,000 |
|  | Yards | 2,083 694 | 4,167 1,389 | 6,250 | 8,333 | 16,667 | 20,833 | 41,667 | $1,000,00$ 83,333 |
|  | Kilometers | ${ }^{694} .635$ | 1,389 1.27 | 2,083 | 2,778 | 5,555 | 6,944 | 13,888 | 27,776 |
|  | Miles | . 393 | 1.27 | 1.91 | 2.54 | 5.08 | 6.35 | 12.7 | 25.4 |
|  | Meters | 635 | 1,270 | 1,910 | 1.58 | 3.15 | 3.94 | 7.9 | 15.76 |
| One centimeter | Inches | 9,843 | 19,685 | 1,910 | 2,540 39,370 | 5,080 | 6,350 | 12,700 | 25,400 |
|  | Feet | 820 | 19,685 1,640 | 29,528 $\mathbf{2 , 4 6 0}$ | 39,370 3,281 | 78,740 6,562 | 98,425 | 196,850 | 393,700 |
|  | Yards | 273 | 1,640 | 2,460 820 | 3,281 1,094 | 6,562 | 8,202 | 16,404 | 32,808 |
|  | Kilometers | . 250 | . 500 | 820 750 | 1,094 | 2,187 | 2,734 | 5,468 | 10,936 |
|  | Miles | . 154 | . 31 | . 760 | 1.0 | 2.0 | 2.5 | 5.0 | 10.0 |
|  | Meters | 250 | 500 | 750 | ${ }_{1,000} .62$ | 1.24 | 1.55 | 3.1 | 6.2 |
|  |  |  |  | 750 | 1,000 | 2,000 | 2,500 | 5,000 | 10,000 |

b. Examples of use.
(1) A map distance of 1 inch is equivalent to a ground distance of 4,167 feet on a map with RF of $1 / 50,000$.
(2) A map distance of 1 inch is equiva-
lent to a ground distance of 3.15 miles on a map with RF of $1 / 200,000$.
(3) A map distance of 1 centimeter is equivalent to a ground distance of 273 yards on a map with RF of $1 / 25,000$.

7-41. Speed Conversion Table, Approximate

| $\begin{gathered} \text { Miles } \\ \text { per hour } \end{gathered}$ | Knots | $\begin{gathered} \text { Feet } \\ \text { per second } \end{gathered}$ | Kilometers per hour | $\begin{gathered} \text { Meters } \\ \text { per second } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: |
| 1 | 0.8684 | 1.4667 | 1.6093 | 0.447 |
| 2 | 1.74 | 2.94 | 3.23 | . 897 |
| 3 | 2.59 | 4.41 | 4.83 | 1.34 |
| 4 | 3.46 | 5.90 | 6.45 | 1.78 |
| 5 | 4.34 | 7.33 | 8.05 | 2.23 |
| 6 | 5.20 | 8.80 | 9.65 | 2.68 |
| 7 | 6.07 | 10.30 | 11.30 | 3.13 |
| 8 | 6.95 | 11.80 | 12.90 | 3.58 |
| 9 | 7.81 | 13.22 | 14.50 | 4.03 |
| 10 | 8.68 | 14.67 | 16.09 | 4.47 |
| 11 | 9.55 | 16.20 | 17.70 | 4.92 |
| 12 | 10.40 | 17.62 | 19.30 | 5.37 |
| 13 | 11.23 | 19.10 | 20.90 | 5.82 |
| 14 | 12.10 | 20.60 | 22.60 | 6.27 |
| 15 | 13.00 | 22.10 | 24.20 | 6.71 |
| 16 | 13.90 | 23.50 | 25.80 | 7.16 |
| 17 | 14.75 | 25.00 | 27.40 | 7.63 |
| 18 | 15.60 | 26.40 | 28.90 | 8.05 |
| 19 | 16.45 | 28.00 | 30.60 | 8.50 |
| 20 | 17.40 | 29.30 | 32.20 | 8.95 |
| 21 | 18.20 | 30.90 | 33.80 | 9.39 |
| 22 | 19.10 | 32.30 | 35.40 | 9.85 |
| 23 | 20.00 | 33.80 | 37.10 | 10.30 |
| 24 | 20.80 | 35.30 | 38.60 | 10.75 |
| 25 | 21.70 | 36.70 | 40.30 | 11.15 |
| 26 | 22.50 | 38.20 | 41.90 | 11.60 |
| 27 | 23.40 | 39.70 | 43.50 | 12.10 |
| 28 | 24.30 | 41.20 | 45.10 | 12.50 |
| 29 | 25.20 | 42.60 | 46.70 | 13.00 |
| 30 | 26.00 | 44.20 | 48.30 | 13.40 |
| 31 | 26.90 | 45.60 | 50.00 | 13.90 |
| 32 | 27.80 | 47.00 | 51.50 | 14.30 |
| 33 | 28.60 | 48.50 | 53.00 | 14.73 |
| 34 | 29.50 | 50.00 | 54.55 | 15.20 |
| 35 | 30.40 | 51.50 | 56.50 | 15.65 |
| 36 | 31.20 | 53.00 | 58.00 | 16.10 |
| 37 | 32.00 | 54.50 | 59.70 | 16.50 |
| 38 | 32.90 | 56.00 | 61.40 | 17.00 |
| 39 | 33.80 | 57.50 | 62.80 | 17.40 |
| 40 | 34.60 | 58.80 | 64.50 | 17.83 |
| 41 | 35.60 | 60.50 | 66.00 | 18.38 |
| 42 | 36.40 | 61.90 | 67.70 | 18.80 |
| 43 | 37.30 | 63.40 | 69.20 | 19.20 |
| 44 | 38.20 | 64.80 | 71.00 | 19.70 |
| 45 | 38.90 | 66.50 | 72.50 | 20.20 |
| 46 | 40.00 | 67.50 | 74.00 | 20.60 |
| 47 | 40.70 | 69.10 | 75.90 | 21.00 |
| 48 | 41.50 | 70.50 | 77.50 | 21.40 |
| 49 | 42.40 | 72.00 | 79.00 | 21.80 |
| 50 | 43.50 | 73.80 | 80.50 | 22.30 |

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| $\begin{aligned} & \text { Miles } \\ & \text { per hour } \end{aligned}$ | Knots | $\begin{gathered} \text { Feet } \\ \text { per second } \end{gathered}$ | Kilometers per hour | Meters per second |
| :---: | :---: | :---: | :---: | :---: |
| 51 | 44.10 | 74.90 | 82.00 | 22.80 |
| 52 | 45.10 | 76.50 | 83.60 | 23.20 |
| 53 | 46.00 | 78.00 | 85.70 | 23.70 |
| 54 | 46.70 | 79.50 | 87.00 | 24.20 |
| 55 | 47.50 | 80.90 | 88.70 | 24.60 |
| 56 | 48.50 | 82.20 | 90.00 | 25.00 |
| 57 | 49.50 | 83.90 | 91.90 | 25.50 |
| 58 | 50.10 | 85.00 | 93.40 | 25.90 |
| 59 | 51.00 | 86.80 | 95.00 | 26.40 |
| 60 | 52.00 | 88.10 | 96.70 | 26.80 |
| 61 | 53.00 | 89.60 | 98.00 | 27.20 |
| 62 | 53.70 | 91.10 | 99.80 | 27.70 |
| 63 | 54.60 | 92.90 | 101.70 | 28.20 |
| 64 | 55.60 | 94.20 | 103.00 | 28.60 |
| 65 | 56.20 | 95.30 | 104.50 | 29.10 |
| 66 | 57.20 | 97.00 | 106.00 | 29.50 |
| 67 | 58.00 | 98.20 | 108.00 | 30.00 |
| 68 | 58.90 | 100.00 | 109.50 | 30.40 |
| 69 | 59.80 | 101.80 | 111.00 | 30.80 |
| 70 | 60.70 | 103.00 | 113.00 | 31.30 |
| 71 | 61.60 | 104.00 | 114.00 | 31.70 |
| 72 | 62.50 | 106.00 | 116.00 | 32.20 |
| 73 | 63.30 | 107.30 | 117.30 | 32.60 |
| 74 | 64.20 | 109.00 | 119.00 | 33.10 |
| 75 | 65.00 | 110.00 | 121.00 | 33.60 |

## 7-42. Conversion of Foreign Measures to United States Measures



| China | Catty <br> Chang <br> Ch'ih <br> Chun <br> Feng <br> Hou <br> Li <br> Picul <br> Shi li <br> Shih tan <br> Tael Kuping <br> Tsun | $\begin{aligned} & 1.333 \mathrm{lb} \\ & 10.49 \mathrm{ft} \\ & 12.6 \mathrm{in} . \\ & 1.26 \mathrm{in} . \\ & 0.1259 \mathrm{in} . \\ & 0.0013 \mathrm{in} . \\ & 1,890 \mathrm{ft} \\ & 133.333 \mathrm{lb} \\ & 1,889.28 \mathrm{ft} \\ & 110.23 \mathrm{lb} \\ & 575.64 \text { grains (troy) } \\ & 1.409 \mathrm{in} . \end{aligned}$ |
| :---: | :---: | :---: |
| Cuba | Libra Vara | $\begin{aligned} & 1.014 \mathrm{lb} \\ & 33.386 \mathrm{in} . \end{aligned}$ |
| Denmark | Centner <br> Mil <br> Mil (geographic) <br> Pund <br> Tende (grain) <br> Tondeland <br> Viertel | 110.23 lb <br> 4.68 miles <br> 4.61 miles <br> 1.102 lb <br> 3.948 bu <br> 1.36 acres <br> 1.701 gal . |
| Dutch Guiana | Livre | 1.089 lb |
| Ecuador | Fanega | 1.574 bu |
| Egypt | Ardeb <br> Cantar <br> Feddan <br> Oke -- <br> Pic -- | $\begin{aligned} & 5.619 \mathrm{bu} \\ & 99.05 \mathrm{lb} \\ & 1.04 \mathrm{acres} \\ & 2.805 \mathrm{lb} \\ & 22.83 \mathrm{in} . \end{aligned}$ |
| France | Tonne | 2,204.62 lb |
| Germany | Klafter <br> Last .- | $\begin{aligned} & 2.074 \mathrm{yd} \\ & 4,409.2 \mathrm{lb} \end{aligned}$ |
| Bremer | Centner | 127.5 lb |
| Brunswick | Centner | 117.5 lb |
| Prussia | Centner | 113.34 lb |
| Greece | Drachma (new) <br> Livre $\qquad$ <br> Mina (old) <br> Oke $\qquad$ | $\begin{aligned} & 1 \text { metric } \mathrm{gr} \\ & 1.1 \mathrm{lb} \\ & 2.202 \mathrm{lb} \\ & 2.82 \mathrm{lb} \end{aligned}$ |
| Guatemala | Fanega Libra Vara | $\begin{aligned} & 1.53 \mathrm{bu} \\ & 1.014 \mathrm{lb} \\ & 32.909 \mathrm{in} . \end{aligned}$ |
| Honduras | Milla Vara | $\begin{aligned} & 1.149 \text { miles } \\ & 32.953 \text { in. } \end{aligned}$ |
| Hong Kong | Catty Picul | $\begin{aligned} & 1.333 \mathrm{lb} \\ & 133.383 \mathrm{lb} \end{aligned}$ |
| Hungary India: | Joch | 1.067 acres |
| Bombay | Candy | 569 lb |
| Madras | Candy ----- | 500 lb |
|  | Chittak <br> Maund (standard) | 900 grains <br> 82.285 lb |
|  | Seer (factory) - | 1.866 lb |
|  | Seer (standard) | 2.057 lb |
|  | $\begin{aligned} & \text { Ser } \\ & \text { Tola } \end{aligned}$ | $\begin{aligned} & 2.204 \mathrm{lb} \\ & 0.4114 \mathrm{oz} \end{aligned}$ |
| Indonesia | Buow <br> Katti <br> Paal | $\begin{aligned} & 1.7536 \text { acres } \\ & 1.36 \mathrm{lb} \\ & 56.16 \text { acres } \end{aligned}$ |



## Country

| Peru | Libra <br> Quintal <br> Vara | $\begin{aligned} & 1.014 \mathrm{lb} \\ & 101.43 \mathrm{lb} \\ & 31.913 \mathrm{in} . \end{aligned}$ |
| :---: | :---: | :---: |
| Philippines | Picul | 139.44 lb |
| Poland | Garnice <br> Vloka | 1.056 gal. <br> 41.5 acres |
| Portugal | Almude <br> Li'ra . | $\begin{aligned} & 4.422 \mathrm{gal} . \\ & 1.012 \mathrm{lb} \end{aligned}$ |
| Spain | Arroba <br> Fanega <br> Pie <br> Quintal | $\begin{aligned} & 4.263 \mathrm{gal} \text {. } \\ & 16 \mathrm{gal} \text {. } \\ & 0.914 \mathrm{ft} \\ & 101.43 \mathrm{lb} \end{aligned}$ |
| Sweden | Centner <br> Last <br> Skalpund <br> Tunna <br> Tunnland | $\begin{aligned} & 93.7 \mathrm{lb} \\ & 9,371.3 \mathrm{lb} \\ & 0.937 \mathrm{lb} \\ & 4.5 \mathrm{bu} \\ & 1.22 \mathrm{acres} \end{aligned}$ |
| Thailand | Catty, standard <br> Catty <br> Coyan | $\begin{aligned} & 1.333 \mathrm{lb} \\ & 2.667 \mathrm{lb} \\ & 2,645.5 \mathrm{lb} \end{aligned}$ |
| Turkey | Cantar <br> Oke <br> Pik | $\begin{aligned} & 124.45 \mathrm{lb} \\ & 2.828 \mathrm{lb} \\ & 27.9 \mathrm{in} . \end{aligned}$ |
| U.S.S.R. | Archine, or Archinne Berkovets <br> Chetvert <br> Dessiatine <br> Duim <br> Founte, or Funt <br> Foute, or Fut <br> Garnetz <br> Poud, or pood <br> Sagene, or Sajene <br> Vedro <br> Versta, or Verst | ```28 in., or 0.7112 meter 361.128 lb 5.957 bu 2.70 acres 1 in. 0.903 lb 1 ft 2.978 qt (dry) 36.113 lb ft 3.25 U.S. gal., 2.71 imperial gal. 0.663 mile``` |
| United Kingdom | Comb <br> Cwt (hundred wt) <br> Gallon <br> Last $\qquad$ <br> Load <br> Quart (liq) <br> Quart (dry) <br> Quarter <br> Sack (flour) <br> Stone <br> Wey | 4.128 bu <br> 112.0 lb <br> 1.2 gal. <br> 82.56 bu <br> 50 cu ft <br> 1.2 qt (liq) <br> 1.3 qt (liq) <br> 8.256 bu <br> 280 lb <br> 14 lb <br> 41.282 bu |
| Uruguay | Cuadra <br> Fanega <br> Libra | $\begin{aligned} & 1.82 \text { acres } \\ & 3.888 \mathrm{bu} \\ & 1.014 \mathrm{lb} \end{aligned}$ |
| Venezuela ---. | Fanega <br> Libra | $\begin{aligned} & 3.334 \mathrm{bu} \\ & 1.014 \mathrm{lb} \end{aligned}$ |
| Yugoslavia | Wagon -- | 10 metric tons |
| Zanzibar --.- | Frasila ----- | 35 lb |


| 7-43. Miscellaneous Conversion Factors for U.S. and British Measures |  |  |
| :---: | :---: | :---: |
| Multiply | $\boldsymbol{B}_{\boldsymbol{y}}$ | To obtain |
| Atmosphere | 14.70 | Pounds per square inch |
| Barrels | 5.61 | Cubic feet |
| Barrels | 42.0 | Gallons |
| Barrels | 6.29 | Kiloliters |
| Board feet | 144.0 | Cubic inches |
| Boiler horsepower | 33,475.0 | Btu per hour |
| Bushels (imperial) | 1.032 | Bushels (U.S.) |
| Bushels (U.S.) | . 969 | Bushels (imperial) |
| Carat | 3.086 | Grains |
| Centimeters | . 03281 | Feet |
| Centimeters | . 3937 | Inches |
| Cubic feet | . 782 | Barrels |
| Cubic feet | . 02832 | Cubic meters |
| Cubic feet | . 01 | Tons (register) |
| Cubic feet per minute | . 1247 | Gallons per second |
| Cubic feet per second | 646,315.0 | Gallons per day |
| Cubic meters | 35.31 | Cubic feet |
| Cubic meters | 1.308 | Cubic yards |
| Cubic yards | . 7646 | Cubic meters |
| Days | 1,440.0 | Minutes |
| Drams | 1.772 | Grams |
| Drams | . 0625 | Ounces |
| Feet | 30.48 | Centimeters |
| Feet of water | . 8826 | Inches of mercury |
| Feet of water | 62.43 | Pounds per square foot |
| Feet of water | . 4335 | Pounds per square inch |
| Gallons (imperial) | . 1605 | Cubic feet |
| Gallons (imperial) | 1.201 | Gallons (U.S.) |
| Gallons (imperial) | 4.543 | Liters |
| Gallons (U.S.) | . 8327 | Gallons (Imperial) |
| Gallons (U.S.) | . 0238 | Barrels |
| Gallons per minute | . 002228 | Cubic feet per second |
| Grams | 15.43 | Grains |
| Grams | . 001 | Kilograms |
| Grams | 1,000.0 | Milligrams |
| Grams | . 03527 | Ounces |
| Grams | . 002205 | Pounds |
| Hours | . 04167 | Days |
| Hours | . 005952 | Weeks |
| Horsepower | 42.40 | Btu per minute |
| Horsepower | 33,000.0 | Foot-pounds per minute |
| Horsepower (boiler) | 33,475.0 | Btu per hour |
| Horsepower-hours | 2,545.0 | Btu |
| Hundredweight | 112.0 | Pounds |
| Hundredweight | . 508 | Quintals |
| Inches | 2.540 | Centimeters |
| Inches | 25.4001 | Millimeters |
| Inches | 1,000.0 | Mils |
| Inches of mercury | . 4912 | Pounds per square inch |
| Inches of water | . 07355 | Inches of mercury |
| Inches of water | . 03614 | Pounds per square inch |
| Kilograms | 1,000.0 | Grams |
| Kiloliters | . 159 | Barrels |
| Knots | 1.0 | Miles per hour (naut) |
| Links (survejors) | 7.92 | Inches |
| Liters | . 2642 | Gallons (U.S.) |
| Liters | 1.76 | Pint (Imperial) |


| Multiply | By |
| :---: | :---: |
| Liters | 2.1134 |
| Liters | 1.057 |
| Meters | 100.0 |
| Millimeters | . 0393 |
| Mils | . 001 |
| Ounces | 20 |
| Ounces | 28.349 |
| Ounces (fluid) | 1.805 |
| Pennyweight | 24 |
| Pounds | 453.0 |
| Pounds of water | . 01603 |
| Pounds of water | . 1198 |
| Pounds per square inch | 2.307 |
| Pounds per square inch | 2.036 |
| Quintals | 1.97 |
| Quires | 25.0 |
| Reams | 500.0 |
| Short ton-miles | 1.45968 |
| Square centimeters | . 1550 |
| Square feet | 929.0 |
| Square feet | 144.0 |
| Square inches | 6.452 |
| Stones | 14.0 |
| Temp ( ${ }^{\circ} \mathrm{C}$ ) plus 17.8 | 1.8 |
| Temp ( ${ }^{\circ} \mathrm{F}$ ) minus 32 | . 5556 |
| Tons (measurement) | 40.0 |
| Tons (register) | 100.0 |
| Weeks | 168.0 |

To obtain
Pint (U.S.)
Quart (liquid)
Centimeters
Inches
Inches
Pennyweights
Grams
Cubic inches
Grains
Grams
Cubic feet Gallons (U.S.)
Feet of water
Inches of mercury
Hundredweights
Sheets (of paper, etc.)
Sheets (of paper, etc.)
Metric ton-kilometers
Square inches
Square centimeters
Square inches
Square centimeters
Pounds
Temp ( ${ }^{\circ} \mathrm{F}$ )
Temp ( ${ }^{\circ} \mathrm{C}$ )
Cubic feet
Cubic feet
Hours

## 7-44. Stowage Factors by Class and Service

a. Computation of Stowage Factor. The stowage factor is the number of cubic feet required to store 1 long ton ( $2,240 \mathrm{lb}$ ) of cargo. It may be computed by the following formula.

Stowage factor ( cu ft ) $=\frac{\text { cube of cargo }(\mathrm{cu} \mathrm{ft})}{\text { weight in pounds }} \times \mathbf{2 , 2 4 0}$
b. Weight-Volume Ratios. Weight-volume ratios are based on average cubage for each item. The measurement tonnage for any item can be found by multiplying its short ton weight by its conversion factor. Weight-volume ratios by classes of supply are given below.

| Item ${ }^{1}$ | $\begin{gathered} \text { Conversion } \\ \text { factor } \\ \text { (STTON to MTON) } \end{gathered}$ | Stowage factor |
| :---: | :---: | :---: |
| Class I : Rations | 2.1 | 94 |
| Class II: |  |  |
| Chemical (incl. class IV) | 2.3 | 103 |
| Engineer | 3.3 | 147 |
| Medjcal (incl. class I and IV). | d 2.5 | 112 |


| Item 1 | $\begin{gathered} \text { Conversion } \\ \text { factor } \\ \text { (STON to MTON }) \end{gathered}$ | Stowage factor |
| :---: | :---: | :---: |
| Ordnance | 1.8 | 80 |
| Ordnance vehicle replacement. | 2.2 | 99 |
| QM clothing and equipage - - | - 2.0 | 89 |
| QM general supplies ----- | - 2.8 | 125 |
| Signal (incl. class IV) ---- | - 3.8 | 170 |
| Class III: |  |  |
| Aviation fuel and lubricants (class IIIA). | 1.5 | 67 |
| Fuel for temperate zone ---- | - 2.0 | 89 |
| Gas, oil, grease ${ }^{2}$ (less aviation). | 1.5 | 67 |
| Class IV: |  |  |
| Aviation, supply and replacement. | 4.0 | 179 |
| Chemical (incl. in class II) |  |  |
| Engineer construction material. | 1.5 | 67 |
| Medical (incl. in class II) |  |  |
| Ordnance motor maintenance - | - 1.0 | 45 |
| QM sales items .-- | 1.7 | 76 |
| Signal (incl. in class II) Transportation | 2.4 | 108 |

[^46]factor Stowage Weight (b)
Class V:
Ammunition (less aviation)
Aviation ammunition ..... 40
Chemical ammunition ..... 1.2 ..... 54factor
${ }^{1}$ Nongas conditions. Figures are based upon average conditions found In European and Paclific theaters; amounts will vary for polar regions.
fuel, 3 peris of the following: 90 percent gasoline. 4 percent diese
7-45. Average of Stowage Factors byService

| Supply service | Class of eupply | Storoage factor |
| :---: | :---: | :---: |
| Chemical | All supplies less Class V | 103 |
| Engineer | All supplies | 107 |
| Medical | All supplies | 112 |
| Ordnance | All supplies less Class V | 75 |
| Quartermaster | All supplies | 87 |
| Signal | All supplies | 170 |
| Transportation | All supplies | 108 |
| Chemical ---- | Class V | 54 |
| Ordnance | Class V | 40 |

7-46. Average Densities of Common Materials and Specified Supply ltems
Figures shown below will aid transportationplanners and operators when making loadingplans for any mode of transportation. The in-formation given is for specific items. Whenplanning loads for the general classes of sup-ply, see paragraphs 7-8, 7-28, 7-44, 7-45.
a. Common Materials.
Material Weight (lb
Acid:
Muriatric, $40 \%$ ..... 75
Nitric, $\mathbf{9 1 \%}$ ..... 94
Sulphuric, $87 \%$ ..... 112
Alcohol, $\mathbf{1 0 0 \%}$
Ethyl ..... 49
Methyl ..... 50
Aluminum, cast-hammered ..... 165
Apple timber ..... 44
Asbestos ..... 153
Ashes and cinders ..... 40-45
Asphaltum ..... 81
Ash timber:
Black ..... 34
White ..... 42
Barley ..... 39
Barytes ..... 281
Basalt ..... 184
Bauxite ..... 159
Benzine ..... 50
Birch timber ..... 44
Bluestone ..... 159
per cust)
per 109 Borax ..... 109
Boxwood, dry ..... 60
Brass, cast-rolled ..... 534
Bronze:
Aluminum ..... 481
Phosphor ..... 554
Tin ..... 509
Brick ..... 100
Calcium ..... 98
Carbon ..... 134
Cedar timber, white or red ..... 22
Cement:
Mortar ..... 135
Portland, loose, dry ..... 94
Portland, set ..... 183
Chalk ..... 143
Chestnut timber ..... 30
Cherry timber, wild red ..... 27
Chloroform ..... 95
Cinders:
Blast furnace ..... 57
Chemical plant ..... 100
Clay:
Damp, plastic ..... 110
Dry ..... 63
Marl (mineral) ..... 137
Wet ..... 80
With gravel, dry ..... 100
Coal:
Anthracite ..... 97
Bituminous ..... 84
Charcoal, oak ..... 33
Charcoal, pine ..... 23
Coke ..... 75
Lignite ..... 78
Peat, turf, dry ..... 47
Coal and coke, piled:
Anthracite ..... 47-58
Bituminous or lignite ..... 40-54
Charcoal ..... 10-14
Coke ..... 23-32
Peat, turf ..... 20-26
Cobalt ..... 546
Concrete:
Plain ..... 140-150
Reinforced ..... 150
Copper:
Cast-rolled ..... 556
Ore, pyrites ..... 262
Cork ..... 15
Cotton, compressed ..... 45
Dolomite ..... 181
Earth:
Dry, loose ..... 76
Dry, packed ..... 95
Moist, loose ..... 78
Moist, packed ..... 96
Mud, flowing ..... 108
Mud, packed ..... 115

Weight (lb per cuft)
Material

78
Ebony timber ..... 78
Elm timber ..... 35
Ether ..... 46
Excelsior, baled ..... 19
Feldspar, orthoclase ..... 162
Fir timber:
Balsam ..... 25
Douglas ..... 32
Flax ..... 26
Flint ..... 162
Garbage:
Green ..... 47
Tankage ..... 27
Glass:
Common ..... 162
Crystal ..... 184
Flint ..... 247
Plate or crown ..... 161
Gneiss ..... 175
Gold :
Cast-hammered ..... 1,205
Coin (U.S.) ..... 1,073
Grain ..... 48
Granite ..... 165
Graphite ..... 135
Gravel:
Damp, loose ..... 87
Dry, compacted ..... 120
Greenstone, trap ..... 187
Gumwood ..... 57
Gypsum, alabaster ..... 159
Hay or straw (bales) ..... 20
Hemlock timber ..... 29
Hemp ..... 90
Hickory timber ..... 48
Hornblende ..... 187
Ice ..... 57
Indigo ..... 63
Iridium ..... 1,383
Iron:
Cast pig ..... 450
Ferrosilicon ..... 437
Gray cast ..... 442
Ore:Hematite325
Hematite in bank ..... 160-180
Hematite loose ..... 130-160
Limonite ..... 237
Magnetite ..... 315
Slag ..... 172
Spiegel-eisen ..... 468
Wrought ..... 485
Ivory ..... 114
Jute ..... 30
Kerosene ..... 50
Lead:
Pure ..... 710
Ore, galena ..... 65
Leather ..... 59
MaterialWeight (lbft)
Lime, gypsum, loose ..... 53-64Limestone
Marble, quartz (solid) ..... 155
Marble, quartz (quarried, piled) ..... 95
Locust timber ..... 45
Logwood, dry (average) ..... 57
Lumber, structural (average) ..... 24
Lye, soda (liquid) ..... 106
Magnesite ..... 187
Magnesium alloys ..... 112
Mahogany timber ..... 44
Manganese :
Pure ..... 475
Ore, pyrolusite ..... 259
Manila ..... 26
Maple timber
Hard or sugar ..... 43
White ..... 33
Marble ..... 170
Masonry:Ashlar:
Bluestone ..... 153
Granite, syenite, gneiss ..... 159
Limestone ..... 153
Marble ..... 162
Sandstone ..... 143
Brick:
Hard brick ..... 128
Medium brick ..... 112
Sand-lime brick ..... 112
Soft brick ..... 103
Concrete:
Cement, cinder, etc ..... 100
Cement, slag, etc ..... 130
Cement, stone, sand ..... 144
Dry rubble:
Granite, syenite, gneiss ..... 130
Limestone, marble ..... 125
Sandstone, bluestone ..... 110
Mortar rubble:
Bluestone ..... 147
Granite, syenite, gneiss ..... 153
Limestone ..... 147
Marble ..... 156
Sandstone ..... 137
Mercury ..... 847
Mica ..... 183
Monel metal, rolled ..... 555
Mortar:
Lime, set ..... 103
Portland cement ..... 135
Mud (river mud) ..... 90
Nickel ..... 537
Oak timber:
Chestnut ..... 46
Live ..... 54
Red or black ..... 42
White ..... 48
Oats ..... 26
Oils:
Mineral (lubricants) ..... 57
Vegetable ..... 58
Paper:
Books ..... 58
Manila ..... 37
News ..... 38
Wrapping ..... 10
Writing ..... 64
Paraffin ..... 56
Petroleum, crude (average) ..... 54
Phosphate rock, apatite ..... 200
Phosphoric acid ..... 97
Pine timber:
Norway ..... 34
Oregon ..... 32
Red ..... 30
Southern ..... 40
White ..... 27
Yellow:
Long-leaf ..... 44
Short-leaf ..... 38
Pitch ..... 69
Plaster ..... 53
Plaster of Paris ..... 140
Platinum, cast-hammered ..... 1,330
Poplar timber ..... 27
Porphyry (mineral ..... 172
Potassium ..... 54
Pumice, natural ..... 40
Quartz, flint ..... 165
Rags, baled:
Cotton ..... 18
Linen ..... 23
Woolen ..... 20
Redwood timber (California) ..... 26
Riprap:
Limestone ..... 80-85
Sandstone ..... 90
Shale ..... 105
Rope ..... 42
Rosin ..... 67
Rubber:
Caoutchouc ..... 59
Goods ..... 94
Pure ..... 60
Rye ..... 45
Salt, granulated, piled ..... 48
Saltpeter ..... 132
Sand and gravel:
Dry, loose ..... 90-105
Dry, packed ..... 105-120
Wet ..... 126
Sandstone ..... 143
Sandstone, quarried, piled ..... 82
Sawdust, dry ..... 7
Serpentine (mineral) ..... 171
Shale:
Quarried, piled ..... 92
Weight ( $a_{0}$
Material Weight (lb per cu ft)
Slate ..... 172
Silver:
Cast-hammered ..... 656
German ..... 536
Sisal ..... 24
Slags:
Bank ..... 67-72
Bank screenings ..... 98-117
Machine ..... 96
Slag-sand ..... 49-55
Snow:
Compacted ..... 20
Fresh ..... 8
Soapstone, talc ..... 169
Soda ash ..... 62
Soda, bicarbonate ..... 86
Sodium ..... 61
Soil, wet ..... 70
Spruce timber, white or red ..... 28
Starch ..... 96
Steel:
Cold-drawn ..... 489
Machine ..... 487
Tool ..... 481
Stone riprap, wet ..... 65
Straw:
Baled ..... 24
Loose ..... 3
Sulphur ..... 125
Sulphuric acid ..... 115
Sycamore timber ..... 37
Syenite (mineral) ..... 165
Talc ..... 170
Tallow ..... 59
Tar, bituminous ..... 75
Teak timber
African ..... 62
Indian ..... 48
Terra Cotta ..... 122
Tin:
Cast-hammered ..... 459
Ore, cassiterite ..... 418
Tobacco ..... 28
Tungsten ..... 1,200
Turpentine ..... 54
Walnut timber:
Black ..... 37
White ..... 26
Water:
Fresh ..... 62
Sea ..... 64
Wax, bees ..... 61
Wheat ..... 48
Willow timber ..... 28
Wood pulp ..... 29
Wool, packed ..... 82
Zinc:
Cast-rolled ..... 440
Ore, blende ..... 253


## b. Subsistence.

(1) Perishables and bulk staples.
Material Weight
per cu ft
Dairy Products:
Butter ..... 59.0
Cheese ..... 30.0
Milk ..... 65.0
Eggs ..... 22.6
Fruits:
Fresh:
Apples ..... 31.3
Apricots ..... 34.8
Bananas ..... 13.2
Blackberries ..... 21.5
Cantaloupe ..... 26.8
Casaba (honeydew melon) ..... 24.0
Cherries ..... 31.2
Cranberries ..... 24.6
Figs ..... 34.8
Grapefruit ..... 31.2
Grapes ..... 28.9
Lemons ..... 33.2
Limes ..... 36.9
Loganberries ..... 21.1
Oranges ..... 34.2
Peaches ..... 23.3
Pears ..... 24.9
Pineapples ..... 22.1
Plums ..... 25.6
Raspberries ..... 22.0
Strawberries ..... 22.0
Tangerines ..... 35.5
Frozen (average for all) ..... 36.2
Meats:
Beef:
Boneless ..... 36.7
Chuck ..... 35.8
Corned ..... 37.1
Dried, canned ..... 39.8
Forequarter ..... 27.0
Hindquarter ..... 19.1
Liver ..... 45.7
Loin ..... 18.1
Rounds ..... 14.7
Ribs ..... 23.3
Tenderloin ..... 46.6
Lamb and Mutton:
Carcass ..... 9.4
Telescope ..... 11.5
Pork:
Bacon ..... 36.9
Boston butt ..... 40.2
Ham ..... 40.2
Ham, canned ..... 37.4
Loin ..... 37.4
Pork shoulder ..... 30.9
Salt pork ..... 33.5
Spare rib ..... 30.9
Poultry:

Waight (lb
per cuft)
Material .....
31.5 .....
31.5 ..... 40.2
Fryer
Fryer
Chicken, cut-up ..... 29.6
Turkey ..... 29.8
Sausage:
Bologna ..... 32.5
Frankfurter ..... 35.2
Liver ..... 36.5
Luncheon meat ..... 37.8
Pork, bulk ..... 46.6
Pork, link ..... 35.2
Salami ..... 34.8
Veal:
Carcass and sides ..... 13.7
Fabricated ..... 14.6
Staples:
Bread ..... 18.0
Cereals, bulk:
Barley ..... 39.0
Buckwheat ..... 42.0
Corn, rye ..... 45.0
Oatmeal ..... 38.0
Oats ..... 26.0
Wheat ..... 48.0
Coffee ..... 37.0
Cornmeal ..... 40.0
Fats (average) ..... 58.0
Flour:
Loose ..... 28.0
Packed ..... 47.0
Honey ..... 90.0
Lard ..... 60.0
Molasses ..... 38.0
Rice ..... 50.0
Sugar:
Brown ..... 45.0
White ..... 42.0
Tea ..... 16.0
Vegetables:
Fresh:
Asparagus ..... 21.0
Beans:
Green or snap ..... 14.7
Lima ..... 18.3
Beets:
Bunched ..... 18.1
Topped ..... 30.9
Broccoli ..... 17.8
Cabbage ..... 24.5
Carrots:
Bunched ..... 18.9
Topped ..... 30.0
Cauliflower ..... 18.9
Celery ..... 23.4
Corn, sweet ..... 16.8
Cucumbers ..... 23.1
Eggplant ..... 16.4
Lettuce ..... 20.5
Material Weight (lbOnions:
Dry ..... 30.9
Green ..... 16.8
Peas:
Green ..... 14.4
Shelled ..... 26.0
Peppers, sweet, green ..... 17.6
Potatoes:
Irish ..... 35.7
Sweet ..... 31.3
Radishes ..... 21.6
Spinach ..... 14.8
Tomatoes ..... 33.3
Turnips ..... 30.9
Frozen (average for all) ..... 27.0
Water food:
Clams ..... 28.2
Crab meat ..... 27.1
Fish:
Drawn ..... 32.8
Fillet ..... 22.1
Smoked ..... 24.6
Smoked fillet ..... 51.6
Oysters ..... 26.5
Shrimp ..... 23.9
(2) Nonperishables in containers.
Weight clb
Material ..... per cu ft)
Apples
(No. 10 can) ..... 40.0
(No. $21 / 2$ can) ..... 37.9
(No. 2 can) ..... 38.0
Apple butter
(No. 10 can) ..... 47.5
(No. $21 / 2$ can) ..... 45.0
(No. 2 can) ..... 44.5
Apples, dry (50-lb bag) ..... 33.3
Apricots
(No. 10 can) ..... 43.8
(No. 2 1/2 can) ..... 42.1
(No. 3 can) ..... 41.0
Bacon (12-lb slab) ..... 37.6
Beans
(No. 10 can) ..... 43.8
(No. $21 / 2$ can) ..... 42.1
(No. 2 can) ..... 41.0
(No. 1 can) ..... 50.7
Beans, dry (100-lb sack) ..... 39.2
Beans, string
(No. 10 can) ..... 41.6
(No. $21 / 2$ can) ..... 40.0
(No. 2 can) ..... 39.5
Beef, canned (6-1b can) ..... 62.0
Beef, roast (No. 10 can) ..... 42.5
Beets
(No. 10 can) ..... 42.5
(No. $21 / 2$ can) ..... 40.0
(No. 2 can) ..... 41.0
Weight 1 lb
Material
Material
Biscuits, Types C (2-lb pack) ..... 28.8
Bouillon cubes ( 100 per pack) ..... 37.3
Butter (5-lb pack) ..... 45.6
Cabbage, dehy (5-lb pack) ..... 13.8
Candy, hard (15-lb pack) ..... 33.1
Carrots
(No. 10 can) ..... 42.5
(No. 2 1/2 can) ..... 40.0
(No. 2 can) ..... 41.0
Catsup
(No. 10 can) ..... 45.0
(No. $21 / 2$ can) ..... 42.1
(No. 2 can) ..... 41.0
Cereal, uncooked (22 oz) ..... 32.7
Cereal, individual ..... 8.7
Cheese, processed (6-lb pack) ..... 54.4
Chile con carne
(No. 10 can) ..... 42.5
(No. 2 1/2 can) ..... 40.0
(No. 2 can) ..... 41.0
Cocoa (5-lb pack) ..... 25.0
Coffee ( $16-\mathrm{lb}$ bag) ..... 30.0
Corn
(No. 10 can) ..... 43.2
(No. 2 1/2 can) ..... 41.1
(No. 2 can) ..... 41.0
Crackers, Graham (2-lb pack) ..... 30.0
Eggs, dehy (No. 10 can) ..... 25.0
Figs
(No. 10 can) ..... 45.0
(No. $21 / 2$ can) ..... 42.1
(No. 2 can) ..... 42.5
Flour (98-lb sack) ..... 36.1
Grapefruit
(No. 10 can) ..... 41.6
(No. 2 1/2 can) ..... 40.0
(No. 2 can) ..... 39.5
Hash, corned beef ( $51 / 2-\mathrm{lb}$ pack) ..... 33.1
Hash, meat and veg (No. 10 can) ..... 43.8
Jam, assorted
(No. 10 can) ..... 52.5
(No. 2 1/2 can) ..... 41.0
(No. 2 can) ..... 47.0
Lard (37-lb container) ..... 46.8
Luncheon meat (6-lb pack) ..... 49.5
Mackerel (14-oz can) ..... 26.7
Milk, powdered (5-lb container) ..... 31.3
Milk, evaporated ( 14 1/2-oz pack) ..... 42.3
Oats, rolled (48-oz pack) ..... 20.9
Peaches and/or pears
(No. 10 can) ..... 43.8
(No. $21 / 2$ can) ..... 41.1
(No. 2 can) ..... 42.5
Peanut butter
(No. 10 can) ..... 43.8
(No. $21 / 2$ can) ..... 41.1
(No. 2 can) ..... 41.0

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Material
Peas
(No. 10 can) ..... 42.8
(No. 2 can) ..... 41.0
Pickles (1-gallon jar) ..... 48.5
Pineapple, sliced:
(No. 10 can) ..... 43.8
(No. $21 / 2$ can) ..... 42.1
(No. 2 can) ..... 41.0
Pineapple juice
(No. 10 can) ..... 41.7
(No. 2 can) ..... 41.0
Potatoes, dehy
(No. 16-lb pack) ..... 33.0
(No. 10-lb pack) ..... 24.7
Prunes, dry
(No. 25-lb bag) ..... 60.0
(No. 5-lb bag) ..... 44.4
Salmon (1-lb container) ..... 47.7
Salt (100-lb bag) ..... 39.2
Sauerkraut
(No. 10 can) ..... 40.9
(No. $21 / 2$ can) ..... 38.9
(No. 2 can) ..... 39.5
Sausage (2-lb pack) ..... 44.3
Sausage, Vienna ( $11 / 2-\mathrm{lb}$ pack) ..... 36.7
Soup, dehy (5-lb pack) ..... 28.6
Spaghetti
(No. 10 can) ..... 43.2
(No. $21 / 2$ can) ..... 41.1
(No. 2 can) ..... 41.0
Spinach
(No. 10 can) ..... 40.6
(No. $21 / 2$ can) ..... 38.9
(No. 2 can) ..... 38.0
Stew, meat and veg (28-oz pack) ..... 40.7
(30-oz pack) ..... 43.6
Sugar, granulated: (10-lb pack) ..... 56.4
(100-lb pack) ..... 40.0
Syrup
(No. 10 can) ..... 52.2
(1-lb container) ..... 62.1
Tea (5-lb box) ..... 13.0
Tomatoes
(No. 10 can) ..... 41.9
(No. $21 / 2$ can) ..... 40.0
(No. 2 can) ..... 39.5
Tomato juice
(No. 10 can ) ..... 41.6
(No. $21 / 2$ can) ..... 40.0
(No. 2 can) ..... 39.5
Vegetables, mixed:
(No. 10 can ) ..... 42.5
(No. 2 can) ..... 39.5
Vinegar (1-gal. jar) ..... 67.0

## c. Clothing and Individual Equipment.

Weight (lb ..... per eight folMaterial
Axe, chopping ..... 20
Bag, barracks ..... 18
Bag, duffel ..... 22
Bag, sleeping ..... 17
Bar, mosquito ..... 20
Belt, cartridge ..... 20
Belt, pistol ..... 22
Blanket, wool, OD ..... 16
Boots, service, combat ..... 18
Bunting wool ..... 21
Can, meat, aluminum ..... 13
Canteen, aluminum ..... 9
Cap, garrison, AG 44 ..... 18
Cap, service, wool ..... 4
Carrier, pack ..... 16
Case, canvas, dispatch ..... 13
Coat, wool ..... 14
Comforter, wool ..... 7
Cover, canteen ..... 11
Cup, canteen, aluminum ..... 11
Drawers, cotton ..... 21
Drawers, winter ..... 18
Gloves, cotton ..... 18
Gloves, leather ..... 25
Gloves, wool ..... 11
Handkerchief ..... 25
Haversack ..... 19
Helmet, steel, boxed ..... 15
Holster (Various types) ..... 15
Jacket, field ..... 21
Jumper, dungaree ..... 21
Laces, shoe ..... 20
Liner, helmet ..... 6
Mittens, inserts ..... 16
Muffler, wool, OD ..... 12
Necktie, mohair ..... 15
Overcoat (w/wool insert) ..... 20
Pack, field, cargo ..... 19
Pack, field, combat ..... 18
Pants, sweat ..... 20
Parka, field, cotton ..... 23
Pin, tent ..... 27
Pocket, cartridge ..... 18
Pocket, magazine ..... 25
Pole, tent, shelter ..... 28
Pouch, first aid ..... 15
Raincoat ..... 30
Roll, bedding ..... 32
Rope, manila ..... 15
Scabbard, rifle ..... 13
Shirt, cotton, khaki ..... 20
Shirt, wool, OG ..... 23
Shoes, low quarter ..... 11
Shovel, intrenching ..... 28
Socks, cotton ..... 16
Socks, wool ..... 14
Suit, HBT, protective ..... 22

Weight (lb Material per cu ft)


Towel, bath
15
Trousers, cotton, khaki ..... 22Trousers, cotton, khak
Trousers, wool serge ..... 23
Undershirt, cotton ..... 18
d. Organizational Field Equipment.
Material Weight (lb per cu ft
Cans, galvanized:
$10-\mathrm{gal}$ ..... 17.6
24-gal ..... 7.9
32-gal ..... 8.4
Chair, folding, metal ..... 12.8
Chair, folding, wood ..... 11.0
Chest, record, fiber ..... 9.0
Container, insulated ..... 16.0
Container, water, 5 -gal ..... 11.6
Cot, canvas, folding ..... 27.0
Cover, mattress ..... 24.0
Desk, field, empty, fiber ..... 9.0
*Duck, cotton ..... 32.0
*Fly, tent, wall ..... 30.0
Kit, barber ..... 23.0
Locker, trunk ..... 9.0
Mattress, cotton ..... 4.0
*Paulin, canvas, small ..... 21.0
*Paulin, canvas, large ..... 43.0
Pillow, feather ..... 8.0
Pillowcase ..... 21.0
Pin, tent, $16^{\prime \prime}$ ..... 36.3
Pin, tent, 24" ..... 30.2
Pole, tent, ridge ..... 27.0
Range, field ..... 22.7
*Screen, latrine ..... 27.1Weight (lb
Material
Materialght Cb
Table, camp, folding ..... 9.2Table, camp, folding
Table, mess ..... 1.8
*Tent, command post ..... 11.7
*Tent, GP, med ..... 23.9
*Tent, storage ..... 36.3
*Tent, wall, small ..... 13.0
*Tent, wall, large ..... 25.0
*Figures are average. Weight will vary with different types ofmaterial.
7-47. Rapid Computation of Weight of a Unit for Shipment

For planning purposes, the weight in short tons of a unit is the sum of the combined weights of-
$a$. TOE personnel and individual equipment, assuming average weight of 240 pounds per man.
b. Major items of organizational equipment.
c. Class I supplies for 3 days, assuming 6.6 pounds per ration per man per day.
d. Class III supplies necessary to move unit 100 miles from destination point after arrival, if authorized in shipment.
$e$. Basic load of class V.
$f$. Added items that may be authorized by theater commander or CONUS commander.

## Section XIII. MATHEMATICAL TABLES AND FORMULAS

7-48. Measurement of Surfaces and Solids

## Figure <br> Formula

a. Area of:

Circle $\qquad$ Square of the diameter times .7854, or square of the radius times 3.1416 .
Sector of _-.-.- Length of the arc times the radius divided by 2 , or 3.1416 times square of radius times angle of the sector divided by 360 .
Segment of _-.- Area of the sector minus the area of the triangle formed by joining radii.
Closed base cone
One-half of slant height times perimeter of base, plus area of base.

|  | Formula |
| :---: | :---: |
| Open base cone | One-half of slant height times perimeter of the base. |
| Frustrum of cone -- | Slant height times sum of circumferences of bases divided by 2 plus sum of the areas of both bases. |
| Cube | Sum of areas of all the sides. |
| Cylinder | Area of 2 ends plus length times perimeter. |
| Ellipse | Long axis times short axis times .7854. |
| Parallelogram | Base times altitude. |
| Polygon ----------- | Perimeter times apothem divided by 2. |
| Prism | Area of 2 ends plus length times perimeter. |


| Figure <br> Pyramid | One-half of slant height |
| :---: | :---: |
|  | times perimeter of base plus area of base. |
| Rectangle | Bases times altitude. |
| Sphere | Square of diameter times 3.1416. |
| Squar | Base times altitude. |
| Straight-lined figure of 4 or more unequal sides. | Divide figure into triangles, find area of each triangle, and add areas. |
| Trapezoid | Altitude times sum of bases divided by 2. |
| Triangle | Base times altitude divided by 2. |
| b. Circumference of: |  |
| Circle | Diameter times 3.1416. |
| Quadrilateral and Polygon. | Sum of all sides. |
| c. Volume of: |  |
|  | Height times area of base divided by 3. |
| Frustrum of cone | Height times $\left(B+B^{\prime}+\sqrt{\left.B \times B^{\prime}\right)}\right.$ |
| Cube | Length times width times depth. |
| Cylinder | Area of the base times height. |
| Prism | Height times area of base. |
| Pyramid | Height times area of base divided by 3. |
| Frustrum of pyramid. | Height times $\left(B+B^{\prime}+\sqrt{\left.B \times B^{\prime}\right)}\right.$ |
| Sphere | Cube of the diameter times .5236. |
| Tank, elliptical _--- | Long axis times short axis times .7854 times length. |
| Irregular figure | Sum of volume of component parts. If possible, immerse figure in water and measure the displacement. |
|  | ote. |
| pothem -----.-.- per | ndicular from center of polyany side. |
| $\begin{array}{ll} B \text { and } B^{\prime}-\ldots-\ldots & \text { area } \\ & \text { respe } \\ \text { or } p y \end{array}$ | of upper and lower bases ctively, of frustrum of cone ramid. |
| Frustrum $\qquad$ that inclu secti paral | part of a pyramid or cone ed between the base and a of the pyramid or cone ll to the base. |
| Polygon $\qquad$ close ing | , straight-lined figure havmore than 4 sides. |
| Quadrilateral $\qquad$ close ing 4 | , straight-lined figure havsides. |
| Regular polygon -- close | , straight-lined figure havqual sides and equal angles. |

Trapezoid Figure
Trapezoid $\qquad$ quadrilateral figure having one pair of parallel sides.

## 7-49. Functions of Numbers

Quantities in the chart below are useful to the transportation planner when solving equations and formulas. Logarithms are particularly useful if a number is to be raised to a power above the cube or to a fractional power. The logarithm of a number is the exponent of the power to which a base must be raised to produce the number. For the purposes of this manual, the base can be considered to be 10. Therefore, the logarithm of a number to the base 12 is the power to which 16 must be raised to produce the number.
For example.

$$
\log _{10} 100=2.00000, \text { since } 10^{2.00000}=100
$$

A logarithm has two parts-the characteristic (that part to the left of the decimal point), and a mantissa (that part to the right of the decimal point). The mantissa is always arranged to be positive. The characteristic is zero or positive and is one less than the number of digits to the left of the decimal point for one and numbers greater than one, and is negative and a minus one greater than the number of zeros to the right of the decimal point for numbers smaller than one. Thus the logarithm of 0.01 is 2.00000 , which may also be expressed as (1.00000-3), (2.00000-4), (3.00000-5), etc. In keeping the mantissa positive for numbers smaller than one, should there be a multiplier of the logarithm, the number to the right in the brackets should be the lowest possible number that will produce a whole number from the multiplier. For example, should the logarithm of a number equal $1 / 3 \times 1.00000$, it should be expressed as $1 / 3 \times(2.00000-3)$, which equals $0.66666-1$, or 1.66666. An example of the use of logarithms is presented by the problem of raising 44 to the 0.36 power.

$$
\begin{aligned}
\text { Let } x & =(44)^{0.30} \\
\text { The } \log x & =0.36 \times \log 44 \\
& =0.36 \times 1.64345 \\
& =0.59164 \\
\text { and } x & =\text { antilog of } 0.59164, \text { or } 3.905 .
\end{aligned}
$$

FM 55-15

| Number | Square | Square root | Cube | Cube root | Logarithm |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1 | 1.0000 | 1 | 1.000 | 0.00000 |
| 2 | 4 | 1.4142 | 8 | 1.260 | . 30103 |
| 3 | 9 | 1.7321 | 27 | 1.442 | . 47712 |
| 4 | 16 | 2.0000 | 64 | 1.587 | . 60206 |
| 5 | 25 | 2.2361 | 125 | 1.710 | . 69897 |
| 6 | 36 | 2.4495 | 216 | 1.817 | . 77815 |
| 7 | 49 | 2.6458 | 343 | 1.913 | . 84510 |
| 8 | 64 | 2.8284 | 512 | 2.000 | . 90309 |
| 9 | 81 | 3.0000 | 729 | 2.080 | . 95424 |
| 10 | 100 | 3.1623 | 1000 | 2.154 | 1.00000 |
| 11 | 121 | 3.3166 | 1331 | 2.224 | 1.04139 |
| 12 | 144 | 3.4641 | 1728 | 2.289 | 1.07918 |
| 13 | 169 | 3.6056 | 2197 | 2.351 | 1.11394 |
| 14 | 196 | 3.7417 | 2744 | 2.410 | 1.14613 |
| 15 | 225 | 3.8730 | 3375 | 2.466 | 1.17609 |
| 16 | 256 | 4.0000 | 4096 | 2.520 | 1.20412 |
| 17 | 289 | 4.1231 | 4913 | 2.571 | 1.23045 |
| 18 | 324 | 4.2426 | 5832 | 2.621 | 1.25527 |
| 19 | 361 | 4.3589 | 6859 | 2.668 | 1.27875 |
| 20 | 400 | 4.4721 | 8000 | 2.714 | 1.30103 |
| 21 | 441 | 4.5826 | 9261 | 2.759 | 1.32222 |
| 22 | 484 | 4.6904 | 10648 | 2.802 | 1.34242 |
| 23 | 529 | 4.7958 | 12167 | 2.844 | 1.36173 |
| 24 | 576 | 4.8990 | 13824 | 2.884 | 1.38021 |
| 25 | 625 | 5.0000 | 15625 | 2.924 | 1.39794 |
| 26 | 676 | 5.0990 | 17576 | 2.962 | 1.41497 |
| 27 | 729 | 5.1962 | 19683 | 3.000 | 1.43136 |
| 28 | 784 | 5.2915 | 21952 | 3.037 | 1.44716 |
| 29 30 | 841 900 | 5.3852 5.4772 | 24389 | 3.072 | 1.46240 |
| 31 | 900 961 | 5.4772 5.5678 | 27000 | 3.107 3.141 | 1.47712 1.49136 |
| 32 | 1024 | 5.6569 | 32768 | 3.175 | 1.50515 |
| 33 | 1089 | 5.7446 | 35937 | 3.208 | 1.51851 |
| 34 | 1156 | 5.8310 | 39304 | 3.240 | 1.53148 |
| 35 | 1225 | 5.9161 | 42875 | 3.271 | 1.54407 |
| 36 | 1296 | 6.0000 | 46656 | 3.302 | 1.55630 |
| 37 | 1369 | 6.0828 | 50653 | 3.332 | 1.56820 |
| 38 | 1444 | 6.1644 | 54872 | 3.362 | 1.57978 |
| 39 | 1521 | 6.2450 | 59319 | 3.391 | 1.59106 |
| 40 | 1600 | 6.3246 | 64000 | 3.420 | 1.60216 |
| 41 | 1681 | 6.4031 | 68921 | 3.448 | 1.61278 |
| 42 | 1764 | 6.4807 | 74088 | 3.476 | 1.62325 |
| 43 | 1849 | 6.5574 | 79507 | 3.503 | 1.68347 |
| 44 | 1936 | 6.6332 | 85184 | 3.530 | 1.64345 |
| 45 | 2025 | 6.7082 | 91125 | 3.557 | 1.65321 |
| 46 | 2116 | 6.7823 | 97336 | 3.583 | 1.66276 |
| 47 | 2209 | 6.8557 | 103823 | 3.609 | 1.67210 |
| 48 | 2304 | 6.9282 | 110592 | 3.634 | 1.68124 |
| 49 | 2401 | 7.0000 | 117649 | 3.659 | 1.69020 |
| 50 | 2500 | 7.0711 | 125000 | 3.684 | 1.69897 |
| 51 | 2601 | 7.1414 | 132651 | 3.708 | 1.70757 |
| 52 | 2704 | 7.2111 | 140608 | 3.733 | 1.71600 |
| 53 | 2809 | 7.2801 | 148877 | 3.756 | 1.72428 |
| 54 | 2916 | 7.3485 | 157464 | 3.780 | 1.73239 |
| 55 | 3025 | 7.4162 | 166375 | 3.803 | 1.74036 |
| 56 | 3136 | 7.4833 | 175616 | 3.826 | 1.74819 |
| 57 | 3249 | 7.5498 | 185193 | 3.849 | 1.75587 |
| 58 | 3364 | 7.6158 | 195112 | 3.871 | 1.76343 |
| 59 | 3481 | 7.6811 | 205379 | 3.893 | 1.77085 |


| Number | Square | Square root | Cube | Cube root | Logarithm |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 60 | 3600 | 7.7460 | 216000 | 3.915 | 1.77815 |
| 61 | 3721 | 7.8102 | 226981 | 3.936 | 1.78533 |
| 62 | 3844 | 7.8740 | 238328 | 3.958 | 1.79239 |
| 63 | 3969 | 7.9373 | 250047 | 3.979 | 1.79934 |
| 64 | 4096 | 8.0000 | 262144 | 4.000 | 1.80618 |
| 65 | 4225 | 8.0623 | 274625 | 4.021 | 1.81291 |
| 66 | 4356 | 8.1240 | 287496 | 4.041 | 1.81954 |
| 67 | 4489 | 8.1854 | 300763 | 4.062 | 1.82607 |
| 68 | 4624 | 8.2462 | 314432 | 4.082 | 1.83251 |
| 69 | 4761 | 8.3066 | 328509 | 4.102 | 1.83885 |
| 70 | 4900 | 8.3666 | 343000 | 4.121 | 1.84510 |
| 71 | 5041 | 8.4261 | 357911 | 4.141 | 1.85126 |
| 72 | 5184 | 8.4853 | 373248 | 4.160 | 1.85733 |
| 73 | 5329 | 8.5540 | 389017 | 4.179 | 1.86332 |
| 74 | 5476 | 8.6023 | 405224 | 4.198 | 1.86923 |
| 75 | 5625 | 8.6603 | 421875 | 4.217 | 1.87506 |
| 76 | 5776 | 8.7178 | 438976 | 4.236 | 1.88081 |
| 77 | 5929 | 8.7750 | 456533 | 4.254 | 1.88649 |
| 78 | 6084 | 8.8318 | 474552 | 4.273 | 1.89209 |
| 79 | 6241 | 8.8882 | 493039 | 4.291 | 1.89763 |
| 80 | 6400 | 8.9443 | 512000 | 4.309 | 1.90309 |
| 81 | 6561 | 9.0000 | 531441 | 4.327 | 1.90849 |
| 82 | 6724 | 9.0554 | 551368 | 4.344 | 1.91381 |
| 83 | 6889 | 9.1104 | 571787 | 4.362 | 1.91908 |
| 84 | 7056 | 9.1652 | 592704 | 4.380 | 1.92428 |
| 85 | 7225 | 9.2195 | 614125 | 4.397 | 1.92942 |
| 86 | 7396 | 9.2736 | 636056 | 4.414 | 1.93450 |
| 87 | 7569 | 9.3274 | 658503 | 4.431 | 1.93952 |
| 88 | 7744 | 9.3808 | 681472 | 4.448 | 1.94448 |
| 89 | 7921 | 9.4340 | 704969 | 4.465 | 1.94939 |
| 90 | 8100 | 9.4868 | 729000 | 4.481 | 1.95424 |
| 91 | 8281 | 9.5394 | 753571 | 4.498 | 1.95904 |
| 92 | 8464 | 9.5917 | 778688 | 4.514 | 1.96379 |
| 93 | 8649 | 9.6437 | 804357 | 4.531 | 1.96848 |
| 94 | 8836 | 9.6954 | 830584 | 4.547 | 1.97313 |
| 95 | 9025 | 9.7468 | 857375 | 4.563 | 1.97772 |
| 96 | 9216 | 9.7980 | 884736 | 4.579 | 1.98227 |
| 97 | 9409 | 9.8489 | 912673 | 4:595 | 1.98677 |
| 98 | 9604 | 9.8995 | 941192 | 4.610 | 1.99123 |
| 99 | 9801 | 0.9499 | 970299 | 4.626 | 1.99564 |
| 100 | 10000 | 10.0000 | 1000000 | 4.642 | 2.00000 |
| 0.1 | 0.01 | 0.3162 | 0.001 | 0.4641 | 1.00000 |
| 0.01 | 0.0001 | 0.1 | 0.000001 | 0.2154 | 2.00000 |
| 0.001 | 0.000001 | 0.03162 | 0.000000001 | 0.1 | 3.00000 |

7-50. Decimal Equivalents

| Inches |  |  | Inches | Millimeters |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | $1 / 64$ | 0.015625 |



7-51. Trigonometric Solution of Triangles

$\operatorname{Sin} A=\frac{a}{c}$
$\operatorname{Cos} A=\frac{b}{c} \quad a^{2}=b^{2}+c^{2}-2 b c \operatorname{Cos} A$
$\operatorname{Tan} A=\frac{a}{b}$
$\operatorname{Cot} A=\frac{b}{a}$
$b^{2}=a^{2}+\underline{c^{2}}-2 a c \operatorname{Cos} B$
$\operatorname{Sec} \quad A=\frac{c}{b}$
$\operatorname{Csc} \quad A=\frac{c}{a}$
$c^{2}=a^{2}+b^{2}-2 a b \operatorname{Cos} C$
Area $=\frac{a b}{2}=\frac{a}{2} \sqrt{c^{2}-a^{2}}=\frac{a^{2} \operatorname{Cot} A}{2}$
Area $=\sqrt{s(s-a)(s-b)(s-c)}$
$=\frac{b^{2} \operatorname{Tan} A}{2}=\frac{c^{2} \operatorname{Sin} 2 A}{4}$
Where

$$
\underline{\varepsilon}=\frac{a+b+c}{2}
$$

## 7-52. Natural Trigonometric Functions

| Angle ${ }^{\text {a }}$ | Sin | Csc | Tan | Cot | Sec | Cos | Angle ${ }^{\text {e }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 | 0.000 |  | 0.000 |  | 1.000 | 1.000 | 90 |
| 1 | . 017 | 57.30 | . 017 | 57.29 | 1.000 | 1.000 | 89 |
| 2 | . 035 | 28.65 | . 035 | 28.64 | 1.001 | . 999 | 88 |
| 3 | . 052 | 19.11 | . 052 | 19.08 | 1.001 | . 999 | 87 |
| 4 | . 070 | 14.34 | . 070 | 14.30 | 1.002 | . 998 | 86 |
| 5 | . 087 | 11.47 | . 087 | 11.43 | 1.004 | . 996 | 85 |
| 6 | . 105 | 9.567 | . 105 | 9.514 | 1.006 | . 995 | 84 |
| 7 | . 122 | 8.206 | . 123 | 8.144 | 1.008 | . 993 | 83 |
| 8 | . 139 | 7.185 | . 141 | 7.115 | 1.010 | . 990 | 82 |
| 9 | . 156 | 6.392 | . 158 | 6.314 | 1.012 | . 988 | 81 |
| 10 | . 174 | 5.759 | . 176 | 5.671 | 1.015 | . 985 | 80 |
| 11 | . 191 | 5.241 | . 194 | 5.145 | 1.019 | . 982 | 79 |
| 12 | . 208 | 4.810 | . 213 | 4.705 | 1.022 | . 978 | 78 |
| 13 | . 225 | 4.445 | . 231 | 4.331 | 1.026 | . 974 | 77 |
| 14 | . 242 | 4.134 | . 249 | 4.011 | 1.031 | . 970 | 76 |
| 15 | . 259 | 3.864 | . 268 | 3.732 | 1.035 | . 966 | 75 |
| 16 | . 276 | 3.628 | . 287 | 3.487 | 1.040 | . 961 | 74 |
| 17 | . 292 | 3.420 | . 306 | 3.271 | 1.046 | . 956 | 73 |
| 18 | . 309 | 3.236 | . 325 | 3.078 | 1.051 | . 951 | 72 |
| 19 | . 326 | 3.072 | . 344 | 2.094 | 1.058 | . 946 | 71 |
| 20 | . 342 | 2.924 | . 364 | 2.747 | 1.064 | . 940 | 70 |
| 21 | . 358 | 2.790 | . 284 | 2.605 | 1.071 | . 934 | 69 |
| 22 | . 375 | 2.669 | . 404 | 2.475 | 1.079 | . 927 | 68 |
| 23 | . 391 | 2.559 | . 424 | 2.356 | 1.086 | . 921 | 67 |


| Anple ${ }^{\circ}$ | Sin | Csc | Tan | Cot | Sec | Cos | Anole ${ }^{\circ}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 24 | . 407 | 2.459 | . 445 | 2.246 | 1.095 | . 914 | 66 |
| 25 | . 423 | 2.336 | . 466 | 2.145 | 1.103 | . 906 | 65 |
| 26 | . 438 | 2.281 | . 488 | 2.050 | 1.113 | . 899 | 64 |
| 27 | . 454 | 2.203 | . 510 | 1.963 | 1.122 | . 891 | 63 |
| 28 | . 469 | 2.130 | . 532 | 1.881 | 1.133 | . 883 | 62 |
| 29 | . 485 | 2.063 | . 554 | 1.804 | 1.143 | . 875 | 61 |
| 30 | . 500 | 2.000 | . 577 | 1.732 | 1.155 | . 866 | 60 |
| 31 | . 515 | 1.942 | . 601 | 1.664 | 1.167 | . 857 | 59 |
| 32 | . 530 | 1.887 | . 625 | 1.600 | 1.179 | . 848 | 58 |
| 33 | . 545 | 1.836 | . 649 | 1.540 | 1.192 | . 839 | 57 |
| 34 | . 559 | 1.788 | . 675 | 1.483 | 1.206 | . 829 | 56 |
| 35 | . 574 | 1.743 | . 700 | 1.428 | 1.221 | . 819 | 55 |
| 36 | . 588 | 1.701 | . 727 | 1.376 | 1.236 | . 809 | 54 |
| 37 | . 602 | 1.662 | . 754 | 1.327 | 1.252 | . 799 | 53 |
| 38 | . 616 | 1.624 | . 781 | 1.280 | 1.269 | . 788 | 52 |
| 39 | . 629 | 1.589 | . 810 | 1.235 | 1.287 | . 777 | 51 |
| 40 | . 643 | 1.556 | . 839 | 1.192 | 1.305 | . 766 | 50 |
| 41 | . 656 | 1.542 | . 869 | 1.150 | 1.325 | . 755 | 49 |
| 42 | . 669 | 1.494 | . 900 | 1.111 | 1.346 | . 743 | 48 |
| 43 | . 682 | 1.466 | . 933 | 1.072 | 1.367 | . 731 | 47 |
| 44 | . 695 | 1.440 | . 966 | 1.036 | 1.390 | . 719 | 46 |
| 45 | . 707 | 1.414 | 1.000 | 1.000 | 1.414 | . 707 | 45 |

## 7-53. Computing Guy Stress For Lifting

To compute the stress, or tension, that should be placed upon a guy, the horizontal and vertical distance relationships for upright poles, the weight of the load to be lifted, the weight of the pole, the horizontal distance from base of pole to the guy anchor, and the perpendicular distance from the base of pole
to the guy must be considered. Relationships for computing stress are shown in figure 7-7; 1 illustrates tension or pull ( $P$ ) for an upright pole when there are known relationships between height of the pole ( $H$ ) and the ground distance from base of the pole to the guy anchor, and 2 shows how to compute guy stress when the pole is inclined.

## Section XIV. TIME, TIDE, AND LIGHT

## 7-54. Time and Light

a. Designating Time and Date.
(1) Time. Expressed in a group of four digits, ranging from 0000 to 2400 . The first two digits are the hours after midnight; the remaining two indicate minutes past the hour. Where the hour can be expressed as a single digit, it is preceded by zero; for example, 0625 for 6:25 a.m.
(2) Date. Day, month, and year expressed in that order-except when necessary to specify a six-digit time group. In a sixdigit time group, the first two digits indicate day of month; the next two the hour; the last two, minutes past the hour. For example, 070625 Dec 62 means 6:25 a.m. on 7 Dec 1962. If desired to keep the date secret, dates may be
expressed by a letter, such as D plus or minus a numeral in place of the first two digits.
(3) Greenwich mean time. Time groups expressing Greenwich mean time are designated by the letter suffix Z immediately following the last digit of the group; for example, 190225Z.
(4) Expressing natural phenomena. Indefinite terms, such as first light, last light, daybreak, daylight, darkness, dusk, dawn, are avoided. Definite terms are permissible, such as sunrise, sunset, beginning or end of evening or morning nautical or civil twilight.
b. Time Zone Chart (fig 7-8).
(1) The earth averages one rotation on its axis every 24 hours. This causes in the same period an apparent travel of the sun


TENSION

$$
\begin{aligned}
t= & \frac{w d}{y} \\
y= & \text { PERPENDICULAR DISTANCE FROM } \\
& \text { BASE OF POLE TO REAR GUY } \\
w= & \text { WEIGHT OF LOAD + } 1 / 2 \text { WEIGHT OF } \\
& \text { POLE } \\
d= & \text { DISTANCE FROM GUY ANCHOR } \\
& \text { TO BASE OF POLE }
\end{aligned}
$$

WHERE

Figure 7-7. Computing guy stress.


Figure 7-8. Time-zone chart.
across $360^{\circ}$ of longitude. Therefore, the surface of the earth is divided into 24 zones $15^{\circ}$ wide in longitude-each 1 hour in width. The initial zone is the one which has the meridian of Greenwich running through the middle of it, and the meridians $71 / 2^{\circ}$ east of Greenwich and $71 / 2^{\circ}$ west of Greenwich marking its eastern and western limits. It is called the "zero zone" because the difference between the standard time of this zone and Greenwich mean time is zero. Each of the zones in turn is designated by a number representing the number of hours by which the standard time of the zone differs from Greenwich mean time. The zones lying in east longitude from the zero zone are numbered in sequence from 1 to 12 , and are called minus zones because, in each of them, the zone number must be subtracted from the standard time in order to obtain the Greenwich mean time. The zones lying in west longitude from the zero zones are numbered in sequence from 1 to 12 , and are called plus zones because, in each of these zones, the zone number must be added to the standard time in order to obtain the Greenwich mean time. The time kept in any zone is the standard time of its central meridian. The twelfth zone is divided medially by the $180^{\circ}$ meridian (the line separating the meridians of east longitude from the meridians of west longitude), and the terms "minus" and "plus" are used in the halves of this zone which lie in the east longitude and west longitude, respectively.
(2) Use of suffixes. The suffix letter used after a four- or six-digit time group indicates the number of hours by which the time expressed differs from Greenwich mean time at the, same instant. For example, Norfolk, Va., is located in the fifth time zone west of Greenwich. For local mean time, the suffix letter would be R.
(3) Converting time from zone to zone. The number in the time zone indicates the number of hours or fraction thereof that local time differs from Greenwich mean time. The time zones extend east and west from Greenwich to the 180 th meridian. To transpose Greenwich mean time to local time, add the zone number if the zone is east of the prime
meridian; subtract it if it is west of the prime meridian. Time conversion for any zone is shown in figure 7-9.

## 7-55. Tides, Sunlight, and Moonlight

a. Chart. Figure 7-10 shows the type of chart which is issued for each major operation or operational area. These charts are prepared by the Joint Intelligence Study Publishing Board and appear in JANIS (Joint Army-Navy Intelligence Study).
b. Area Covered. Astronomical data are for sea level and do not vary more than 5 minutes over a radius of 60 miles ( 97 kilometers).
c. Time Used for the Time Meridian Indicated in the Heading. When another time meridian is used in the field, the figures representing hours on the left of the large diagram are changed to conform to the new time. If the time meridian to be used is in a zone number east of the one shown on the diagram, the number is increased by 1 hour for each 15 ; if west, the number is decreased by 1 hour for each $15^{\circ}$.
d. Dates. In the upper diagram of figure 7-9, each day from midnight to midnight is represented by a space between two lines. In the lower diagram, the days are represented by vertical lines covering the period from noon of one day to noon of the next. The dates at the bottom of the diagram differ from those at the top because the dates change in passing through midnight.
e. Tides. Times of the tides are shown by curves in the lower diagram. By noting the sequence of the tides during the day, the height of any particular tide can be found by consulting the diagram.
f. Twilight (fig. 7-11).
(1) Twilights are the periods of solar illumination before sunrise and after sunset. Both morning and evening twilights are divided into three periods: astronomical, nautical, and civil.
(a) Astronomical. Offers meager light, if any; for military purposes, considered period of darkness.

KAGOSHIAGA - WAN, KYUSHU =
DECERABER 1945
LAT $31^{\circ} 30^{\prime} \mathrm{N} .$, LONG $130^{\circ} 40^{\prime} \mathrm{E}$.
TIAGE RAERIDIAN: $135^{\circ} \mathrm{E}$.
SUNLIGHT AND MOONLIGHT DATA COAPUTED FOR LAT $31^{\circ} 30^{\circ}$ N., LONG $130^{\circ} 40^{\circ} E$.



* THIS YIAGRAM, HITH THE CHAFGES IHDIGATED, IS ALSO APPLIGABLE TO THE FOLLOHIDG PLAGES: TOAAARI URA.-ADD ID RIAUTES TO TIMES OF HI日H ANO LDE TIDES, SUBTRACT $1 / 2$ FOOT FROM HEIOHTS OF HIGM TIDES.
ODOAARI-GYAN _ SUETRACT RS MIRUTES FROM TIUES OF HIGH ANO LOG TIDES. SUBTRACT I FOOT FROM HEIGHTS OF HIGH TIOES.

Figure 7-10. Sample diagram of tides, sunlight, and moonlight.


NOTE-Degrees refer to center of sun below horizon.

Figure 7-11. Twilight factors.

| Y |
| :--- |

(b) Nautical. Provides enough light to carry on most types of ground movement without difficulty. Visibility limited to 400 yards ( 366 meters) or less.
(c) Civil. Offers enough light to carry on normal day activities.
(2) Except for high latitudes, durations of astronomical, nautical, and civil twilights may be considered equal.
g. Moonlight. For astronomical twilight and solar darkness, periods of moonlight and solar darkness are shown on the lower diagram of figure 7-10. During the period of moonlight, the intensity of light varies between the brightness of the full moon at zenith and about one-third of this value. During the period of dim moonlight, the intensity varies from about one-third
to one-tenth of the brightness of the full moon at zenith.
h. Moon's Phases. In figure 7-10 the phases of the moon are shown below the days on which they occur.
i. Effect of Weather on Light. Smog, fog, clouds, refraction, reflection, and precipitation affect the degree of illumination. These factors can be included in the calculations by means of experience tables compiled in the area and from meteorological forecasts for the area.

## 7-56. Hours of Daylight

[Time between sunrise and sunset. It is light for approximately 30 minutes before sunrise and after sunset. For latitude south, subtract figure given from 24]


## 7-57. Calendar 1900-1999

a. Calendar.

| Key letter ${ }^{1}$ | Year |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| T | 1900 |  |  |  |
| U | 1901 | 1929 | 1957 | 1985 |
| V | 1902 | 1930 | 1958 | 1986 |
| W | 1903 | 1931 | 1959 | 1987 |
| XY | 1904 | 1932 | 1960 | 1988 |
| Z | 1905 | 1933 | 1961 | 1989 |
| T | 1906 | 1934 | 1962 | 1990 |
| U | 1907 | 1935 | 1963 | 1991 |
| VW | 1908 | 1936 | 1964 | 1992 |
| $\mathbf{X}$ | 1909 | 1937 | 1965 | 1993 |
| Y | 1910 | 1938 | 1966 | 1994 |
| Z | 1911 | 1939 | 1967 | 1995 |
| TU | 1912 | 1940 | 1968 | 1996 |
| V | 1913 | 1941 | 1969 | 1997 |
| W | 1914 | 1942 | 1970 | 1998 |
| X | 1915 | 1943 | 1971 | 1999 |
| YZ | 1916 | 1944 | 1972 |  |
| T | 1917 | 1945 | 1973 |  |
| U | 1918 | 1946 | 1974 |  |
| V | 1919 | 1947 | 1975 |  |


| Key letter 1 | Year |  |  |
| :---: | :---: | :---: | :---: |
| WX | 1920 | 1948 | 1976 |
| Y | 1921 | 1949 | 1977 |
| Z | 1922 | 1950 | 1978 |
| T | 1923 | 1951 | 1979 |
| UV | 1924 | 1952 | 1980 |
| W | 1925 | 1953 | 1981 |
| $\mathbf{X}$ | 1926 | 1954 | 1982 |
| Y | 1927 | 1955 | 1983 |
| ZT | 1928 | 1956 | 1984 |

${ }^{1}$ Two letters together are shown for leap years. The first is to be used for January and February, the second for
other months.

b. Examples of Use.
(1) Given March 6, 1962, find the day of the week. Opposite the year 1962 is the key letter T. Opposite the month of March, the key letter T appears in the fourth column from the left. Under this key letter, opposite the 6th day, Tuesday is found.
(2) Given Saturday, November _, 1962, find the possible days of the month that Saturday falls upon. Opposite the year 1962 is the key letter T. Opposite the month of November, the key letter T appears in the fourth column from the left. Under the key letter, opposite Saturday, the numbers 3, 10, 17 and 24 are the possible days for November.
(3) Given Tuesday, $\qquad$ 6, 1963, find the possible months in which this combination could occur. Opposite 1963, the key letter U is found. Opposite the 6th day, Tuesday appears in the 4th "Day of week" column. Above the column, the key letter U is found opposite August.
(4) Given Monday, February 29, __, find the possible year(s). Opposite the 29th day, Monday appears in the last column. Above this column, the key letter X is found opposite February. Since February is shown as having 29 days, it must be leap year, which means that the first key letter of a 2-letter group must be used. For the key letter X, the possible years are 1904, 1932, 1960, and 1988.

## Section XV. TERRAIN FACTORS

## 7-58. Gradient

Gradient, or percent of any slope is the vertical rise divided by the horizontal distance times 100. This information is sometimes needed by operators in the field, and can be
determined from observations on the spot or from a map. These methods are outlined and explained below. When possible, both methods should be used, so that one may serve as a check on the other.
a. Field Method. By use of the Abney hand level or engineer clinometer, the percent slope of a hill or road can be read directly. The level of clinometer is held to the eye and the index arm is moved until the bubble is centered and the observer is looking at a height equal to his line of sight above the top of the slope being measured. The percent of slope may then be read directly from the graduated arc.
b. Map Method. Measure the horizontal distance in feet on the map between your location and top of the slope per map scale. Then determine the difference in elevation between these two points using the contour internal and lines of the map. Use the following formula to obtain gradient in percent.

$$
\frac{a}{b} \times 100=\text { percent of slope. }
$$

## Where

$a=$ change in elevation in feet
$b=$ horizontal distance in feet between the two points

## 7-59. Maps

This paragraph provides information and guidance for all personnel in the use of military maps. The readers should refer to FM 21-26, FM 41-30, and TM 21-31 for more detailed information on map reading.
a. Marginal Information. All information concerning a particular map and its use is located in the margin of that map sheet. Because not all maps are alike, it is usually necessary to examine the marginal data before using a map. The following items are of critical importance:
(1) Grid reference box. Instructions for using grid references on the map.
(2) The legend. Identifies the topographic symbols used on the map.
(3) Declination diagram. Indicates the relationship of map features to grid, true, and magnetic north.
(4) Contour interval note. Indicates the vertical distance between contour lines on the map.
(5) Scale note. Indicates the scale of the map sheet.
b. Map Orientation. Maps may be oriented either by use of a compass or by terrain recognition. The compass method is best if a compass is available. Where well-defined terrain features are evident, the map may be oriented by terrain recognition.
(1) Compass method. Place the map sheet on a flat surface. Open the compass and place it flat on the map with the cover pointing in the direction of grid north and the straightedge parallel to a grid line. Rotate the map and compass, as one, until the magnetic declination (shown on the declination diagram) is reproduced on the face of the compass. The angle of magnetic declination will be formed between the black index line on the glass cover and the luminous arrow of the compass. The map is now exactly oriented to the surrounding ground.
(2) Terrain recognition method. This is a method of matching the local terrain features to the same features shown on the map. This method may be aided by orienting the map approximately to north or south by use of one of the expedient direction-finding techniques discussed in subsequent paragraphs.
c. Map Grid System. The grid system is used for locating or referencing the location of points. It consists of two sets of equally spaced parallel lines at right angles to each other, forming grid squares of a standard size. The proper method of using the grid system is found in the grid reference box located in the margin of the map.
d. Scale and Horizontal Distance. It is expressed as the ratio of a distance on the map to the corresponding distance on the ground measured in the same units (feet, kilometers, etc.). This ratio of representative fraction is expressed as one unit of measure on the map to X units of measure on the ground.

Example. 1:500,000 or $\frac{1}{50,000}$.
Distances can be measured directly on the map using the bar scale located in the margin of the map. The map distance can also be
obtained by measuring a distance and then multiplying that distance by the denominator of a representative fraction; this results in a ground distance in the same unit of measure as was used to measure the map distance.
e. Elevation. Elevation and relief are shown on a topographic map by the use of contour lines. A contour line is an imaginary line in the ground along which all points are the same elevation. Contour lines indicate vertical distance above mean sea level. The vertical distance between contour lines is the contour interval. The vertical distance is constant throughout the area of the map and is found in the marginal data. On the map itself, index contour lines, which are heavier drawn lines than the regular contours, will be broken and the elevation of that index contour line given.
f. Horizontal Direction. Horizontal direction is expressed as a clockwise angle called an azimuth, from either true, magnetic, or grid north. These three kinds of direction are defined below. The relationship between these north directions, and any annual changes to them is found in the declination diagram.
(1) True north. A line from any position on the earth's surface to the north pole. All lines of longitude are true north lines. True north is symbolized by a star.
(2) Magnetic north. The north that is established by the compass. Magnetic north is symbolized by half hours. Azimuths read directly with a compass are magnetic azimuths and must be corrected to grid north before using that azimuth on the map itself.
(3) Grid north. The north that is established by the grid lines on the map. Grid north is symbolized by the letters GN.
g. Expedient Direction-Finding Techniques.
(1) Daytime. Use of a watch set on standard time.
(a) Northern hemisphere. The hour hand on the watch should be pointed at a direction on the horizon directly below the sun. A line bisecting the smallest angle between the hour hand and 12 o'clock points south.
(b) Southern hemisphere. Point the 12 o'clock position on the watch in a direction
which is directly below the sun. A line bisecting the smallest angle between the hour hand and 12 o'clock points north.
(c) Limitations. Use of the watch method should be restricted to the north and south temperate zones and the hours between 0700 and 1700.
(2) Nighttime—use of stars.
(a) Northern hemisphere. Use of the north star (polaris). The two pointer stars which form the side of the cup farthest from the handle of the big dipper are in line with the north star, which is located above the north pole. The distance from the north star to the nearest pointer star is approximately five times the distance between the pointer stars.
(b) Southern hemisphere. The Southern Cross, composed of four stars, is used for direction determination. A point above the South Pole is located on an extension of the long axis, four and one-half times the length of that axis, in the direction of the longer part of that axis.
h. Intersection. The process of locating an unknown point by successively occupying two known positions and sighting on the unknown point. If a compass is available, shoot azimuth to the unknown point from both known locations and plot these lines on the map. The unknown point is located at their point of intersection. Care must be taken in plotting compass azimuths to assure that the magnetic azimuths are converted to grid azimuths before plotting. If a compass is not available, the straightedge method may be used.
(1) Straightedge method. Orient the map and place it on the ground. Place a straightedge on the map and sight along it from your known location on the map to the unknown point. Repeat this process at the other point. The unknown point is located by the intersection of these lines.
(2) Resection. The method of determining the user's location by sighting on two known features that can be located on the map. The previous instructions are simply reversed. Your location is at the point where the lines intersect.



$\square$

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}

## APPENDIX A

## REFERENCES

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Transportation Light Helicopter Company.
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Transportation Light-Medium Truck Company.
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By Order of the Secretary of the Army:

Official:
HAROLD K. JOHNSON, General, United States Army, Chief of Staff.
KENNETH G. WICKHAM,
Major General, United States Army,
The Adjutant General.

## Distribution:

To be distributed in accordance with DA Form 12-11 requirements for Transportation Reference Data.

transportation motor transport battalion, TOE 55-16. truck company.

To provide transportation for the movement of general cargo, bulk petroleum products, and refrigerated cargo by motor transport.

To a field army, corps, or a logistical command. Normally attached to a headquarters and headquarters detachment, transportation motor transport battalion, TOE 55-16.
company can transport the following:
a. When equipped with $21 / 2$-ton trucks:
(1) For local hauls- 720 short tons of cargo ( 4 tons per truck) based on 75-percent availability of vehicles and 4 trips daily on highway or 3,600 passengers ( 20 passengers per truck) on or off highway.
(2) For line hauls-360 short tons of cargo (4 tons per truck) based on 75 -percent availability of vehicles and 2 trips daily on highway or 1,440 passengers ( 16 passengers per truck) on or off highway.
(3) 112.5 short tons of cargo ( $21 / 2$ tons per truck) in one lift off highway.
b. When equipped with 5-ton trucks:
(1) Local hauls- 1,080 short tons of cargo ( 6 tons per truck) based on 75-percent availability of vehicles and 4 trips daily on or off highway or 3,600 passengers ( 20 passengers per truck) on or off highway.
(2) Line hauls- 540 short tons of cargo ( 6 tons per truck) based on 75 -percent availability of vehicles and 2 trips daily on highway or 1,620 passengers ( 18 passengers per truck) on or off highway.
(3) 180 short tons of cargo (4 tons per truck) in one lift off highway.
a. At full strength, with 45 semitrailer combinations available making four round trips per day in. local hauls or two round trips per day (one per 10-hour shift) in line hauls, a medium truck company can transport the following:
(1) When equipped with 12 -ton cargo semitrailers:
(a) Local hauls-2,160 short tons of cargo (12 tons per semitrailer) or in an emergency only, 9,000 passengers ( 50 passengers per semitrailer).
(b) Line hauls- 1,080 short tons of cargo (12 per semitrailer) or in an emergency only, 4,500 passengers ( 50 passengers per semitrailer).
(2) When equipped with 5,000 gallon petroleum semitrailers:
(a) Local hauls- 900,000 gallons.
(b) Line hauls-450,000 gallons.
(3) When equipped with $71 / 2$-ton refrigerator semitrailers carrying 6 tons per vehicle:
(a) Local hauls- 1,080 short
tons.
(b) Line hauls- 540 short tons.
b. With minor modifications, i.e., military desert design tires, this unit can provide logistical and combat support in desert areas of the world.
a. Each platoon when equipped with sedans can transport 75 personnel in one lift.
b. Each platoon when equipped with $1 / 4$-ton trucks and trailers can transport 45 personnel and $21 / 2$ tons of baggage or small-sized supplies or $61 / 4$ tons of small-sized supplies and cargo, mail, or light commodities in one lift.
c. Each platoon when equipped with $3 / 4$-ton trucks can transport $111 / 4$ tons of cargo or 120 people in one lift.
d. Each composite platoon composed of ten $1 / 4$-ton trucks and trailers and ten $3 / 4$-ton trucks (designated the airborne platoons in the airborne organization) is capable of transporting 82 personnel and $71 / 2$ tons of baggage or small-sized supplies or 10 tons of

To transport personnel and light cargo by motor vehicles.
a. To a field army or logistical command. Normally attached to headquarters and headquarters detachment, transportation motor transport battalion, TOE 55-16, may also be assigned to independent corps force or to a corps.
b. To an airborne corps.
small-sized supplies and cargo, mail or light commodities in one lift.
$e$. All capabilities are computed on a 75-percent availability of vehicles and all vehicles carrying rated capacity.
$f$. When organized for assignment to in airborne corps, the parachute pla. ©oon has the capability of being landed by parachute or aircraft. All per.onnel in this platoon are airborne qualified.
At full strength (level 1) this unit is capable of the following:
a. With all vehicles available, transporting in one lift 288 short tons of cargo.
b. In sustained operations, based on 75-percent vehicle availability, transporting 216 short tons of cargo or, when equipped with tank units, transporting 43,200 gallons of fuel 50 miles forward daily. of tanks and other heavy or bulky vehicles and to transport heavy, bulky, or outsized cargo.

To a division employed in regions where wheeled vehicles cannot operate as effectively. To a corps, field army, or logistical command, as required.

Transportation lightmedium truck company.

To provide truck transportation for the movement
To provide transportation for supply distribution in regions where wheeled vehicles cannot operate effectively.

Transportation heavy
truck company.

To provide transportation for the movement of general cargo and personnel by motor transport.

To a field army support command, corps support brigade, or a logistical command. Normally attached to a supply and service battalion, transportation general support

At full strength, operating two $10-$ hour shifts per day, with 18 tractor trucks and semitrailers available, this unit can:
a. For local hauls-transport 2,880 short tons of cargo or tanks or similar vehicles, averaging 40 tons per truck, four round trips daily.
b. For line hauls-transport 1,440 short tons of cargo or tanks or similar vehicles, averaging 40 tons per truck, two round trips daily.

Cargo Personnel
a. At full strength,
all vehicles available,
one-time lift .-.-...-.-... $360 \quad 1,700$
h. At full strength,

75 percent of vehicles available, one-time lift .- $276 \quad 1,300$
c. Local haul, 15

Transportation motor
55-87
transport company, armored or mechanized division supply and transport battalion.

Transportation motor transport company, supply and transport battalion, infantry division.

Transportation motor transport company, supply and transport battalion, airborne division.
a. To provide transportation for unit distribution of all classes of supply except class $V$.
b. To transport the division reserve supplies for which the unit is responsible.
c. To furnish vehicles required for displacing division headquarters and division administration company and to supplement means available to other elements of the division.
a. To provide transportation for unit distribution of all classes of supply except class $V$.
b. To transport the division reserve supplies for which the unit is responsible.
c. To furnish vehicles required for displacing division headquarters and the division administration company and to supplement means available to other elements of the division.
To provide transportation for unit distribution of all classes of supply except class $V$.
battalion, or transport battalion (DS).
miles forward, two shift operations, 75 to 80 percent of vehicles available, 4 trips cargo and 6 trips personnel .-1,104 7,800
d. Line haul, 75 miles forward, two shift operations, 75 to 80 percent of vehicles available, 2 trips daily ...... $552 \quad 2,600$

Organic to supply and transport battalion, armored division or infantry division (mechanized), TOE 29-65.

Organic to supply and transport battalion, infantry division, TOE 29-5.

Organic to supply and transport battalion, airborne division, TOE 2945.

At full strength (level 1) this unit has, based on 75 -percent vehicle availability, a capability of transporting:

|  | Single Lift | Shuttle |
| :--- | ---: | ---: |
|  | 270 | 360 |
| Cargo, short tons -- | 270 |  |
| POL, gallons --- - | 75,000 | 75,000 |

At full strength (level 1) based on 75-percent vehicle availability, transports in one lift:
a. 270 short tons of general cargo and 37,500 gallons of POL in one lift.
b. 120 short tons of unit impedimenta in shuttle service.
a. At full strength, based on 75percent vehicle availability, transports in one lift:
(1) 108 short tons of general cargo.
(2) 3,600 gallons of POL .

| Unit | TOE |
| :---: | :---: |
|  |  |
| Team GA, trailer trans- |  |
| fer point operations. |  |

## fer point operations.

Team GB, highway regu- 55-540 lating point.

To operate a trailer transfer point, marshalling yard or truck terminal in conjunction with linehaul operations.

To a transportation motor transport command or similar organization responsible for lines of communication (LOC) highway operations.

To operate highway regu- To a logistical command or lating to coordinate the movement of authorized traffic and to effect changes in truck or convoy routings.
b. At full strength, this unit is capable of providing transportation for two 10 -hour shifts during an around-the-clock operation.

Operates in conjunction with a linehaul operation, a trailer transfer point with a maximum capacity of 250 12-ton trailer units in and out per day. The operation includes receiving, segregating, and assembling loaded or empty semitrailers for convoys; maintaining POL dispersing facilities to refuel hauling equipment; and servicing, inspecting, and if required, making emergency repairs to incoming vehicles.

Performs the following on a 24 -hour-per-day basis:
a. Reports on convoys and other elements arriving at and clearing the point so that progress may be reported and recorded; adjusts their rate of advance as required.
b. Receives, correlates, and disseminates information on forecast or passing traffic; makes reports on current highway conditions and changes as they occur.
c. Transmits orders from higher headquarters to passing units or organizations and makes diversions and effects changes in priorities of traffic as directed by the appropriate traffic headquarters or comparable unit.
d. Receives and passes to appropriate agency requests for road clearance; checks clearances of passing units.

At 75-percent vehicle availability, provides the following transport for personnel and light cargo by motor vehicle:
$a$.When equipped with sedans, can

To transport passengers, messengers, and a limited amount of cargo by sedan or light truck.
field army. Normally attached to a headquarters and headquarters detachment, transportation motor transport group.

To headquarters and headquarters detachment, transportation motor transport battalion, TOE $55-16$, or may operate

Team GD, bus squad ..- 55-450

Team GE, heavy truck 55-450 squad

Team GF, light truck squad.

To transport cargo and personnel over poor roads or off road by light truck when use of heavier, more economical types of transport vehicles is impractical.

To transport personnel or litter patients by bus.
separately, under the supervision of an appropriate commander.

To headquarters and headquarters detachment, transportation motor transport battalion, TOE $55-16$, or may operate separately under the supervision of an appropriate commander.

To provide truck transportation for the movement of tanks and other heavy or bulky vehicles, and to transport heavy, bulky, and outsized cargo.

To headquarters and headquarters detachment, transportation motor transport battalion, TOE $55-16$, or may operate separately under the supervision of an appropriate commander.

To headquarters and headquarters detachment, transportation motor transport battalion, TOE $55-16$, or may operate separately under the supervision of an appropriate commander.
transport 30 personnel in one lift.
b. When equipped with $1 / 4$-ton trucks with trailers, can transport 22 personnel and 2 tons of baggage or small size supplies, or 4 tons of small size supplies and cargo, mail, or light commodities in one lift.

With 75-percent vehicle availability, provides transport for 166 passengers or 80 litter patients per lift.

At full strength operating two 10 hour shifts, with 75-percent vehicle availability, this team can transport the following:
a. For local hauls: 488 short tons of cargo or tanks or similar vehicles, averaging 40 tons per truck, four round trips daily.
b. For line hauls: 240 short tons of cargo or tanks or similar vehicles, averaging 40 tons per truck, two round trips daily.
$c$. Returning inoperative wheel and track vehicles by haulaway from forward areas to maintenance shops for repairs.
a. At full strength with 75 -percent vehicle availability, making four round trips per day in local hauls or two round trips per day (one per 10 -hour shift) in line hauls, this team can transport the following when equipped with $21 / 2$ ton trucks:
(1) For local hauls: 130 short tons of cargo ( 4 tons per truck) on highway, or 600 passengers ( 20 passengers per truck) on or off highway.
(2) For line hauls: 60 short tons of cargo ( 4 tons per truck) on highway, or 240 passengers ( 16 passengers per truck) on or off highway.
(3) 18.75 short tons of cargo ( $21 / 2$ tons per truck) in one lift off highway.
b. When equipped with 5 -ton trucks:
(1) Local hauls: 180 short tons of cargo ( 6 tons per truck) on high way or 600 passengers ( 20 passengers per truck) on or off highway.
(2) Line hauls: 90 short tons of cargo ( 6 tons per truck) on highway or 270 passengers ( 18 passengers per truck) on or off highway.
(3) In one lift off highway, 30 short tons of cargo (4 tons per truck).

To transport general cargo bulk petroleum products or refrigerated cargo by medium trucks and trailers.
Team GH, driveaway $\quad 55-540$
platoon. platoon.

Team GG, medium truck $55-540$ squad.

To headquarters and headquarters detachment, transportation motor transport battalion, TOE $55-16$, or may operate separately under the supervision of an appropriate commander.

With 75-percent vehicle availability at full strength with vehicles making four round trips daily in local hauls or two round trips per day in line hauls (two 10-hour shifts), this team can transport the following:
a. When equipped with 12 -ton cargo semitrailers:
(1) Local hauls: 360 short tons of cargo ( 12 tons per semitrailer) or, in an emergency only, 1,500 passengers ( 50 passengers per semitrailer).
(2) Line hauls: 180 short tons of cargo, or 750 troops.
$b$. When equipped with 5,000 -gallon petroleum semitrailers:
(1) Local hauls: 150,000 gallons.
(2) Line hauls: 75,000 gallons.
c. When equipped with $71 / 2$-ton refrigerator semitrailers carrying 6 tons per vehicle:
(1) Local hauls: 180 short tons.
(2) Line hauls: 90 short tons.
a. Moving 45 operable vehicles between forward and rear areas by driveaway. The numbers of vehicles can be increased by use of tow bars
$55-16$, or may operate separately under the supervision of an appropriate commander.
or by hauling smaller vehicles in cargo compartments of larger vehicles.
b. Providing transportation of general cargo to be delivered along the route of the driveaway operation.

## Section II. VEHICLES AND EQUIPMENT

## 3-2. Vehicle Characteristics



|  | Payload (lb) |  | Cargo bodyspace (cu ft) | Fuel tank capacity (gal.) | $\begin{gathered} \text { Cruising } \\ \text { range } \\ \text { (miles) } \end{gathered}$ | $\underset{\substack{\text { Fuel } \\ \text { consumption } \\ \text { (mpg) }}}{ }$ | Gradeability | Fording depth (in.) |  | Crankease capacity (qt) | $\begin{gathered} \text { Cooling } \\ \text { syotem cap. } \\ (q t) \end{gathered}$ | 3 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nomenclature | $\begin{aligned} & \text { highway } \\ & \text { off } \end{aligned}$ | $\begin{aligned} & \text { highway } \end{aligned}$ |  |  |  |  |  | Without kit | $\underset{k i t}{\text { With }}$ |  |  | un |
| Truck, tractor, $211 / 2$-ton, 6x6, M275 | 7,000 | 12,000 |  | 50 | 350 | 7 | 57.5 | 30 | 78 | 9 | 22 | $\cdots$ |
| Truck, tractor, 5-ton, 6x6, M52 | 15,000 | 25,000 |  | 110 | 300 | 3 | 77 | 30 | 78 | 22 | 44 |  |
| Truck, tractor, 10-ton, 6x6, M123, C and D | 30,000 | 35,000 |  | 166 | 300 | 1.8 | 60 | 30 | 78 | 22 | 66 |  |
| Truck, tractor, 12 -ton, 6x6, M26A1 |  | 60,000 |  | 120 | 120 | 1 | 30 | 56 | -. | 28 | 56 |  |
| Truck, van, shop, $21 / 2$-ton, 6x6, M109, A1, C and D. | 5,350 | 5,350 |  | 50 | 350 | 7 | 48 | 30 | 72 | 9 | 22 |  |
| Truck, van, shop, $211 / 2$-ton, $6 \times 6, \mathrm{M} 220, \mathrm{C}$ and D .- | 5,000 | 7,500 |  | 56 | 300 | 5.4 | 66 | 30 | 80 | $83 / 4$ | 22 |  |
| Truck, van, shop, $2 \frac{1}{2}$-ton, $6 \times 6, \mathrm{M} 512, \mathrm{C}, \mathrm{D}, \mathrm{E}$ and G |  | 5,350 |  | 50 | 300 | 6 | 60 | 30 | 72 | 9 | 22 |  |
| Truck, van expansible, $21 / 2$-ton, 6x6, M292 | 5,000 | 5,000 |  | 50 | 350 | 7 | 60 | 30 | 72 | 9 | 22 |  |
| Truck, wrecker, crane, $21 / 2$-ton, 6x6, M108 | 5,000 | 5,000 |  | 50 | 300 | 6 | 63 | 40 | 72 | 9 | 22 |  |
| Truck, wrecker, light, $21 / 2$-ton, $6 \times 6, \mathrm{M} 60$ | 6,000 | 10,000 |  | 50 | 300 | 6 | 63 | 40 | 72 | 9 | 22 |  |
| Truck, tractor, wrecker, 5-ton, 6x6, M246 | 12,000 | 16,000 |  | 78 | 229 | 4.4 | 47 | 30 | 78 | 22 | 42 |  |
| Truck, wrecker, med, 5-ton, 6x6, M62 | 7,000 | 12,000 |  | 78 | 214 | 2.7 | 36 | 30 | 78 | 18 | 44 |  |
| Truck, wrecker, med, 5-ton, 6x6, M543 | 7,000 | 12,000 | ---- | 133 | -- - | -- | 36 | 30 | 78 | 18 | 44 |  |

## 3-3. Typical Truck Equipment for Motor Transport Units

a. Basic Issue List Item. Equipment listed is typical but subject to change. For exact quantities the latest authorizations must be checked.
b. TOE Material. The issue of this material varies with each type truck. It includes flashlight, MX-991 U; and goggles, M-1944.
c. Special Material.
Chains, tire, pair
Extinguisher, fire, dry
chemical, $21 / 2-1 b$.

Kit, deepwater fording Kit, winterization

As required by local weather conditions.

As authorized by AR 38555
When authorized by theater of operations commander.

## Section III. OPERATIONS

## 3-4. Outline of Standing Operating Procedure for Motor Transport Movements (Within Divisions, Logistical Commands, or Higher Echelons)

a. General. Policies and factors involved in movements are-
(1) Highway regulation. Purpose, application or scope, responsibilities, methods and procedures for accomplishment.
(2) Convoy clearance. Minimum vehicle requirements, convoy symbols, procedures, format for requesting and furnishing clearance, routing, halts, convoy composition, restrictions on tracked, overweight, or outsized vehicles.
(3) Highway regulation points. Purpose, basis of establishment, responsibilities and procedures for operations, required records.
(4) Traffic control. Responsibilities, relationship to highway regulation, coordination measures effected with provost marshal.
(5) Return loads. Policies, methods, and procedures for securing and reporting.
(6) Convoy commanders. Appointment,
responsibilities, and functions; relationships with transportation personnel; instructions to be furnished.
(7) Halts. Types, policies, procedures, and responsibilities for establishment and conduct of halts; area policing.
(8) Security. Responsibilities and methods of conducting defensive measures.
(9) Records and reports. Responsibilities and methods for maintenance of required records, reference to reports to be submitted.
(10) Communications. Responsibilities and means of communication.

## b. Supply Movements.

(1) Releases. When required, methods of obtaining, formats, dissemination, actions required.
(2) Diversions and reconsignments. Authority to effect diversions with consideration for various command areas, procedures for initiating requests, and execution.
(3) Records and reports. Types of records required to be maintained on supply movements, reference to reports to be submitted.


Figure 3-1. Traffic circulation plan.

## 3-5. Outline of Standing Operating Procedure for Motor Transport Service

a. General. Policies involved in control, operation, and maintenance of facilities, equipment, and installation; command responsibility; technical supervision required and agencies involved.
b. Mission. Service provided, extent of operation.
c. Functions.
(1) Scheduled and nonscheduled operations.
(2) Maintenance of equipment-responsibilities, procedures, facilities, and inspection practices.
d. Operational Planning. Computation of troop and equipment requirements, capability estimate, communication procedure and requirements, rehabilitation requirements.


COMPANY AREA: . 0959 SQ MILES OR 61.4 ACRES COMPANY FRONT: 1,900 YD ( 1,737 METERS) PLATOON FRONT: 630 YD (576 METERS) CP AREA: 75 YD ( 69 METERS) RADIUS

Figure 3-2. Schematic diagram, typical bivouac arear, light truck company-passive defense emphasized.
e. Operations. Operational procedures and controls, pooling and utilization of equipment.
f. Maintenance. Responsibilities and procedures for maintenance, regulations, and reports.
g. Supply Procedure. Responsibilities for supplies, authorized levels, requisitioning procedures, accounting methods, disposal of excesses.
h. Intelligence and Reconnaissance. Responsibility for collection, collation, evaluation, and dissemination of highway transportation intelligence and reconnaissance information.
i. Security. Responsibilities, plans-disaster and defense, convoy and cargo security, equipment and facilities.
j. Records and Reports. Responsibility, operational and personnel status reports, technical reports, miscellaneous.
k. Training. Responsibility-unit and technical training.

## 3-6. Vehicle Commitment Format

Routine commitment of vehicles requires the type of information outlined below. Those items not required for a particular unit should be eliminated. For nonroutine commitment and commitment of an entire unit for a substantial period of time, consideration should be given to the use of the five-paragraph operation order (FM 101-5).
a. Heading. The headquarters receiving the commitment, its location, and the date and hour of receipt.
b. Task (or Request).
(1) Request number
(2) Received from
(name \& rank) (org) (phone)
(3) To transport

Cube (tons) (type of cargo) (No. pers)
From $\qquad$ To
(shape, etc.)
(4) Recommended number and type of vehicles
(5) Terminal capabilities.

Origin $\qquad$ Est load time $\qquad$ Destination $\qquad$
Est unload time
(6) Vehicles report to:

> (name, rank, title)

Location $\qquad$ Phone
Time and date: Spot $\qquad$ Move $\qquad$
(7) On arrival at destination, report to: $\longrightarrow$, location $\qquad$
(name, rank, title)
c. Coordinating Instructions.
(1) Type of commitment:

One-time: $\qquad$
Recurring: $\qquad$
If recurring, from
through
(2) Road information:
(special routing, weather
effects, limitations, etc.)
(3) Shipment (has) (has not) been coordinated with consignor and con-
signee, regarding (refer to paragraph numbers above, or enter special information).
(4) It (is) (is not) an emergency movement. If emergency, authorized by
(name, rank, title, org)
Phone $\qquad$ .
(5) Trailer pickup, movement, and delivery schedule.
(Spot) (Pick up) trailers at origin at

to
By date-time $\qquad$
Move trailer from $\qquad$
to
By date-time $\qquad$
Deliver trailers to destination for (unloading) (return loading) (return) at (date-time)
d. Administrative and Logistical Matters.
(1) Class III: (available origin) available destination) (unit provide own).
(2) Meals and billets: (available origin) (available destination) (not available).
(3) Remarks: $\qquad$ .
e. Command and Signal.
(1) Reports required: $\qquad$
(2) Highway clearance requested
(date-time)
$\qquad$ received $\xrightarrow[\text { (date-time) }]{ }$, clearance number $\qquad$
(3) Special instructions:

## 3-7. Traffic Circulation Plans

(fig. 3-1).
a. Traffic circulation plans (maps) are used to indicate a road net system of routes and to give necessary information and pertinent traffic restrictions.
b. The circulation plan establishes one-way, two-way, and alternating routes of traffic flow. Care must be taken to insure that routes are available for a circuitous flow in the required directions. A one-way route normally requires
2. IIE Hail dispath poikt
2. INCOMING TRAILER PARK AND INSPECTION AREA
3. POL AREA AND TRACTOR INSPECTION AREA
4. MAINTENANCE AREA
5. BIVOUAC AREA FOR TERMINAL PERSONNEL
6. LOCAL TRACTOR READY IINE
7. mess and administrative AREA
8. LOCAL HAUL DISPATCH POINT
9. LINE HAUL READY LINE
10. BIYOUAC AREA FOR LINE haUl DRIVERS
11. marshaling yard

tO DESTINATION TERMINAL

1. LINE HAUL DISPATCH POINT

c. Traffic circulation plans show the road net that is planned to be used and maintained and how it will be used. Normally it contains route designations and the most restrictive route features; direction of movement; location of boundaries, units, highway regulation points, traffic control posts, and principal supply activities; major geographic features; and light lines, if applicable.
d. Circulation plans frequently consist of a standard map and an overlay which together give the needed information. If the necessary information is too much to put on one overlay, separate overlays may be used to show different types of information. The sketch in figure 3-1 is one example of a traffic circulation plan. When making a traffic circulation plan, the planner or operator must be guided by what information is required by users of the plan.

## 3-9. Rivouac Defense, Truck Company

a. Standard Pattern. Company standing operating procedure (SOP) gives a standard pattern that can be modified to suit the situation and terrain. This SOP should contain the sound or visual signals communication plan. Upon arriving at the bivouac site, each platoon takes its predetermined position in the perimeter without orders. Company headquarters and the maintenance section occupy the center as a reserve. Figure 3-2 shows typical temporary bivouac areas for a light truck company.
b. Conduct of Defense. The unit commander places on the perimeter the minimum number of men required to maintain reasonable security. The number of men on the perimeter depends upon the probability of attack by regular troops or guerrillas, upon the terrain and weather-including visibility, and upon the number of men available. The unit commander keeps himself informed on the nearness and activity of enemy forces. He gains this information from his next higher headquarters, from the unit he is supporting or to which he is attached, and/or from friendly adjacent troops. When ground attack is imminent, men occupy the two-man foxholes. If required, one man stays alert while the other man sleeps.

Each squad is given a sector. The squad leader and assistant squad leader occupy positions in rear of the squad. At all times the platoon leader and the squad leaders must know exactly where their men are and be prepared to alert them immediately.
c. Trucks. Trucks may be dispersed individually or in small groups, with about 100 yards ( 91 m ) between trucks or groups. Trucks are camouflaged and parked fa-ing the nearest exit road.
d. Mines and Flares. If available and authorized, a protective minefield consisting of fragmentation-type antipersonnel mines and trip flares is placed around the outer rim of the perimeter about 200 yards ( 183 m ) in. front of the foxholes and machinegun emplacements (FM 20-32). One trailer in each platoon may carry numbered mines. These are placed in a standard sequence in every bivouac -mine No. 1 at 12 o'clock, then clockwise. The protective minefield can be installed quickly, and all mines can be located promptly and recovered when bivouac is cleared. Each minefield will be recorded and reported in accordance with the provisions of chapter 6, FM 20-32.
e. Grenade Launchers and Machineguns. Grenade launchers are used to protect areas most likely or suitable for enemy mechanized attack. Machineguns are placed to secure interlocking fires on the perimeter.
f. Passive Defense. The unit commander must continuously stress passive defense measures. All personnel should construct foxholes with adequate overhead cover immediately after occupying a bivouac area. Exposed personnel, even in rear areas, should be limited to the minimum number required to provide security and perform other necessary duties in the bivouac area.

## 3-8. Bivouac Defense, Truck Company

Figure 3-3 shows a typical origin truck terminal. Arrangement of facilities may deviate from the illustration, but the facilities indicated should be considered the minimum necessary for effective operation of the terminal.


Figure 3-4. Example of route reconnaissance overlay.

## 3-10. Route Reconnaissance

a. Route Reconnaissance Overlay. Information obtained by either a hasty or a deliberate reconnaissance can be conveyed to interested personnel on a route reconnaissance overlay. The route reconnaissance overlay is an accurate and concise report of the conditions affecting traffic flow along a specified route and is the preferred method of preparing a route reconnaissance report. An overlay normally satisfies the requirements of hasty route reconnaissance. If, however, more detail is required to support the reconnaissance, the overlay is supplemented with written reports describing critical route characteristics in more detail. For additional information, see FM 5-36. An example of a route reconnaissance overlay is shown in figure 3-4.
b. Route Reconnaissance Checklist. To insure that critical terrain data during route reconnaissance are not overlooked and to aid in the preparation of reconnaissance reports, a checklist based on the characteristics of the area of operations is recommended. The fol-
c. Route Reconnaissance Symbols.
lowing items should be considered in preparing reconnaissance reports:
(1) Identification and location of the reconnoitered route.
(2) Distances between points easily recognized both on the ground and on the map.
(3) Percent of slope and length of grades which are 7 percent or greater.
(4) Sharp curves whose radii are 100 feet ( 30 m ) or less.
(5) Bridge military load classifications and limiting dimensions, and suitable bypasses.
(6) Locations and limiting data of fords and ferries.
(7) Route restrictions, such as underpasses, which are below minimum standard and, if appropriate, the distances such restrictions extend.
(8) Locations and limiting dimensions of tunnels, suitable bypasses.
(9) Suitable areas for short halts and bivouacs which offer drive-off facilities, adequate dispersion, cover, and concealment.
(10) Areas of rockfalls and rockslides which may present a traffic hazard.

| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Civil or military route designation |  | Designation written in parenthesis along route. | $\begin{aligned} & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Critical point |  | To be numbered and described in legend. Critical points may be used to point out festures not sdequately covered in other reconnsissance symbols. | $\begin{aligned} & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Limits of sector |  | Limits of reconnoitered sector of route. | $\begin{aligned} & \text { STANAG } 2253 \\ & \text { SOLOG } 95 \end{aligned}$ |
| Route classification formalas | $10.5 \mathrm{~m} \times 120$ 6 mz 8 (OB) 9 m Y 20(OB) W | Expressed in order of: width, type, military load classification, obstructions, if present, and regular flooding or snow blockage: <br> X - all-weather route <br> Y - sll-weather route (limited traffic) <br> Z - fair weather route <br> T - regular snow blocksge <br> W - regular flooding | $\begin{aligned} & \text { FM } 5-36 \\ & \quad(\mathrm{sec} . \text { I, } \\ & \text { ch 2) } \\ & \text { STANAG } 2015 \\ & \text { SOLOG } 53 \end{aligned}$ |


| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Gradea |  | Arrows point in uphill direction; to the right of symbol is shown the actual percent of alope; length of arrow represents length of grade if map scale permits. | $\begin{aligned} & \text { FM 5-36 } \\ & \text { (sec. III, } \\ & \text { ch 2) } \\ & \text { STANAG } 2253 \\ & \text { SOOG } 96 \end{aligned}$ |
| Sharp curves |  | Vertex of triangle points to map location of curve. Radius in feet or meters is inscribed within symbol. | $\begin{aligned} & \text { FM } 5-36 \\ & \text { (sec, II, } \\ & \text { ch 2) } \\ & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Full bridge symbol |  | Arrow extenda to map location of bridge; minimum width is placed below, overhead clearance to the left, and overall length to the right of basic aymbol. Lower portion of symbol indicates bridge serial number; upper portion, military load clasaification data. Underlined values are those below minimum standard. | $\begin{aligned} & \text { FM } 5-36 \\ & \text { (aec. VII, } \\ & \text { ch 2) } \\ & \text { DA FOrm } 1295 \\ & \text { STANAG } 2096 \\ & \text { STANAG } 2252 \\ & \text { SOLOG } 94 \\ & \text { SOLOG } 107 \end{aligned}$ |


| Explanation | Symbo: | Remarka | Reference |
| :---: | :---: | :---: | :---: |
| Abbreviated bridge symbol |  | Arrow extends to map location of bridge. Lower portion of symbol indicates bridge serisl number; upper portion, military load classification for single flow traffic; asterisk denotes other classifications to be found in accompanying inclosure. | FM $5-36$(sec. <br> ch 2 )DA Form 1249STANAG 2096STANG 2252SOLOG 94SOLOG 107 |
| Bypass easy |  | Used in confunction with bridge and tunnel reconnsissance symbols. |  |
| Bypass difficult |  | Used in confunction with bridge and tunne 1 reconnaissance symbols. | $\begin{aligned} & \text { FM } \begin{array}{l} 5-36 \\ \text { (sec. } \\ \text { ch } 2 \text { ) } \end{array} \\ & \text { SIII, } \\ & \text { STANAG } 2252 \\ & \text { SOLAG } 2253 \\ & \text { SOLG } 96 \end{aligned}$ |

FM 55-15

| Explanation | Symbol | Remarka | Reference |
| :---: | :---: | :---: | :---: |
| Bypass impossible |  | Used in conjunction with bridge and tunnel reconnaissance symbols. | $\begin{aligned} & \text { FM } 5-36 \\ & \text { (sec. VII, } \\ & \text { ch 2) } \\ & \text { STANAG } 2252 \\ & \text { STANAG } 2253 \\ & \text { SOLOG } 94 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Ford |  | Arrow extends to ford location. Data above the lines expressed in order of serial number, ford type, stream velocity in meters per second, and seaaonal limitations. <br> Data below the line expressed in order of length, width, bottom type and depth. Question marks indicate unknown information. Difficult approaches are represented by zigzsg lines corresponding in position to shore where approach is located. <br> Ford type <br> A-vehicular <br> P-foot <br> D-deepwater, tank <br> S-swimming vehicles <br> Seasonal variations <br> $X$-none <br> Y-significant | ```FM 5-36 (sec. V, ch 2) DA Form 1251 STANAG }227 STANAG }209 SOLOG }10``` |


| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Ford (Cont) |  | Bottom type $\begin{aligned} & \text { M-mad } \\ & \text { C-clay } \\ & \text { S-sand } \\ & \text { G-gravel } \\ & \text { R-rock } \\ & \text { P-artificial paving } \end{aligned}$ |  |
| Ferry |  | Arrow extenda to map location. Data above symbol is expressed in order of ferry serial number and ferry type. Data inside aymbol sre expressed in order of military load clsssification and dead weight capacity; data below symbol are expressed in order of turnaround time snd width and length of cargo apace. Question mark indicatea unknown information. Difficult spproaches are represented by zigzag lines corresponding in position to shore where spproach is located. <br> Ferry type <br> AF-vehicular <br> PF-foot <br> 2F-military | ```FM 5-36 (sec. V, ch 2) DA Form 1252 STANAG }209 STANAG }227 SOLOG }10``` |

FM 55-15

| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Width constriction | $3 m$ | Route constriction in width; width expressed in feet or meters of usable traveled way in triangle corresponding to the side of traveled way in which the constriction occurs. | $\begin{aligned} & \text { FM } \begin{array}{l} 5-36 \\ \text { (sec. } \\ \text { ch } 2) \end{array} \\ & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Arch constriction |  | Width expressed in meters or feet to right of symbol, overhead clearance to left. | ```FM 5-36 (sec. V, ch 2) STANAG 2253 SOLOG 96``` |
| Rectangular construction with sidewalks |  | Width of traveled way followed by total width including sidewalk expressed in feet or meters to right of symbol, overhead clearance to left. | ```FM 5-36 (sec. IV, ch 2) STANAG 2253``` |
| Tunnel with sidewalks |  | Arrow extends to map location. Serial number is placed inside the symbol. The width of the traveled way followed by total width including sidewalks in meters or feet is placed below the symbol. Underlined widths indicate reduction of widths below that of the outside route. | $\begin{aligned} & \text { FM } \begin{array}{l} 5-36 \\ \text { (sec. } \end{array} \text { IV, } \\ & \text { ch 2) } \\ & \text { DA Form } 1250 \\ & \text { STANAG } 2096 \\ & \text { STANG } 2274 \\ & \text { SOLOG } 107 \end{aligned}$ |


| Explanation | Symbol | Remarks | Reference |
| :---: | :---: | :---: | :---: |
| Tunnel with sidewalks (Cont) |  | Overhead clearance is placed to the left of the symbol and total tunnel length to the right. A question mark represents unknown information. Bypasses are shown by standard symbol notations |  |
| RR grade crossing |  | Level crossing; passing trains will interrupt traffic flow. | STANAG 2253 SOLOG 96 |
| Concealment |  | Route lined with trees; deciduous trees (left) and evergreen (right). | $\begin{aligned} & \text { STANAG } 2253 \\ & \text { SOLOG } 96 \end{aligned}$ |
| Concealment and vehicular turnoff |  | Arrow denotes possibility of driving off route for concealment in a mixed forest stand. | STANAG 2253 <br> SOLOG 96 |
| Roadblock, craters, and blown bridges <br> a. Proposed <br> b. Prepared but passable <br> c. Completed |  | Center of the symbol indicates position of block. | FM 21-30 STANAG 2019 SOLOG 28 |



## 3-11. Route Classification

For the purpose of classification, routes are designated by their ability to withstand the effects of weather. Route type is determined by the worst section of the route. Routes as classified by types are-
a. Type $X$. All-weather route is any route which, with reasonable maintenance, is passable throughout the year to traffic never appreciably less than maximum capacity. The roads which form this type of route normally have waterproof surfaces and are only slightly affected by precipitation or temperature fluctuations. At no time is the route closed to traffic by weather effects other than temporary snow or flood blockage.
b. Type Y. All-weather route (limited traffic due to weather) is any route which, with reasonable maintenance, can be kept open in all
weather but sometimes only to traffic considerably less than maximum capacity. The roads which form this type of route usually do not have waterproof surfaces and are considerably affected by precipitation or temperature fluctuations. Traffic may be completely halted for short periods. Heavy unrestricted use during adverse weather may cause complete collapse of the surface.
c. Type Z. Fair weather route is any route which quickly becomes impassable in adverse weather and cannot be kept open by maintenance short of major construction. This category of route is so seriously affected by weather that traffic may be brought to a halt for long periods.

## 3-1.2. Military Load Classification

The military load classification system is a load capacity rating system which considers a


Figure 3-5. Typical bridge-class and information signs.


Figure 3-6. Typical dual-class bridge signs.
vehicles' weight and type and its effect on routes and bridges. The classification system is represented by whole numbers assigned to vehicles, bridges, and routes. (For detailed discussion, see FM 5-36.) Most allied military vehicles are externally marked with their respective classification number. Bridges and routes are assigned military load classification based on their safe load capacity and physical dimensions.
a. Route Classification. Normally, the lowest
bridge military load classification number regardless of vehicle type or conditions of traffic flow determines the military load classification of a route. By selecting the lowest bridge classification number, it is assured that the route is not overloaded. In those cases where vehicles bear a higher military load classification than the route, the route reconnaissance overlay is checked or a special reconnaissance is initiated to determine if a change in traffic control procedures, such as a single-flow crossing, may permit use of the route by heavier traffic. If no bridge is located on the route or if roads are particularly bad, the worst section of road governs the route's classification.
b. Obstructions to Traffic Flow. Route obstructions are factors which restrict the type and amount or speed of traffic flow. Route obstructions, with the exception of bridge capacities, which are reported separately as a military load classification, are indicated in the route classification formula (para 3-13) by the abbreviation OB. Moreover, reconnaissance symbols are used to describe the nature of each obstruction on the route reconnaissance overlay. Obstructions to be reported include-
(1) Overhead obstructions such as bridges, tunnels, underpasses, overhead wires,


Figure 3-7. Typical arrangement of road-guide, information, and two-lane bridge-class signs.
and overhanging buildings whose overhead clearance is less than 14 feet ( 4.25 m ).
(2) Reduction in traveled way widths which are below standard minimums prescribed for the type of traffic flow (single or double, wheeled or tracked, see FM 5-36). Examples are bridges, tunnels, craters, lanes through mined areas, and projecting buildings or rubble.
(3) Gradients (slopes) of 7 percent or greater.
(4) Curves whose radii of curvature are less than 100 feet ( 30 m ).
(5) Ferries.
(6) Fords.

## 3-13. Route Classification Formula

The route classification formula is developed from notations expressed in the standardized sequence of minimum traveled way width, route type, lowest military load classification, and obstruction(s) if present. The formula briefly describes a specific route and is used together with a route reconnaissance overlay.

If an obstruction(s) appears in the route classification formula, it is necessary to refer to the route reconnaissance overlay in order to determine the exact nature and location of the obstruction(s). Illustrative formulas are shown in a through $d$ below.
a. 20 Ft $Z$ 10. This example formula describes a fair-weather route with a minimum traveled way of 20 feet and a military load classification of 10 . This route, based on its minimum width of traveled way accommodates both wheeled and tracked, single-flow traffic without obstruction. Minimum route widths, according to STANAG 2151, for wheeled and tracked vehicles in single and double flow traffic are tabulated below.

| fow | Traffic possibilities | Route Widths (STANAG Widths for wheeled vehicles | 51) <br> Widths for tracked vehicles |
| :---: | :---: | :---: | :---: |
| Single | flow | $\begin{aligned} & -18 \text { to } 3 \text { feet }(5.5 \\ & \text { to } 7 \mathrm{~m}) . \end{aligned}$ | $\begin{aligned} & 19.5 \text { to } 26 \text { feet }(6 \\ & \text { to } 8 \mathrm{~m} \text { ). } \end{aligned}$ |
| Double | flow | $\text { Over } 23 \text { feet }$ $(7 \mathrm{~m}) .$ | Over 26 feet ( 8 m ). |

b. $20 \mathrm{Ft} \mathrm{Z} 10(\mathrm{OB})$. This example formula describes a route with similar characteristics


Figure 3-8. Typical arrangement of road-guide, information, and single-lane bridge-class signs.
as in a above, but with obstruction(s). It should be noted that 20 feet of traveled way limits this route to single-flow traffic without a width obstruction. If the route is to be used for double-flow traffic, however, 20 feet of traveled way constitutes an obstruction and is indicated in the formula both as a minimum traveled way width ( 20 ft ) and as an obstruction.
c. $7 \mathrm{~m} Y 50(O B)$. This example formula describes a limited all-weather route with a minimum traveled way width of 7 meters and a military load classification of 50 with obstruction(s). The traveled way width of this route is adequate for wheeled, but not tracked, vehicles in double-flow traffic. Therefore, this width constriction would be indicated as (OB) in the route classification formula if the route were to be used for both types of vehicles.
d. $10.5 \times 120(O B)$. This example formula describes an all-weather route with a minimum traveled way width of 10.5 meters, which
is suitable for double-flow traffic of both wheeled and tracked vehicles, a military load classification of 120 with obstruction(s).

## 3-14. Bridge Signs

a. Circular Signs (figs. 3-5 and 3-6). These are placed at bridges to indicate the bridge classification. The signs have a yellow background; the bridge classification and appropriate symbol are in black.
b. Rectangular Signs (figs. 3-7 and 3-8). These signs give additional instructions and technical information. Minimum size is 16 inches high or wide. They have a yellow background and black symbols and lettering.

## 3-15. Bridge and Vehicle Weight Classification

a. Posting Bridges. Every military bridge is posted with a number indicating the highest vehicle weight class that can cross safely. Vehicles of higher weight class are barred except for special crossings. Fixed bridges may also


Figure 3-9. Vehicle weight classification marking.
be marked with the length in feet of the span to which the posted capacity applies.
b. Marking Vehicles. Self-propelled vehicles in class 3 or higher and towed vehicles in class 1 or higher are marked to indicate the class, except that prime movers are marked with either their own class or the class of the nor-
mal combination of prime mover and trailer or semitrailer. Markings on the front of the trucks should be on the right front, on or above the bumper, but below the driver's vision. Examples of vehicle markings are shown in figure 3-9.
c. Military Load Classification List. The symbols found in the heading of the listing are defined below:

E-Weight or class of vehicle without payload
C-Weight or class of vehicle combat loaded or with rated maximum crosscountry payload
H -Weight or class of vehicle combat loaded with rated maximum highway payload
The weight classification number to be posted on vehicles will be assigned from the number listed under "C" subcolumn of the class column. This number is taken from the normal design load of the vehicle. Where no number appears in the " $C$ " column, take the number appearing in the " H " column, and if both of these columns are blank take the number from the " $E$ " column.

| Vehicle description |  | Weight <br> hart ton |  |  | Cla |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |
|  | $E$ | C | H | E | c | H |
| TRACKED VEHICLES |  |  |  |  |  |  |
| Bulldozer, earthmoving, M4, tank-mtd (light tank M24) | 20.70 | 22.05 | 22.05 | 20 | 22 | 22 |
| Bulldozer, earthmoving, M6, tank-mtd (tank, combat, 90 mm gun M47). | 40.50 | 51.60 | 51.60 | 0 | 3 | 53 |
| Bulldozer, earthmoving, M8 (tank, combat, 90 mm gun M48) | 52.89 | 57.39 | 57.39 | 52 | 60 | 60 |
| Bulldozer, earthmoving, tank-mtd, M9 (tank, combat, 105 mm gun, M60 and M60A1). | 52.94 | 54.74 | 54.74 | 50 | 52 | 52 |
| Bulldozer, earthmoving, tractor-mtd, M5 (tractor, high-speed, M8A2). | 24.25 | 33.50 | 33.50 | 23 | 32 | 32 |
| Carrier, cargo, amphibious, M76 | 4.16 | 6.02 | 6.02 | 4 | 6 | 6 |
| Carrier, cargo, amphibious, tracked, M116 | 3.94 | 5.44 | 5.44 | 4 | 5 | 5 |
| Carrier, cargo, tracked, 6-ton, XM548E1 | 8.00 | 14.00 | 14.00 | 7 | 13 | 13 |
| Carrier, command post, light-tracked, XM577 | 11.40 | 11.95 | 11.95 | 11 | 11 | 11 |
| Carrier, personnel, full-tracked, armored, M59 | 19.75 | 21.30 | 21.30 | 18 | 19 | 19 |
| Carrier, personnel, full-tracked, armored, M75 | 18.34 | 20.75 | 20.75 | 17 | 20 | 20 |
| Carrier, personnel, full-tracked, armored, M113 | 11.71 | 11.95 | 11.95 | 9 | 9 | 9 |
| Carrier, personnel, full-tracked, armored, M114A1 | 6.45 | 7.37 | 7.37 | 7 | 7 | 7 |
| Flamethrower, self-propelled, M132 |  | 11.46 | 11.46 |  | 9 | 9 |
| Gun, antiaircraft artillery, self-propelled, twin $40 \mathrm{~mm}, \mathrm{M} 42$ and M42A1. | 22.15 | 24.90 | 24.90 | 20 | 23 | 23 |
| Gun, antiaircraft, artillery, self-propelled, twin 40 mm , M19A1 | 16.88 | 19.25 | 24.90 19.25 | 16 | 18 | 18 |
| Gun, antitank, self-propelled, 90 mm , M56 | 6.25 | 7.87 | 7.87 | 6 | 8 | 8 |

## Vehicle description

| Vehicle description | Short tona |  |  |  | Loaded |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Loaded |  |  |  |  |  |
|  | $E$ | c | H | E | C | H |
| Gun, field artillery, self-propelled, 155 mm , M53 | 44.50 | 48.00 | 48.00 | 42 | 46 | 46 |
| Gun, field artillery, self-propelled, 175mm, M107 | 28.80 | 31.05 | 31.05 | 29 | 29 | 29 |
| Howitzer, heavy, self-propelled, full-tracked, 8-inch; M55 | 45.00 | 49.00 | 49.00 | 41 | 46 | 46 |
| Howitzer, heavy, self-propelled, 8-inch, M110 | 26.80 | 29.25 | 29.25 | 27 | 27 | 27 |
| Howitzer, light, self-propelled, full-tracked, 105mm, M37 | 19.32 | 23.00 | 23.00 | 18 | 22 | 22 |
| Howitzer, light, self-propelled, full-tracked, 105 mm , M52 and M5A1. | 24.90 | 26.50 | 26.50 | 23 | 25 | 25 |
| Howitzer, light, self-propelled, 105 mm , M108 | 18.00 | 23.11 | 23.11 | 20 | 20 | 20 |
| Howitzer, medium, self-propelled, full-tracked, 155 mm , M44 and M44A1. | 29.00 | 32.00 | 32.00 | 27 | 30 | 30 |
| Howitzer, medium, self-propelled, 155mm, M109 | 21.75 | 26.23 | 26.23 | 24 | 24 | 24 |
| Landing vehicle, tracked, command, M5 (LVTP5A1 (CMD)) | 32.1 | 36.23 | 36.23 | 28 | 36 | 36 |
| Landing vehicle, tracked, engineer, M1 (LVTE1) .-. | 41.37 | 48.75 | 48.75 | 37 | 46 | 46 |
| Landing vehicle, tracked, howitzer, M6 (LVTH6A1) | 37.10 | 43.30 | 43.30 | 33 | 40 | 40 |
| Landing vehicle, tracked, personnel, M5 (LVTP5A1) | 32.1 | 43.89 | 43.89 | 28 | 40 | 40 |
| Landing vehicle, tracked, recovery, M1 (LVTR1A1) | 37.51 | 41.10 | 41.10 | 33 | 37 | 37 |
| Landing vehicle, tracked, armored, MK4 | 17.72 | 20.00 | 20.00 | 15 | 18 | 18 |
| Landing vehicle, tracked, MK4 | 13.70 | 18.20 | 18.20 | 12 | 16 | 16 |
| Launcher, M48A2 tank chassis, transporting |  | 49.29 | 49.29 | - - | 50 | 50 |
| Launcher, M48A2 tank chassis, transporting, with bridge armored ver,icle launched, scissoring type, Class 60. |  | 64.4 | 64.4 |  | 64 | 64 |
| Launcher, M60 chassis, transporting |  | 41.0 | 41.0 | -- | 38 | 38 |
| Launcher, M60 chassis, transporting, with bridge armored vehicle launched, scissoring type, Class 60. |  | 50.6 | 50.6 | -- | 54 | 54 |
| Mortar, infantry, self-propelled, full-tracked, 107 mm (4.2 inch) M84. | 20.56 | 23.55 | 23.55 | 19 | 22 | 22 |
| Recovery vehicle, full-tracked, heavy, M51 | 56.25 | 60.00 | 60.00 | 54 | 58 | 58 |
| Recovery vehicle, full-tracked, medium, M74 | 44.30 | 46.87 | 46.87 | 51 | 54 | 54 |
| Recovery vehicle, full-tracked, medium, M88 | 54.00 | 56.00 | 56.00 | 53 | 55 | 55 |
| Recovery vehicle, full-tracked, light, armored, M578 | 23.5 | 27.00 | 27.00 | 25 | 25 | 25 |
| Rifle, self-propelled, full-tracked, multiple, 106 mm , M50 | 8.22 | 9.52 | 9.52 | 8 | 9 | 9 |
| Tank, combat, light, 75 mm gun, M24 | 18.90 | 20.25 | 20.25 | 18 | 19 | 19 |
| Tank, combat, full-tracked, 76 mm , M41, M41A1, M41A2, and M41A3. | 22.35 | 25.90 | 25.90 | 21 | 25 | 25 |
| Tank, combat, full-tracked, medium, 90mm gun, M46 and M46A1 - | 46.40 | 48.50 | 48.50 | 45 | 48 | 48 |
| Tank, combat, full-tracked, 90 mm gun, M47 | 46.50 | 48.50 | 48.50 | 45 | 48 | 48 |
| Tank, combat, full-tracked, 90 mm gun, M48 and M48C | 46.56 | 49.50 | 49.50 | 46 | 50 | 50 |
| Tank, combat, full-tracked, 90 mm gun, M48A1, M48A2, and M48A2C. | 48.50 | 52.00 | 52.00 | 46 | 52 | 52 |
| Tank, combat, full-tracked, 105mm gun, M60 and.M60A1 | 47.65 | 52.50 | 52.50 | 45 | 50 | 50 |
| Tank, combat, full-tracked, 120mm gun, M103 and M103A1 | 58.50 | 62.50 | 62.50 | 57 | 61 | 61 |
| Tank, combat, full-tracked, flamethrower, M67A1 | 50.48 | 52.89 | 52.89 | 51 | 51 | 51 |
| Tractor, full-tracked, high-speed, 13-ton, M5, M5A1, M5A2, and M5A4. | 12.60 | 15.17 | 15.17 | 12 | 14 | 14 |
| Tractor, full-tracked, high-speed, 18 -ton, M4, M4A1, M4A1C, M4A2 and M4C. | 13.56 | 15.70 | 15.70 | 13 | 15 | 15 |
| Tractor, full-tracked, high-speed, M8A1 and M8A2 | 22.25 | 31.50 | 31.50 | 21 | 30 | 30 |
| Tractor, full-tracked, high-speed, 38-ton, M6 | 34.30 | 38.00 | 38.00 | 32 | 37 | 37 |
| Vehicle, combat engineer, full-tracked, T118E1 ---------------- | 50.45 | 57.5 | 57.5 | 54 | 57 | 57 |
| HALF-TRACKED VEHICLES |  |  |  |  |  |  |
| Car, half-track, M2A1 |  | 9.80 | 9.80 | -- | 9 | 9 |
| Carriage, motor, multiple gun, M16 | ---- | 10.82 | 10.82 | -- | 10 | 10 |
| Carrier, 81mm mortar, half-track, M21 |  | 10.00 | 10.00 | -- | 9 | 9 |
| Carrier, personnel, half-track, M3 and M3A1 |  | 10.25 | 10.25 | -- | 9 | 9 |


| Vehicle description | Weight <br> (short tons) |  |  |  | Class |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Loaded |  |  |  | Loaded |  |
|  | E | c | H | E | $c$ | H |
| WHEELED VEHICLES |  |  |  |  |  |  |
| Ambulance, metropolitan, 4-litter, 3/4 ton | 2.70 | ---- | 3.52 | 3 | -- | 4 |
| Bus, ambulance, 18-litter, 4x2 | 9.04 | ---- | 10.79 | 8 |  | 9 |
| Bus, 29-passenger, 4x2 | 5.25 | --- | 7.75 | 5 |  | 8 |
| Bus, 37-passenger, 4x2 | 7.60 | ---- | 11.95 | 7 |  | 12 |
| Bridge, float, mobile assault amphibious (French) | -- - - | 26.50 | 26.50 | - | 25 | 25 |
| Car, armored, light, 6x6, M8 |  | 8.25 | 8.25 |  | 8 | 8 |
| Car, armored, type V-100 (commando) | 6.80 | 8.13 | 8.13 | 7 | 8 | 8 |
| Car, armored, utility, M20 |  | 7.83 | 7.83 |  | 7 | 7 |
| Chassis, truck, $21 / 2$-ton, 6x6, M44 and M44C | 5.33 | --. - | -.. - | 5 | -- | -- |
| Chassis, truck, $21 / 2$-ton, $6 \times 6, \mathrm{M45}$ and M45C | 5.47 |  |  | 5 | -- | -- |
| Chassis, truck, $21 / 2$-ton, 6x6, M46 and M46C | 5.64 |  | ---- | 5 | -- | -- |
| Chassis, truck, $21 / 2$-ton, 6x6, M57 | 5.41 |  |  | 5 | -- | -- |
| Chassis, truck, $21 / 2$-ton, $6 \times 6$, M58 | 5.43 | --- | ---- | 5 | -- | -- |
| Chassis, truck, $21 / 2$-ton, 6x6, M133 | 5.58 |  | ---- | 5 | -- | -- |
| Chassis, truck, $21 / 2$-ton, 6x6, M207 and M207C | 5.80 | --- | --- | 5 | -- | -- |
| Chassis, truck, $21 / 2$-ton, 6x6, M209 | 5.60 |  | --- | 5 | -- | -- |
| Chassis, truck, 5-ton, 6x6, M39 | 8.77 | --... | ---- | 8 | -- | -- |
| Chassis, truck, 5-ton, 6x6, M40 and M40C | 9.20 |  | ---- | 8 | -- | -- |
| Chassis, truck, 5-ton, 6x6, M61 | 9.02 | --- | ---- | 8 | -- | -- |
| Chassis, truck, 5-ton, 6x6, M63 and M63C | 9.62 |  |  | 8 | -- |  |
| Chassis, truck, 5-ton, 6x6, M139, M139C and M39D | 13.68 | 18.68 | 23.68 | 8 | -- | -- |
| Decontaminating apparatus, power-driven, trk-mtd, M9, M45 chassis. | 8.38 | 10.08 | 10.08 | 7 | 9 | 9 |
| Decontaminating apparatus, power-driven, trk-mtd, M3A3, M45 chassis. | 7.14 | 8.84 | 8.84 | 6 | 7 | 7 |
| Lighter, amphibious, resupply, cargo, 5 -ton, (LARC-V) | 10.00 | 15.00 | 15.00 | 10 | 15 | 15 |
| Lighter, amphibious, resupply, cargo, 15-ton, (LARC-XV) | 22.50 | 37.50 | 37.50 | 27 | 50 | 50 |
| Service unit, flamethrower, trk-mtd, M4, M45 chassis |  | 938 | 9.38 | - | 8 | 8 |
| Shop equipment, contact maintenance, set No. 3 |  | 4.45 | 4.45 | -- | 4 | 4 |
| Shop equipment, emergency repair, M2 |  | 3.88 | 3.88 | -- | 4 | 4 |
| Shop equipment, general purpose repair |  | 8.44 | 8.44 |  | 8 | 8 |
| Shop equipment, organizational repair, set No. 2 |  | 12.0 | 12.0 |  | 10 | 10 |
| Shop equipment, heavy mach shop |  | 7.70 | 7.70 | -- | 8 | 8 |
| Shop equipment, small tool repair |  | 8.44 | 8.44 | - | 8 | 8 |
| Shop equipment, welding |  | 7.70 | 7.70 | -- | 8 | 8 |
| Superstructure transporter, amphibious, self-propelled, with superstructure, interior bay mobile assault bridge-ferry. |  | 23.35 | 23.35 | - | 21 | 21 |
| Superstructure transporter, amphibious, self-propelled, with superstructure, end bay mobile assault bridge-ferry. |  | 25.80 | 25.80 | -- | 24 | 24 |
| Topographic reproduction set, trk-mtd, $21 / 2$-ton truck, $6 \times 6$, carrying one of the following sections: |  |  |  |  |  |  |
| Photo mechanical process section | --- | 12.13 | 12.13 | -- | 11 | 11 |
| Plate grainer section |  | 10.21 | 10.21 | -. | 10 | 10 |
| Press section |  | 11.53 | 11.53 |  | 11 | 11 |
| Map layout section |  | 9.04 | 9.04 | -- | 9 | 9 |
| Plate process section |  | 9.47 | 9.47 | .. | 9 | 9 |
| Camera section |  | 9.74 | 9.74 | -- | 10 | 10 |
| Topographic photomapping equipment, trk-mtd $21 / 2$-ton, $6 \times 6$, carrying one of the following sections: |  |  |  |  |  |  |
| Cartographic section |  | 10.82 | 10.82 | -- | 10 | 10 |
| Copy and supply section |  | 11.97 | 11.97 | -- | 10 | 10 |
| Rectifier section --- |  | 12.03 | 12.03 | - | 11 | 11 |
| Map revision section |  | 10.49 | 10.49 | -- | 9 | 9 |
| Multiplex section |  | 12.13 | 12.13 | -- | 11 | 11 |
| Photomapping section |  | 10.72 | 10.72 |  | 9 | 9 |

## Vehicle description

| $V$ ehicle description | ton |  |  |  | Loaded |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Loaded |  |  |  |  |  |
|  | E | $c$ | H | E | c | H |
| Truck, ambulance, 3/4-ton, 4x4, M43 | 4.39 | 5.90 | 5.90 | 3 | 4 | 4 |
| Truck, ambulance, $11 / 4$-ton, $4 \times 4$, XM676 | 2.51 | 3.50 | 3.50 | 2 | 3 | 3 |
| Truck, amphibious, 2 1/2-ton, 6x6, DUKW, M147 | 9.60 | 12.10 | 13.60 | 9 | 11 | 13 |
| Truck, body and hydraulic crane, fwd model B-666 | 13.80 |  |  | 12 | - |  |
| Truck, bolster, $21 / 2$-ton, 6x6, M44 chassis | 5.49 |  |  | 8 | -- | -- |
| Truck, bolster, 2 1/2-ton, 6x6, M45 chassis | 6.5 |  |  | 8 | -- | -- |
| Truck, bolster, 5-ton, 6x6, M40 | 9.49 |  |  | 7 |  |  |
| Truck, cargo, 3/4-ton, 4x4, M37 and M37B1 | 2.85 | 3.60 | 4.85 | 3 | 4 | 4 |
| Truck, cargo, $11 / 2$-ton, 4x4, XM676 | 2.33 | 3.50 | 3.50 | 2 | 3 | 3 |
| Truck, cargo, 1 1/2-ton, 4 -door, 4x4, XM677 | 2.48 | 3.50 | 3.50 | 2 | 3 | 3 |
| Truck, carryall, $11 / 4$-ton, $4 \times 4, \mathrm{XM} 678$ | 2.51 | 3.50 | 3.50 | 2 | 3 | 3 |
| Truck, cargo, $21 / 2$-ton, 6x6, M34 | 6.10 | 8.77 | 11.27 | 5 | 8 | 10 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6, \mathrm{M} 35$ | 6.44 | 8.94 | 11.44 | 5 | 8 | 10 |
| Truck, cargo, 2 1/2-ton, 6x6, M36 and M36C | 7.62 | 10.12 | 12.62 | 6 | 8 | 10 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6, \mathrm{M} 135$ | 6.37 | 9.04 | 11.54 | 6 | 9 | 11 |
| Truck, cargo, $21 / 2$-ton, 6x6, M211 | 6.79 | 9.47 | 11.97 | 6 | 8 | 1.1 |
| Truck, cargo, 5-ton, 6x6, M41 | 9.62 | 14.92 | 17.42 | 9 | 15 | 18 |
| Truck, cargo, 5-ton, 6x6, M54 | 9.97 | 14.97 | 19.97 | 9 | 14 | 19 |
| Truck, cargo, 5-ton, 6x6, M54A2 | 10.46 | 15.46 | 20.46 | 9 | 14 | 20 |
| Truck, cargo, 5-ton, 6x6, M55 and M55A2 | 12.03 | 17.03 | 22.03 | 10 | 16 | 21 |
| Truck, cargo, 16-ton, 4x4, XM437E1 | 19.34 | 35.54 | 35.54 |  |  |  |
| $10^{\prime}$ span |  |  |  | 22 | 45 | 45 |
| Spans over $50^{\prime}$ |  |  |  | 16 | 30 | 30 |
| Truck, cargo, 10-ton, 6x6, M125 | 16.89 | 26.89 | 31.89 | 14 | 25 | 33 |
| Truck, cargo, 8-ton, 4x4, XM520E1 (GOER) | 12.18 | 20.38 | 20.38 | 12 | 18 | 18 |
| Truck, command, 3/4-ton, 4x4, M42 | 2.98 | 3.73 | 3.90 | 3 | 4 | 4 |
| Truck, dump, $21 / 2$-ton, 6x6, M59 | 7.23 | 9.91 | 12.41 | 6 | 8 | 10 |
| Truck, dump, $21 / 2$-ton, 6x6, M215 | 7.44 | 9.49 | 12.11 | 7 | 9 | 11 |
| Truck, dump, $21 / 2$-ton, 6x6, M342 | 7.70 | 10.29 | 12.79 | 7 | 9 | 12 |
| Truck, dump, 5-ton, 6x6, M51 | 11.33 | 16.33 | 21.33 | 10 | 16 | 21 |
| Truck, dump, 10 cu yd, (15-ton) white model SB-3001, 2320-5403119. | 17.70 |  | 32.70 | 18 | -- | 76 |
| Truck, dump, 15-ton, 4x2, DED euclid M5FD | 14.3 | 29.3 | 29.3 | 15 | 72 | 72 |
| Truck, dump, 15-ton, 4x2, DED MACK model LR | 16.25 | 31.25 | 31.25 | 15 | 72 | 72 |
| Truck, dump, 15-ton, 4x2, GED sterling MSB-301 | 17.71 | 31.25 | 32.71 | 18 | 76 | 76 |
| Truck, firefighting, pumper hesse, M-HC-26, 500 GPM, 2 1/2-ton, 6x6, M44 chassis. | 8.7 | 10.3 | 10.3 | 8 | 9 | 9 |
| Truck, firefighting, crash and pumper, water, 1500 GPM, 7-ton GED. | 12.78 | 18.00 | 18.00 | 11 | 17 | 17 |
| Truck, hopper, 5-ton, international model 201, 2320-273-4426 | 6.12 |  | 11.10 | 5 | .- | 13 |
| Truck, lift, fork, GED, rough terrain, pneumatic tired, 6000pound cap, at 24-in. load center, baker model, RJF-060: |  |  |  |  |  |  |
| FSN 3930-679-4458 | 8.51 | 11.51 | 11.51 | 9 | 16 | 16 |
| FSN 3930-073-8751 | 11.00 | 14.00 | 14.00 | 12 | 18 | 18 |
| FSN 3930-073-8750 | 15.30 | 20.30 | 20.30 | 15 | 29 | 29 |
| Truck, maintenance, 3/4-ton, $4 \times 4$, M201, and M201B1 (signal corps) V41/GT. | 3.48 | 4.23 | 4.48 | 3 | 4 | 4 |
| Truck, maintenance, earth boring, machine and pole setter, $21 / 2$ ton, $6 \times 6, \mathrm{~V} 18 \mathrm{~A} 1 \mathrm{MTQ}$. | 8.58 | 9.77 | 11.77 | 8 | 9 | 11 |
| Truck, maintenance, telephone construction and maintenance, 2 1/2-ton, 6x6, V17A/MTQ. | 8.28 | 9.42 | 11.42 | 8 | 9 | 11 |
| Truck, maintenance, repair shop, $21 / 2$-ton, $6 \times 6$, M 46 chassis |  | 956 | 9.56 | -. | 8 | 8 |
| Truck, stake, bridge transport, 5-ton, 6x6, M139 | 13.2 | 21.0 | 21.0 | 10 | 18 | 18 |
| Truck, stake and platform, $11 / 2$-ton, $4 \times 2$ | 2.84 | 4.34 | 6.23 | 3 | 4 | 7 |
| Truck, tank, gasoline, $21 / 2$-ton, 6x6, 1200-gal., M49, and M49C | 6.95 | 9.63 | 10.88 | 6 | 8 | 10 |


| Vehicle deacription | Weight (Bhort tors) |  |  | Class |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Loaded |  |  | Loaded |  |  |  |
|  | E | c | H | $\boldsymbol{E}$ | c | H |  |
| Truck, tank, gasoline, $21 / 2$-ton, 6x6, 1200-gal., M217 and M217C | 7.17 | 9.85 | 11.35 | 6 | 9 | 10 |  |
|  | 11.91 | 17.91 | 17.91 | 10 | 18 | 18 |  |
| Truck, tank, fuel servicing, 2500-gal., 4x4, XM559E1 (GOER) | 14.10 | 23.87 | 23.87 | 12 | 22 | 22 |  |
| Truck, tank, fuel servicing, 5000-gal., 4x4, XM438E2 (GOER) | 19.24 | 35.87 | 35.87 | -- | -- | -- |  |
| $10^{\prime}$ Span |  | --. - |  | 22 | 46 | 46 |  |
| Spans over 50' |  |  |  | 16 | 30 | 30 |  |
| Truck, tank, water, 2 1/2-ton, $6 \times 6,700$-gal | 5.96 | 8.63 | 8.63 | 6 | 8 | 8 |  |
| Truck, tank, water, $21 / 2$-ton, 6x6, 1000-gal., M50 | 7.52 | 10.19 | 11.84 | 7 | 8 | 11 |  |
| Truck, tank, water, $21 / 2$-ton, $6 \times 6,1000-\mathrm{gal}$. , M222 | 7.05 | 8.98 | 11.48 | 6 | 8 | 10 |  |
| Truck, tractor, $21 / 2$-ton, 6x6, M48 | 5.92 | -- - - | --- - | 6 | -- | -- |  |
| Truck, tractor, 2 1/2-ton, 6x6, M221 | 6.05 | -- - - |  | 5 | - - | -- |  |
| Truck, tractor, $21 / 2$-ton, 6x6, M275 | 5.80 | ---. | ---. | 5 | -- | -- |  |
| Truck, tractor, 5-ton, 6x6, M52 and M52A1 | 9.72 | --- | ---- | 8 | -- | -- |  |
| Truck, tractor, 5-ton, 4x2, federal model 45M2 | 4.90 |  | ---- | 4 | -- | -- |  |
| Truck, tractor, 5-ton, 4x2, international-harvester model L-201 | 5.11 | ---- | -- | 5 | -- | -- |  |
| Truck, tractor, 5-ton, 4x2, international-harvester model R-202 | 5.12 | ---- | ---- | 5 |  | -- |  |
| Truck, tractor, 10 -ton, 6x6, M123, M123C | 16.12 | --- | --- - | 14 | -- | -- |  |
| Truck, tractor, 10-ton, 8x8, XM191 | 17.18 | ---. |  | 15 | -- | -- |  |
| Truck, tractor, 12 -ton, 6x6, M26A1 | 24.45 | ---. | ---- | 28 | -- | -- |  |
| Truck, tractor, 25-ton, M523E2 | 20.49 | ---- |  | 18 | -- |  |  |
| Truck, tractor, 15-ton, 8x8, XM194E1 | 24.08 | --- | . . . | 20 | -- | -- |  |
| Truck, tractor, 15-ton, 8x8, XM194E2 and E3 | 24.22 | ---- |  | 21 | -- |  |  |
| Truck, tractor, 15-ton, 8x8, XM194E4 | 26.30 | ---- | ---- | 23 | -- | -- |  |
| Truck, tractor, wrecker, 5-ton, 6x6, M246 | 16.42 | 22.42 | 24.42 | 15 | 20 | 23 |  |
| Truck, van, expansible, $21 / 2$-ton, 6x6, M292 | 10.80 | 12.80 | 12.80 | -- | 11 | 11 |  |
| Truck, van, expansible, 5-ton, 6x6, M291 | 12.75 | 15.25 | 20.25 | 11 | 14 | 19 |  |
| Truck, van, shop, $21 / 2$-ton, M109, M109C and M109D | 7.62 | 10.29 | 11.37 | 7 | 9 | 10 |  |
| Truck, van, shop, $21 / 2$-ton, M220, M220C and M220D | 7.54 | 10.22 | 11.47 | 7 | 9 | 10 |  |
| Truck, wrecker, crane, $21 / 2$-ton, 6x6, M108 | 9.89 | 10.37 | 11.82 | 6 | 9 | 11 |  |
| Truck, wrecker, crane, $21 / 2$-ton, 6x6, XM519 | 7.41 | 8.91 | 8.91 | 6 | 8 | 8 |  |
| Truck, wrecker, light, $21 / 2$-ton, 6x6, M60 | 11.98 | 12.73 | 13.73 | 11 | 12 | 13 |  |
| Truck, wrecker, medium, 5-ton, 6x6, M62 | 17.01 | 20.51 | 23.01 | 16 | 21 | 23 |  |
| Truck, wrecker, medium, 5-ton, M543A2 | 17.33 | 17.33 | 17.33 | 17 | 17 | 17 |  |
| Truck, wrecker, 10-ton, 4x4, XM553 (GOER) | 19.42 | 23.93 | 23.93 | 17 | 22 | 22 |  |
| Truck, wrecker, 20 -ton, 4x4, XM554 (GOER) | 28.80 | 33.33 | 33.33 |  | -- |  |  |
| $10^{\prime}$ span |  |  |  | 39 | 43 | 43 |  |
| Spans over $50{ }^{\prime}$ |  |  |  | 24 | 28 | 28 |  |
| TOWED VEHICLES |  |  |  |  |  |  |  |
| a. Artillery. |  |  |  |  |  |  |  |
| Gun, antiaircraft artillery, towed, 75 mm , weapons system, M51 |  | 9.64 | 9.64 | -- | 8 | 8 |  |
| Gun, antiaircraft artillery, towed, 90 mm , M2, mount 90 mm , M2 .. |  | 16.15 | 16.15 | - . | 16 | 16 |  |
| Gun, antiaircraft artillery, towed, 90mm, M118 -.-.------..- |  | 4.15 | 4.15 | -- | 5 | 5 |  |
| Gun, antiaircraft artillery, towed, 120 mm , M1 with mount 120 mm , M1 and M1A1. |  | 30.75 | 30.74 | . | 38 | 38 |  |
| Gun, field artillery, towed, 4.5-inch |  | 6.70 | 6.70 | . | 9 | 9 |  |
|  |  | 13.85 | 13.85 | -- | 14 | 14 |  |
| Gun, field artillery, towed, 8-inch, tlr mount M1A1 (wagon transport M1A1). | -- - | 26.32 | 26.32 | . | 24 | 24 |  |
| Howitzer, light, towed, 105mm, M101 or M101A1-.-..------. |  | 2.49 | 2.49 | - - | 4 | 4 |  |
| Howitzer, medium, towed, 155mm, M114 and M114A1 ------ |  | 6.44 | 6.44 | -- | 9 | 9 |  |
| Howitzer, medium, towed, 155 mm , auxiliary propelled, M123A1 |  | 6.75- | 6.75 | - - | 9 | 9 |  |
| Howitzer, heavy, towed, 8-inch, M115 --.--------------1. |  | 14.80 | 14.80 | -- | 15 | 15 |  |
| Howitzer, heavy, towed, 240 mm , M1, wagon transport M2A1 $\ldots$.-. |  | 23.86 | 23.86 |  | 21 | 15 |  |
| Howitzer, heavy, towed, $240 \mathrm{~mm}, \mathrm{M} 1$ or gun field artillery, towed, 8 -inch, M2 on carriage transport, wagon M3A1. | ---- | 25.55 | 25.55 |  | 21 | 21 |  |
| 3-30 |  |  |  |  |  |  |  |

## Vehicle deacription

| Vehicle deacription |  |  |  |  | oaded |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Loaded |  |  |  |  |  |
|  | $E$ | c | H | $E$ | c | H |
| b. Trailers. |  |  |  |  |  |  |
| Trailer, ammunition, $11 / 2$-ton, 2 -whl, M332 | 1.40 | 2.90 | 2.90 | 2 | 4 | 4 |
| Trailer, ammunition, 2-ton, 2 -whl, M10 | 1.40 | 3.40 | 3.40 | 2 | 5 | 5 |
| Trailer, ammunition, 4-ton, 2-whl, M21 (Oneida, Trailmobile) | 2.65 | 6.65 | 6.65 | 4 | 9 | 9 |
| Trailer, ammunition, 8-ton, 4 -whl, M23 | 5.00 | 13.00 | 13.00 | 5 | 11 | 11 |
| Trailer, basic utility, pole type, $21 / 2$-ton, 2 -whl | 1.20 | 3.70 | 3.70 | 2 | 5 | 5 |
|  | 1.10 | 3.60 | 3.60 | 2 | 5 | 5 |
| Trailer, bolster, pole handling, $31 / 2$-ton, 2 -whl, M271 and M271A1. | 1.21 | 4.71 | 4.17 | 2 | 7 | 7 |
| Trailer, bolster, 4-whl, special tandem 7- to 14-ton (4DT), Eidel Mfg Co. | 3.60 | 17.60 | 17.60 | 4 | 21 | 21 |
| Trailer, bomb, 2-ton, 4-whl, M143 and M143A1 | 3.20 | 5.20 | 5.20 | 3 | 5 | 5 |
| Trailer, bomb, $21 / 2$-ton, 3 -whl, M5 (Oneida) | 1.60 | 4.10 | 4.10 | 2 | 5 | 5 |
| Trailer, cable reel, $31 / 2$-ton, 2 -whl, M310 (Signal Corps Model K-37-B). | 1.26 | 4.76 | 4.76 | 1 | 7 | 7 |
| Trailer, cargo, 1 1/2-ton, 2-whl, M104, M104A1 and M104A2 | 1.36 | 2.86 | 4.11 | 2 | 4 | 6 |
| Trailer, cargo, $11 / 2$-ton, 2-whl, M105, M105A1 and M105A2 | 1.32 | 2.82 | 3.57 | 2 | 4 | 6 |
| Trailer, clamshell bucket, 3-ton, Gramma Model M-16 | 1.22 | 4.12 | 4.12 | 2 | 5 | 5 |
| Trailer, firefighting pumper, Sabre Model TT 2000 |  |  |  |  |  |  |
| Trailer, flat-bed, 7-ton, LaCrosse Model CTP7F, | 4.85 |  |  | 6 |  |  |
| FSN 2230-255-9190 | 5.67 | 12.67 | 19.67 | 7 | 15 | 24 |
| FSN 2330-255-9191 | 5.67 | 12.67 | 12.67 | 6 | 15 | 15 |
| Trailer, flat-bed, 4-whl, special tandem, 10-ton, for craneshovel attachment. | 5.58 | 15.58 | 15.58 | 6 | 17 | 17 |
| Trailer, flat-bed, 10-ton, 4 Decal Medship Wheels, FSN 2330-377-0389. | 5.63 | 15.63 | 15.63 | 6 | 18 | 18 |
|  | 5.63 | 15.63 | 18.63 | 6 | 18 | 20 |
| <Trailer, flat-bed, Guided Missile, M261 | 3.85 | 5.47 | 5.47 | 4 | 5 | 5 |
| Trailer, low-bed, 8-ton, Fontaine Model T8-105 | 4.83 | 12.83 | 12.83 | 4 | 12 | 12 |
| Trailer, low-bed, 8-ton, Fruehauf Model CPT-8 Special | 4.76 | 12.50 | 12.50 | 4 | 12 | 12 |
| Trailer, low-bed, 8-ton, Jahn Model, LKS-408 | 3.80 | 11.80 | 11.80 | 4 | 12 | 12 |
| Trailer, low-bed, 8-ton, Hobbs Model F-1386 | 4.89 | 12.89 | 12.89 | 4 | 13 | 13 |
| Trailer, low-bed, 8-ton, LaCrosse Model DF 4C-8F | 4.83 | 12.83 | 12.83 | 4 | 14 | 14 |
| Trailer, low-bed, 60-ton, Rodgers Model D-60-DS-5 | 17.00 |  | 77.00 | 13 | - - | 110 |
| Trailer, low-bed, 60-ton, Rógers Model DW-60-LS-6 | 14.06 |  | 79.06 | 10 | -- | 123 |
| Trailer, low-bed, 60-ton, Rogers Model D-60-DS-7 | 16.35 |  | 76.35 | 12 | -- | 117 |
| Trailer, low-bed, 60-ton, Steel Products, Model Great Dane | 15.58 |  | 75.58 | 10 |  | 130 |
| Trailer, low-bed, antenna mitd, M260 and M260A1 | 2.57 | 4.95 | 4.95 | 2 | 4 | 4 |
| Trailer, low-bed, guided missile, 7-ton, 4-whl, XM529 | 7.22 | 13.80 | 13.80 | 6 | 12 | 12 |
| Trailer, tank, 6-ton, 1500-gal., VIC Model 72, FSN 2330-2946302. | 10 |  | 11.10 | 4 |  | 10 |
| Trailer, tank, water, $11 / 2$-ton, 2 -whl, 400 -gal., M106, M106A1, M106A2, M107, M107A1, M107A2 and M149. | 1.25 | 2.97 | 2.97 | 2 | 4 | 4 |
| Trailer, transporter, 45-ton, 12 -whl, M9 | 10.08 |  | 55.08 | 8 |  | 82 |
| Trailer, van, shop, folding sides, $11 / 2$-ton, 2 -whl, M448 | 1.48 | 2.98 | 3.73 | 2 | 4 | 6 |
| Trailer, van, launching control, M262 | 3.40 | 6.20 | 6.20 | 4 | 6 | 6 |
| Trailer, van, radar tracking control, M258 | 3.43 | 5.97 | 5.97 | 3 | 5 | 5 |
| Trailer, van, director station, M259 | 3.53 | 6.31 | 6.31 | 3 | 5 | 5 |
| Trailer, van, fire control, 2 -ton, 4 -whl, M244 | 3.56 | 6.04 | 6.04 | 4 | 6 | 6 |
| Transporter, liquid rolling wheel | 1.07 | 4.27 | 4.27 | 1 | 6 | 6 |
| Transporter, liquid rolling wheel (2 in tandem) | 2.14 | 8.42 | 8.42 | 2 | 7 | 7 |
| Transporter, liquid rolling wheel ( 3 in tandem) | 3.21 | 12.63 | 12.63 | 2 | 10 | 10 |
| Transporter, liquid rolling wheel (4 in tandem) <br> c. Semitrailers | 4.28 | 16.83 | 16.83 | 3 | 12 | 12 |
| Semitrailer, LOX, 9-ton, 2-whl | 8.82 | 17.82 | 17.82 | 7 | 16 | 16 |



## Vehicle description

Compressor, air, GED, whl-mtd, 600 CFM, Ingersoll-Rand Model DR-600.
Compressor, reciprocating, DED, 500 CFM, whl-mtd, Worthington Model Blue Brute 500.
Compressor, reciprocating, power-driven, 80 CFM, 5000 psi , trkmtd, M45 chassis, Joy Model 8-HGC-3-MS-1.
Compressor, reciprocating, power-driven, 80 CFM, 5000 psi, trkmtd, M45 chassis, Joy Model 80-HGC2-MS-1
Compressor, reciprocating, power-driven, GED, 80 CFM, 5000 psi, trk-mtd, M45 chassis, Clark Model HO-6-5G.
Compressor, reciprocating, power-driven, 210 CFM, Davy Model 210WDS, FSN 4310-272-8128.
Compressor, power-driven, GED, 210 CFM, 100 psi, trk-mtd, Joy Model RPA-210 GD3-MS-1.
Compressor, reciprocating, power-driven, 210 CFM, 100 psi, trkmtd, LeRoi Model 210-G2.
Compressor, reciprocating, air, GED, trk-mtd, 210 CFM, 100 psi, LeRoi Model 210G1.
Compressor, rotary, power-driven, GED, 210 CFM, 100 psi, trkmtd, M45 chassis,. Harris Model J-210.
Compressor, rotary, power-driven, whl-mtd, 600 CFM, 100 psi, Ingersoll-Rand Model DR 600 WTRZD.
Conversion-storage-charging unit, cargon-dioxide, Cardox Model FE 34365.
Conversion unit, carhon-dioxide, semitrailer-mtd, Girdler Model 131-4910.
Conveyor, belt, whl-mtd, electric, 300 tons per hour, 50 -foot, Barber-Greene Model PG-70, FSN 3910-790-2175.
Cooling tower, liquid semitrailer-mtd, Badger Model CT-1, FSN 3655-606-0820.
Crane-shovel, basic unit, crawler-mtd, GED, 10-ton, $3 / 4$ cu yd, American Hoist Model 375-BC.
Crane-shovel, basic unit, crawler-mtd, DED, 40-ton, 2 cu yd, Baldwin-Lima-Hamilton Model 802.

Spans under 20 feet
Spans over 20 feet
Crane-shovel, basic unit, crawler-mtd, GED, 10 -ton, $3 / 4$ cu yd, Baldwin-Lima-Hamilton Model 34.
Crane-shovel, basic unit, crawler-mtd, DED, 40-ton, 2 cu yd, Bucyrus-Erie Model 51-B.

Spans under 20 feet
Spans over 20 feet
Crane-shovel, basic unit, crawler-mtd, GED, 5 -ton, $3 / 4$ cu yd, Bucyrus-Erie Model 22-B.
Crane-shove, basic unit, crawler-mtd, GED, 10 -ton, $3 / 4$ cu yd, Byers Model 83.
Crane-shovel, basic unit, crawler-mtd, DED, 40-ton, 2 cu yd, Harnischfeger Model 855-BG.
Crane-shovel, basic unit, crawler-mtd, DED, 40-ton, 2 cu yd, Harnischfeger Model 855-BG3.
Crane-shovel, basic unit, crawler-mtd, DED, 35-ton, 2 cu yd, Harnischfeger Model 855-B.

Spans under 20 feet
Spans over 20 feet

Weight
Clasa
(ghort tons)

|  | Loaded |  |  | Loaded |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $E$ | c | H | E | c | H |
| --- | 5.59 | 5.59 | - | 6 | 6 |
| --- | 5.68 | 5.68 | -- | 6 | 6 |
| ---- | 9.21 | 9.21 | -- | 8 | 8 |
| --- | 9.21 | 9.21 | -- | 8 | 8 |
| . . - | 9.25 | 9.25 | -- | 8 | 8 |
| - | 7.92 | 7.92 | -- | $\bigcirc$ | 7 |
|  | 7.35 | 7.35 | -- |  | 6 |
|  | 8.04 | 8.04 | -- | $\frac{2}{7}$ | 7 |
| --- | 7.65 | 7.65 | -- | 7 | 7 |
| --- | 7.53 | 7.53 | -- | 7 | 7 |
| ---- | 5.62 | 5.62 | -- | 6 | 6 |
| ---- | 16.40 | 16.40 | -- | 16 | 16 |
|  | 19.33 | 19.33 | -- | 17 | 17 |
|  |  | 4.82 | -- | -- | 6 |
|  |  | 8.22 | -- | -- | 7 |
|  | 18.7 | 18.7 | - | 14 | 14 |
| .... | 66.25 | 66.25 | -- | - | -- |
|  |  | .... | -- | 153 | 153 |
|  | ---- | --- | -- | 81 | 81 |
| -- - - | 16.58 | 16.58 | -- | 22 | 22 |
|  | 66.00 | 66.00 | -- | -- | -- |
|  |  | ---- | -- | 134 | 134 |
|  | --. - | --- | -- | 79 | 79 |
| - | 19.17 | 19.17 | -- | 19 | 19 |
|  | 19.8 | 19.8 | -- | 19 | 19 |
| .- | 40.38 | 40.38 | -- | 56 | 56 |
| --- | 50.51 | 50.51 | -- | 58 | 58 |
|  | 53.2 | 53.2 | -- | -- | -- |
|  | ---- | ---- | -- | 72 | 72 |
| -... | ---- | ---- | -- | 56 | 56 |



## Vehicle description

Crusher, roll, diesel and electric, 75 TPH, whl-mtd, Eagle Model 5230 B .
Crushing and screening unit, GED, whl-mtd, 6-whl, 40 to 140 TPH, Pioneer Model 42-VA.
Crushing and screening unit, GED, crawler-mtd, 100 to 190 TPH, Pioneer Model 54-VA.
Crushing and screening unit, GED, crawler-mtd, 100 to 190 TPH, Iowa Model 2-A.
Crushing, screening, and washing unit, DED, whl-mtd, 6-whl, 40 to 250 TPH, Iowa Model DJ-50.
Cruṣhing, screening, and washing unit, DED, whl-mtd, 40 to 250 TPH, Pioneer Model 33R Triplex.
Crushing, screening, and washing unit, DED, whl-mtd, 6-whl, 40 to 250 TPH, Universal Model 1830-CWL.
Dehydrator, sand, tlr-mtd, Pioneer Model 1833
Dehydrator, sand, tlr-mtd, Universal Model 20PW
Dehydrator, sand, tlr-mtd, Pioneer Model 2220 SDE
Dehydrator, sand, tlr-mtd, Pioneer Model P-300W
Dehydrator, sand, 120 tp 150 TPH, Iowa Model 5022E
Distributor, bituminous material, tank type, GED, trk-mtd, 800gal., Etnyre Model MIL-D32.
Distributor, bituminous material, tank type, GED, trk-mtd, 800gal., General Steel Tank Model SCD
Distributor, bituminous material, tank type, GED, trk-mtd, 800gal., Etnyre Model MXRE D-30.
Distributor, bituminous material, tank type, 1250-gal., Etnyre Model MX Style RE.
Distributor, water, tank type, GED, trk-mtd, 1000-gal., force feed, Municipal Model WD-1000.
Distributor, water, tank type, trk-mtd, 1000-gal., VIC Model M73A.
Distributor, water, tank type, trk-mtd, 1000-gal., force feed, MacLeod Model W-IM3.
Distributor, water, tank type, trk-mtd, 1000-gal., force feed, MacLeod Model 3-IM5.
Distributor, water, tank type, trk-mtd, 1000-gal., force feed, Butler Model 6743.
Distributor, water, tank type, trk-mtd, 1000-gal., ROSCO Model MOE.
Distributor, water, tank type, trk-mtd, 1000-gal., ROSCO Model MME.
Ditching machine, DED, whl-mtd, ladder type, Unit Rig and Equip Model 4262.
Drier aggregate, GED, tlr-mtd, 2-whl, 10 to 25 TPH, Barber Greene Model 830.
Drier aggregate, DED, tlr-mtd, 80 to 120 TPH, Barber Greene Model 837.
Dust collecting machine, paving materials, DED, 22,000 CFM, semitlr-mtd, Barber Greene Model 857.
Generating and charging plant, carbon dioxide, semitlr-mtd, Girdler Model 32-4027, FSN 3655-390-8562.
Generating and charging plant, carbon dioxide, semitlr-mtd, Gridler Model 32-4176, FSN 3655-554-4558.
Generating and charging plant, hydrogen-carbon dioxide, semitlrmtd, Electric Heating Equipment Model H2-CO2, FSN 3655-288-2993.


| Vehicle description |  | Weight hort tone |  |  | Clae |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |
|  | $E$ | c | H | $E$ | c | H |
| Generating and charging plant, oxygen-nitrogen, semitlr-mtd, Air Products Model A2. |  | 15.0 | 15.0 | -- | 17 | 17 |
| Generator, carbon dioxide, semitlr-mtd, Electric Gridler Model 32-4027. |  | 24.01 | 24.00 | -- | 25 | 25 |
| Graduation control unit, aggregate tlr-mtd, Barber Greene Model 866 |  | 15.28 | 15.28 | - | 12 | 12 |
| Grader, road, motorized, DED, Austin-Western Model 99-H |  | 10.7 | 10.7 |  | 9 | 9 |
| Grader, road, motorized, DED, Caterpillar Model 12 |  | 12.5 | 12.5 |  | 10 | 10 |
| Grader, road, motorized, DED, Caterpillar Model 212 |  | 7.46 | 7.46 |  | 6 | 6 |
| Grader, road, motorized, Gallion Model 118 |  | 12.70 | 12.70 |  | 10 | 10 |
| Grader, road, motorized, DED, Huber-Warco Model 4D |  | 12.59 | 12.59 |  | 11 | 11 |
| Grader, road, motorized, DED, LeTourneau-Westinghouse Model 220. |  | 7.98 | 7.98 |  | 7 | 7 |
| Grader, road, motorized, Riddell Model 4D-100 |  | 12.41 | 12.41 |  | 10 | 10 |
| Grader, road, towed, Adams Model 124S |  | 5.93 | 5.93 |  | 5 | 5 |
| Heater, bitumen, GED tlr-mtd, steam, Williams Bros Model SG-52TA. | 3.13 |  |  | 5 |  |  |
| Loader, scoop-type, GED, $11 / 2 \mathrm{cu}$ yd, Clark Model $85-\mathrm{AM}$ | 7.35 |  | 10.35 | 9 | -- | 14 |
| Loader, scoope-type, DED, $21 / 2$ cu yd, 4 -whl, Hough Model H-90M, FSN 3805-803-2672. | 14.20 |  | 18.2 | 15 | -- | 30 |
| Loader, scoop-type, DED, 4 -whl, $21 / 2 \mathrm{cu}$ yd, Clark Model 175A-M23. | 14.41 |  | 19.00 | 16 |  | 22 |
| Loader, bucket-type, DED, crawler, mtd, Haiss Model 77-PC | 11.5 |  |  | 12 |  |  |
| Loader, belt-type, GED, crawler, self-propelled, 10 to 20 cu yd per min, Barber Greene Model 538B. | 7.84 |  |  | 11 | -- |  |
| Mixer, bituminous material, DED, 110-200 TPH, tlr-mtd, Barber Green Model 848. | 15.70 |  |  | 16 |  |  |
| Mixer, concrete, tlr-mtd, Construction Model 16-S | 3.00 |  |  | 3 |  |  |
| Mixer, concrete, tlr-mtd, liquid-cooled, 16 cu ft , Gallion Model 16S-SCE. | 3.65 |  |  | 4 | -- |  |
| Mixer, concrete, tlr-mtd, Ransome Model 14SU | 3.00 |  |  | 3 |  |  |
| Mixer, rotary tiller, DED, self-propelled, Seaman Model TP-84M | 5.74 |  |  | 5 |  |  |
| Paving machine, bituminous material, GED, Barber Green Model 879-A. | 12.12 | . |  | 21 | - |  |
| Paving machine, bituminous material, GED, Barber Greene Model 879-B. | 11.25 | . -- |  | 14 | - |  |
| Power unit, gasoline, whl-mtd, Minneapolis-Moline Model 1210-12A. | 7.19 | ---. | ---. | 8 | -- |  |
| Roller, motorized, Buffalo-Springfield Model KT-24B, FSN 3895-187-2645. | 8.75 | ...- |  | 10 | -- |  |
| Roller, motorized, GED, 3 -whl, 9 -ton, Buffalo-Springfield Model KX-16-C2. | 6.30 |  |  |  | -- |  |
| Roller, motorized, Buffalo-Springfield Model KT-16B, FSN 3895-194-8536. | 6.00 | - |  | 7 | -- |  |
| Roller, motorized, GED, 5- to 8-ton, Gallion Model 3T9G | 10.76 |  |  | 12 |  |  |
| Roller, motorized, GED, 5- to 8-ton, Gallion Model T-5G | 5.90 |  |  |  |  |  |
| Roller, motorized, road, Gallion Model T-8G, FSN 3895-290-4993_ | 8.84 |  |  | 11 |  |  |
| Roller, motorized, DED, 8 - to 12 -ton, Gallion Model Chief | 10.02 |  |  | 11 |  |  |
| Roller, motorized, GED, 10- to 20-ton, Gallion Model Chief CG | 10.60 |  |  | 13 | - |  |
| Roller, motorized, GED, 3-whl, 10-ton, Gallion Model Chief Rollo-Matic. | 10.83 | ---- | -- | 13 | -- |  |
| Roller, towed, pneu tire, 4-whl, 7-ton, Shovel Supply Model RT-100CE. | 6.95 |  | . | 10 | . |  |
| Roller, towed, pneu tire, 71/2-ton, Grace Model Wltr | 7.25 | --- | . --- | 10 |  |  |
| Rooter, towed, Southwest Model RH-3 | 6.62 | ---- | --.. | 10 | -- |  |

Vehicls description

Rooter, towed, LeTourneau Model LW-H-3
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Saw Mill, circular, DED, tlr-mtd, Jackson Lumber Harvester Model RMS.
Scraper, earthmoving, towed, 7.2 cu yd, Heil Model OC-9, FSN 3805-378-9805.
Scraper, earthmoving, towed, 7.5 cu yd, Be-Ge Model 6595, FSN 3805-554-5051.
Scraper, earthmoving, towed, 7.5 cu yd, Murry Model AR88M, FSN 3805-683-9126.
Scraper, earthmoving, towed, $12 \mathrm{cu} y d$, Woolrich Model OS-122-A, FSN 3805-691-6161.
Scraper, earthmoving, towed, $12 \mathrm{cu} y d$, LeTourneau-Westinghouse Model LPO -3805-351-9542.
Scraper, earthmoving, towed, 13.5 cu yd, Southwest Welding Model S-152, FSN 3805-691-6132.
Scraper, earthmoving, towed, 18 cu yd, Curtiss-Wright Model CWT-18-M.
Scrubber and washer, aggregate, Lowa Model 720
Scrubber and washer, aggregate, GED, whl-mtd, 80 to 120 TPH, Pioneer Model Log Washer.
Snow removal unit, GED, rotary, trk-mtd, $71 / 2$-ton, $4 \times 4$, KLAUR Model TU-3.
Snowplow, trk-mtd, Wausau Model M-1123, mtd on Oskosh Model WT2206.
Tank, storage, liquid, argon-nitrogen-oxygen, semi-tlr-mtd, Cambridge Model 217-30.
Tractor, wheeled, Industrial, Case Model LA1, FSN 2420-1900347.

Tractor, whl, Industrial, DED, Caterpillar Model DW-20M, FSN 2420-200-1297.
Tractor, whl, Industrial, DED, LeTourneau-Westinghouse Model Super C TournaTractor.
Tractor, whl, Industrial, DED, LeTourneau-Westinghouse Model Super C Tournadozer.
Tractor, whl, Industrial, MRS Model 72AGT
Tractor, whl, DED, MRS Model 100, FSN 2420-792-6163
Tractor, whl, Industrial, MRS Model 125
Tractor, whl, Industrial, DED, air transportable, MRS Model 150 AGT.
Tractor, whl, Industrial, DED, air transportable, MRS Model 150 .
Tractor, whl, Industrial, DED, MRS Model 190 .-.................
Tractor, whl, Industrial, DED, Westphall Model SWD 300
Tractor, full-tracked, low-speed, DED, Allis-Chalmers Model HD6M.
Tractor, full-tracked, low-speed, DED, Caterpillar Model 933
--.
Tractor, full-tracked, low-speed, DED, 44-in. min ga, Caterpillar Model D-4.
Tractor, full-tracked, low-speed, DED, 60-in. min ga, Caterpillar Model D-4, FSN 2410-190-0196.
Tractor, full-tracked, low-speed, DED, 60-in. min ga, Caterpillar Model D-4, FSN 2410-190-0020.
Tractor, full-tracked, low-speed, DED, 60-tin. min ga, Caterpillar Model D-4, FSN 2410-190-0217.
Tractor, full-tracked, low-speed, DED, 56-in. min ga, Caterpillar Model D-6, FSN 2410-190-0049.

Weight
Class
(short tons)

|  | Loaded |  |  | Loaded |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| E | c | H | $E$ | c | H |
| 3.82 | ---- | --. - | 6 | -- | -- |
| 4.80 | --. | -...-. | 7 | -- | -- |
| 7.70 | 14.70 | 14.70 | 7 | 14 | 14 |
| 7.06 | 14.06 | 14.06 | 6 | 14 | 14 |
| 4.9 | 13.81 | 13.81 | 4 | 15 | 15 |
| 12.10 | 27.10 | 27.10 | 9 | 37 | 37 |
| 9.75 | 21.75 | 21.75 | 8 | 26 | 26 |
| 12.00 | 28.00 | 28.00 | 9 | 37 | 37 |
| 15.45 | 40.45 | 40.45 | 16 | 77 | 77 |
| ---- | 17.69 | 17.69 | -- | 16 | 16 |
|  | 23.6 | 23.6 | -- | 21 | 21 |
| ---- | 11.32 | 11.32 | -- | 10 | 10 |
| ---- | 16.10 | 16.10 | -- | 23 | 23 |
|  | ---- | --- | 7 | -- | 16 |
|  | 6.25 | 6.25 | -- | 8 | 8 |
| ---- | 24.82 | 24.82 | -- | 34 | 34 |
| ---- | 16.24 | 16.24 | - | 19 | 19 |
|  | 17.30 | 17.30 | -- | 19 | 19 |
|  | 7.88 | 7.88 |  | 9 | 9 |
| .-. | --. - | --. | -- | 8 | 8 |
|  | 10.75 | 10.75 | -- | 10 | 10 |
|  | 7.87 | 7.87 | -- | 8 | 8 |
|  | 17.65 | 17.65 | -- | 21 | 21 |
| -.-- | 15.39 | 15.39 | -- | 17 | 17 |
| ---- | 21.20 | 21.20 | -- | 33 | 33 |
|  | 8.00 | 8.00 | -- | 8 | 8 |
| -. - - | 7.99 | 7.99 | -- | 9 | 9 |
| ---- | 7.0 | 7.0 | -- | 9 | 9 |
| ---- | 7.27 | 7.27 | -- | 8 | 8 |
| ---- | 7.50 | 7.50 | .- | 9 | 9 |
|  | 7.98 | 7.98 | -- | 10 | 10 |
| --. | 16.31 | 16.31 | - | 21 | 21 |


|  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Vehicle description |  |  |  |  |  |


| Vehicle description | Weight <br> (short tona) |  |  |  | Class |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Loaded |  |  |  | Loaded |  |
|  | $E$ | c | H | $E$ | C | H |
| Facilities distribution, mtd on tlr, $11 / 2$-ton, 2 -whl, M-105A2 |  | 2.54 | 2.54 |  | 4 | 4 |
| Generator, $45-\mathrm{KW}$, mounted on tlr, 2 -whl, $31 / 2$-ton, MX353 ... b. Sergeant. | --- | 3.78 | 3.78 | -- | 6 | 6 |
| Launching station, 4-whl, semitlr-mtd, guided missile XM504 ..- |  | 8.5 | 8.5 | -- | 7 | 7 |
| Combined with truck, tractor, 5-ton, 6x6, M52 |  | 18.22 | 18.22 |  | 14 | 14 |
| Transport trailer, 4 -whl, 6 -ton, XM527 w/2 forebodies |  | 5.11 | 5.11 | -- | 4 | 4 |
| Transport trailer, 4-whl, 6-ton, XM527 w/missile motor, fin and guidance. |  | 7.74 | 7.74 | -- | 6 | 6 |
| Semitrailer, motor-guidance transport -..---------.--------- |  | 7.75 | 7.75 |  | 7 | 7 |
| Combined with truck, tractor, $21 / 2$-ton, $6 \times 6$, M48, M221, M275. |  | 13.80 | 13.80 |  | 10 | 10 |
| Test station, organizational maintenance, AN/MSM-35 |  | 7.75 | 7.75 | -- | 6 | 6 |
| Combined with truck, tractor, $21 / 2$-ton, 6x6, M275 |  | 13.55 | 13.55 |  | 10 | 10 |
| Test station, field maintenance, AN/MSM-36 |  | 7.75 | 7.75 |  | 6 | 6 |
| Combined with truck tractor, $21 / 2-$ ton, $6 \times 6$, M275 <br> c. Little John. |  | 13.55 | 13.55 | -- | 10 | 10 |
| Handling unit, rocket, trk-mtd, 318MM, M572 <br> d. Honest John. | 6.75 | 9.25 | 9.25 | 6 | 8 | 8 |
| Handling unit, 762 mm rocket, tlr-mtd, M405 and M405A1 | 4.31 | 7.31 | 7.31 | 5 | 7 | 7 |
| Heating and tiedown unit, 762 mm rocket, trk-mtd, M78 and M78A1. | 12.43 | 15.39 | 15.39 | 10 | 14 | 14 |
| Kit, 762 mm rocket, XM78E1, M55 trk dual rear whl, cargo body with winch. | 12.31 | 18.92 | 18.92 | 10 | 17 | 17 |
| Launcher, 762 mm rocket, trk-mtd, M289 | 20.90 | 23.80 | 23.80 | 19 | 22 | 22 |
| Launcher, 762 mm rocket, trk-mtd, M386 | 17.12 | 20.08 | 20.08 | 16 | 19 | 19 |
| Trailer, rocket transporter, 762 mm rocket, M329A1 and M329A2. <br> e. Hawk. | 2.50 | 5.50 | 5.50 | 3 | 7 | 7 |
| Loader-transporter guided missile, XM501E1, XM501E2 and XM 501. | 2.77 | 4.75 | 4.75 | 3 | 5 | 5 |
| Generator, 45-KW, mtd on chassis, tlr, M200A1 |  | 4.25 | 4.25 |  | 5 | 5 |
| Radar set, pulse acquisition, tlr-mtd, AN/MPQ-35 . f. Nike-Ajax. |  | 3.97 | 3.97 | -- | 6 | 6 |
| Antenna-receiver-transmitter group, TGT tracking, tlr-mtd, (tlr, low-bed, antenna, mtd, M260). |  | 5.47 | 5.47 | -- | 5 | 5 |
| Director station, guided missile, tlr-mtd, AN/MSA-7 and AN/ MSA-17. |  | 6.32 | 6.32 | -- | 6 | 6 |
| Electronic shop, tlr-mtd, M304 and M304A1 |  | 6.59 | 6.59 |  | 6 | 6 |
| Launching control group, tlr-mtd, OA-867/MSE-2 |  | 6.00 | 6.00 | -- | 6 | 6 |
| Tracking station, guided missile, tlr-mtd, AN/MPA-4 ........... g. Nike-Hercules. |  | 6.18 | 6.18 | -- | 5 | 5 |
| Antenna-receiver-transmitter group, missile tracking, OA-1340/ MPA, OA-1487/MPA, and OA-1487A/MPA, tlr-mtd, (antenna, tlr, M406). |  | 6.36 | 6.36 | -- | 6 | 6 |
| Director station, guided missile, tlr-mtd, AN/MSA-19 |  | 6.79 | 6.79 |  | 6 | 6 |
| Electronic shop, tlr-mtd, M304 and M304A1 | --- | 6.57 | 6.57 | -- | 6 | 6 |
| Launching control group, guided missile, tlr-mtd, AN/MSW-4 |  | 5.19 | 5.19 |  | 6 | 6 |
| Tracking station, guided missile, tlr-mtd, AN/MPA-5 |  | 6.42 | 6.42 | -- | 5 | 5 |
| Test equipment, electronic shop, field maint, tlr-mtd, AN/MPM44, XM383. |  | 6.50 | 6.50 | -- | 6 | 6 |
| Test equipment, electronic shop, field maint, tlr-mtd, AN/MPM46, XM382. | ---- | 6.50 | 6.50 | - | 6 | 6 |
| COMBINATION VEHICLES |  |  |  |  |  |  |
| Truck, cargo, 3/4-ton, 4x4, M37. |  |  |  |  |  |  |
| Trailer, cargo, 1/4-ton, 2 -whl, M100 | 3.24 | 4.24 | 4.24 | 3 | 4 | 4 |
| Trailer, cargo, 3/4-ton, 2-whl, M101 | 3.63 | 5.13 | 5.76 | 3 | 5 | 5 |


| Vehicle description | Weight (short tons) |  |  | Clasa |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Loaded |  |  | Loaded |  |  |
|  | $\boldsymbol{E}$ | $c$ | H | $E$ | $c$ | $\boldsymbol{H}$ |
| Truck, cargo, 2 1/2-ton, M35. |  |  |  |  |  |  |
| Trailer, cargo, $11 / 2$-ton, 2 -whl, M105 | 7.77 | 11.77 | 15.02 | 6 | 9 | 12 |
| Trailer, tank, water, 400 gal., M106 | 7.58 | 11.75 | 14.25 | 6 | 9 | 12 |
| Howitzer, light, towed, 105 mm , M101 | 8.93 | 11.43 | 13.93 | 7 | 9 | 11 |
| Trailer, cargo, $11 / 2$-ton, 2 -whl, M104 | 7.64 | 11.64 | 15.39 | 7 | 10 | 12 |
| Trailer, basic utility, pole type, $21 / 2$-ton, 2 -whl | 7.64 | 12.64 | 15.14 | 6 | 10 | 12 |
| Truck, cargo, $21 / 2$-ton, $6 \times 6, \mathrm{M} 36$. |  |  |  |  |  |  |
| Compressor, air, tlr-mtd, 4-whl, DED, 315 CFM | 13.84 | 16.34 | 18.84 | 10 | 12 | 15 |
| Conveyor, belt, whl-mtd, 300 TPH, Barber Greene Model PG-70. | 11.06 | 13.56 | 16.06 | 8 | 10 | 12 |
| Truck, cargo, 2 1/2-ton, 6x6, M211. |  |  |  |  |  |  |
| Trailer, cargo, 1 1/2-ton, 2-whl, M104 | 7.99 | 12.17 | 15.92 | 7 | 10 | 18 |
| Trailer, cargo, 1 1/2-ton, 2-whl, M105 | 8.12 | 12.29 | 15.55 | 7 | 10 | 12 |
| Trailer, tank, water, 400-gal., $11 / 2$-ton, 2 -whl, M106 | 7.93 | 12.28 | 14.78 | 7 | 10 | 11 |
| Trailer, basic utility, pole type, $21 / 2$-ton, 2 -whl | 7.99 | 13.17 | 15.67 | 7 | 10 | 12 |
| Semitrailer, van, cargo, 6-ton, 2 -whl, M118, with dolly converter, 2 -whl, 6 -ton, M197. | 11.84 | 20.51 | 25.12 | 10 | 17 | 20 |
| Truck, cargo, 5-ton, 6x6, M41. |  |  |  |  |  |  |
| Trailer, cargo, 1 1/2-ton, M104 | 11.12 | 17.79 | 21.54 | 10 | 15 | 18 |
| Compressor, air, tir-mtd, 4-whl, DED, 315CFM | 16.80 | 21.97 | 24.47 | - - | .- | - - |
| Dryer, aggregate, 80-150 TPH, tlr-mtd, Barber Greene Model 833. | 31.62 |  | 39.29 | 24 | -- | 30 |
| Trailer, ammunition, 8 -ton, 4 -whl, M23, w/limber, carriage M5. | 15.86 | 29.03 | 31.53 | 11 | 22 | 25 |
| Mixer, bituminous material, 110-200 TPH, tlr-mtd, Barber Greene Model 848. | 23.42 |  | 35.19 | 19 |  | 30 |
| Truck, cargo, 5-ton, $6 \times 6$, M54. <br> Dryer, aggregate, 80-150 TPH, tlr-mtd, Barber Greene Model |  |  |  |  |  |  |
| Dryer, aggregate, 80-150 TPH, tlr-mtd, Barber Greene Model 833. | 31.67 |  | 41.84 | 24 |  | 32 |
| Howitzer, heavy, towed, 8-inch, M115 | 24.97 |  | 35.14 | 20 |  | 29 |
| Mixer, bituminous material, 110-200 TPH, tlr-mtd, Barber Greene Model 848. | 23.47 |  | 27.74 | 19 | -- | 32 |
| Semitrailer, tank, gasoline, 5000-gal., 4-whl, M131A1 w/tlr converter M198A1. | 18.83 | 33.82 | 44.31 | 16 | 27 | 37 |
| Trailer, cargo, 1 1/2-ton, 2-whl, M104 | 11.17 | 17.84 | 24.09 | 9 | 15 | 20 |
| Trailer, low-bed, 8-ton, Fruehauf Model CPT-8 | 14.47 |  | 32.64 |  |  |  |
| Truck, cargo, 5-ton 6x6, M55. <br> Howitzer, heavy, towed, 8 -inch, M115 <br> Trailer, ammunition, 8-ton, 4 -whl, M23, w/limber, carriage M5. |  |  |  |  |  |  |
|  | 27.03 | 32.03 | 37.03 | 21 | 25 | 30 |
|  | 17.97 |  | 35.97 | -- | -- | -- |
| Truck, cargo, 10-ton, 6x6, M125. |  |  |  |  |  |  |
| Mixer, bituminous material, 110-200 TPH, tlr-mtd, Barber Greene Model 848. | 29.12 | - | 48.22 | 23 | -- | 41 |
| Howitzer, heavy, towed, 8-inch, M115 | 30.60 | 40.40 | 46.60 | 24 | 32 | 36 |
| Trailer, ammunition, 8-ton, 4 -whl, M23, w/limber, carriage M5. | 21.74 |  | 44.74 | 17 | -- | 37 |
| Truck, dump, 5-ton, 6x6, M51. |  |  |  |  |  |  |
| Bin, aggregate loading, tlr-mtd, 30-ton, Universal Model PB-20. | 17.19 |  | 17.19 | 12 | -- | 12 |
| Mixer, bituminous material, 110-200 TPH, tlr-mtd, Barber Greene Model 848. | 24.83 |  | 39.11 | 20 | - | 33 |
| Trailer, basic utility, pole type, $21 / 2$-ton, 2 -whl | 12.53 | 20.21 | 25.21 | 10 | 17 | 21 |
| Truck, tractor, $21 / 2$-ton, $6 \times 6, \mathrm{M} 221$. <br> Semitrailer, van, cargo, 6-ton, 2-whl, M119 and M119A1 ... | 9.82 | 15.82 | 17.92 | 8 | 14 | 16* |


|  |  | Weight <br> short tona) |  |  | Clas |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Vehicle |  |  |  |  |  |  |
|  | E | c | H | E | c | H |
| Truck, tractor, $21 / 2$-toñ, $6 \times 6$, M275. |  |  |  |  |  |  |
| Semitrailer, stake and platform, 5-ton, 2-whl, Olsen Model 516 | 9.12 | 14.12 | 16.62 | 8 | 12 | 15 |
| Truck, tractor, 5-ton, 6x6, M52. |  |  |  |  |  |  |
| Codling tower, semitrailer-mtd, 4 -sec., 2400 GPM |  | 17.3 | 17.3 | -- | 13 | 13 |
| Semitrailer, tank, gasoline, 12 -ton, 4 -whl, 5000 -gal., M131 | 16.93 | 26.74 | 32.20 | 13 | 22 | 28 |
| Semitrailer, tank, gasoline, 12 -ton, 4 -whl, 5000 -gal., M131C | 16.58 | 27.77 | 33.86 | 13 | 24 | 30 |
| Semitrailer, van, cargo, 12-ton, 4 -whl, M127 | 16.25 | 28.25 | 34.25 | 12 | 25 | 31 |
| Semitrailer, low-bed, 15 -ton, 4 -whl, M172 | 16.78 |  | 31.78 | 12 | - - | 25 |
| Semitrailer, low-bed, 25 -ton, 4-whl, M172A1 | 16.78 |  | 41.78 | 12 |  | 35 |
| Semitrailer, low-bed, wercker, 12 -ton, 4 -whl, M270 | 18.25 | 30.25 | 38.25 | 13 | 23 | 30 |
| Semitrailer, tank, alcohol, 3000-gal., 2-whl, M338 | 13.21 | 21.19 | 21.19 | 10 | 18 | 18 |
| Semitrailer, stake, 12 -ton, 4 -whl, M127A1 | 15.68 | 27.78 | 33.78 | 12 | 23 | 29 |
| Semitrailer, mobile, sawmill, Sawmobile Model 58 |  | 28.87 | 28.87 |  | 22 | 22 |
| Truck, tractor, 10 -ton, 6x6, M123. |  |  |  |  |  |  |
| Semitrailer, tank transporter, 50-ton, 8-whl, M15A2 | 33.20 |  | 89.83 | 21 | -- | 72 |
| Semitrailer, tank transporter, $45-$ ton, 8 -whl, M15A1 | 35.66 | -..- | 80.66 | 24 | -- | 65 |
| Semitrailer, tank transporter, 45-ton, 8-whl, M15 | 35.66 | ---- | 75.66 | 24. | -- | 60 |
| Semitrailer, tank, gasoline, 12-ton, 4-whl, 5000-gal., M131 | 21.90 | 31.71 | 37.17 | 17. | 26 | 31 |
| Semitrailer, low-bed, wrecker, 12-ton, 4-whl, M269 | 21.57 | 33.57 | 41.57 | 16 | 26 | 33 |
| Semitrailer, low-bed, 25-ton, 4-whl, M172A1 | 22.63 | -47.63 | 52.63 | 17 | 37 | 42 |
| Truck, tractor, 12 -ton, 6x6, M26. |  |  |  |  |  |  |
| Trailer, low-bed, 60-ton, Rogers Model D-60-DS | 41.45 | ---- | 101.45 | 30 | -- | 108 |
| Semitrailer, tank transporter, 45-ton, 8-whl, M15A1 | 45.64 | --- | 90.64 | 32 | -- | 73 |
| Semitrailer, tank transporter, 40-ton, 8-whl, M15 .- | 45.64 |  | 85.64 | 32 |  | 68 |
| Semitrailer, tank, gasoline, 12-ton, 4-whl, 5000-gal., M131 | 31.88 | 41.69 | 47.15 | 25 | 33 | 37 |
| Truck, tractor, wrecker, 5 -ton, 6x6, M246. |  |  |  |  |  |  |
| Dryer, aggregate, 80-120 TPH, tlr-mtd, Barber Green Model 833. |  | ---- | 43.66 | -- | -- | 35 |
| Trailer, ammunition, 8-ton, 4-whl, M23, w/limber, carriage M5 | 22.35 |  | 38.53 | 18 | - | 32 |
| Mixer, bituminous material, $110-200 \mathrm{TPH}$, tlr, mtd, Barber Greene Model 848. | 29.91 |  | 42.19 | 24 |  | 35 |
| Semitrailer, tank, gasoline, 12-ton, 4-whl, 5000-gal., M131 | 23.85 | 33.66 | 39.12 | 19 | 28 | 33 |
| Semitrailer, low-bed, 12 -ton, 4 -whl, M270A1 | 25.17 | 37.17 | 37.17 | 19 | 28 | 28 |
| Tractor, full-tracked, high-speed, 13-ton, M5. |  |  |  |  |  |  |
| Howitzer, medium, towed, 155 mm , M114 |  | 21.61 | 21.61 |  | 18 | 18 |
| Gun, antiaircraft, artillery, towed, 90 mm , M118 |  | 19.32 | 19.32 |  | 16 | 16 |
| Tractor, full-tracked, high-speed, 18-ton, M4. |  |  |  |  |  |  |
| Howitzer, heavy, towed, 8-inch, M115 | ---- | 30.50 | 30.50 |  | 25 | 25 |
| Gun, antiaircraft, artillery, towed, 90 mm , M2, mount 90 mm , M2. | -- | 30.95 | 30.95 |  | 27 | 7 |

## 3-16. International (Geneva Convention) Road Signs

The road signs discussed in this paragraph were agreed upon at the United Nations Conference on Road and Motor Transport in 1949. Although these signs are not military, Army personnel should be familiar with them since they are used in oversea areas.
a. Dimensions of Signs. Dimensions of various signs are standardized in each country to insure maximum uniformity. In general, two
sizes are used for each type of sign-a standard size and a reduced size for use where conditions do not permit or the safety of road users does not require erection of the standard size. In exceptional circumstances, a small sign may be used inside built-up areas or for repetition of the main sign.
b. Danger Signs (class I) (fig. 3-10). Danger signs are in the shape of an equilateral triangle with one point upward, except in the case of the sign PRIORITY ROAD AHEAD


DANGEROUS BEND


DOUBLE BEND (FIRST TOTHE LEFT)


OPENING ERIDGE


CHILDREN


LEVEL R.R. CROSSING WITH GATES


DOUBLE BEND (FIRST TO THE RIGHT)
 WITHOUT GATES


Right bend
LEFT BEND


dangerous hill
LEVEL CROSSING

other danger


PEDESTRIAN CROSSING


PRIORITY ROAD
AHEAD


ROADWAY NARROWS (APPROACH SIGN)
Figure s-10. International road signs-danger.


STOP AT INTERSECTION


BICYCLES PROHIBITED


NO RIGHT TURN


NO ENTRY FOR VEHICLES HAVING OVERALL WIDTH EXCEEDING


STOP--CUSTOMS


NO STOPPING OR WAITING


NO ENTRY FOR VEHICLES EXCEEDING WEIGHT
 EXCEEDING_METERS


CLOSED TO ALL VEHICLES



NO ENTRY FOR GOODSCARRYING VEHICLES EXCEEDING_TONS LADEN WEIGHT


NO PARKING

Figure 3-11. International road signs-definite instructions.
which has one point downward. These signs have red borders with white or yellow backgrounds. Symbols are black or some other dark color. For signs of standard size, the length of each side of the triangle is not less than 2 feet 11.4 inches ( 0.90 m ), and, for the reduced size, not less than 1 foot 11.6 inches ( 0.60 m ). Signs are not more than 7 feet 2.6 inches ( 2.20 m ) above the ground at the highest point. Away from built-up areas, they are not less than 1 foot 11.6 inches ( 0.60 m ) above the ground at the lowest point. Signs are so placed that they are clearly visible but do not impede pedestrians.
c. Signs Giving Definite Instructions (class II). The signs of this class indicate an order, which may be in the nature of either a prohibition or an obligation (fig. 3-11). They are circular with a diameter of at least 1 foot 11.6 inches ( 0.60 m ) for signs of standard size, and at least 1 foot 3.7 inches ( 0.40 m ) for signs of reduced size. They are placed in the immediate vicinity of the point where the prohibition or obligation begins and at intervals along the route. They are not more than 7 feet 2.6 inches $(2.20 \mathrm{~m})$ above the ground at the highest point, and not less than 1 foot 11.6 . inches ( 0.60 m ) above the ground at the lowest point.
(1) Prohibitory signs (class II A). These signs are white or light yellow with red borders, and the symbols are black or some other dark color. Examples of signs in this category are-
(a) Prohibitions for all traffic.
(b) Prohibitions for certain classes of vehicles.
(c) Restrictions on the dimensions, weight, or speed of vehicles.
(2) Mandatory signs (class II B). These signs are blue with white symbols. Examples of mandatory signs are-
(a) A direction to be followed.
(b) Where cyclists must ride.
d. Informative Signs. (class III) (fig. 3-12). Signs of this class are rectangular. Where the colors are not specifically prescribed, red does not dominate.
(1) Indication signs (class III A). Signs of this type are used to indicate parking areas, hospitals, first aid stations, telephones, filling stations, and priority roads. These signs have blue backgrounds, except those indicating priority roads. Signs indicating priority roads are diamond shaped and are white with black or dark rims on the outside and have yellow centers. Priority road signs are square with one point downward. The side of the square is at least 1 foot 11.6 inches ( 0.60 m ) for the standard size, and at least 1 foot 3.7 inches ( 0.40 m ) for the reduced size. For signs repeated within built-up areas, the side of the square is 9.8 inches ( 0.25 m ).
(2) Advance direction signs and direction signs (class III B). The size of these signs is such that the indication can be understood easily by drivers in time to enable them to comply. They have either light backgrounds with dark lettering or dark backgrounds with light lettering. Advance direction signs are placed at a distance of between 328 feet ( 100 m ) and 820 feet ( 250 m ) from the intersection on normal roads. On special roads, e.g., concrete multilane roads, this distance is increased to 1,640 feet ( 500 m ). Direction signs are rectangular with the longer side horizontal and end in an arrowhead. Names of places lying in the same direction may be added to the sign. Colors of these signs are the same as for advance direction signs. When distances are indicated, the figures giving distances are inscribed between the name of the place and the arrowhead.
(3) Place identification signs (class III C). Signs indicating a locality are rectangular with the longer side horizontal. They are of such size and location that they are visible at night. They have either light backgrounds with dark lettering, or dark backgrounds with light lettering. They are placed before the beginning of a built-up area, and at other points necessary to indicate place locations.

## 3-17. NATO Military Road Signs

To facilitate the movement of armed forces of the North Atlantic Treaty Organization (NATO) in any territory controlled by opera-



MECHANICAL HELP


TELEPHONE


LEVEL R.R. CROSSING WITHOUT GATES IN IMMEDIATE VICINITY


END OF SPEED LIMIT


PRIORITY ROAD


APPROACH TO END OF PRIORITY ROAD


END OF PRIORITY ROAD

Figure 3-12. International road signs-informative.

## Stockholm 17

## 

## DISTANCE SIGNS



LOCALITY SIGNS


DIRECTION
SIGNS
MILESTONE


A


B


C


0

SUPPLEMENTARY RAILWAY SIGNS
IF SIGN A OR SIGN B IS DISPLAYED, IT MUST BE FOLLOWED EY SIGN C AND THEN SIGN D, INDICATING $2 / 3$ AND $1 / 3$ OF THE DISTANCE TO THE DESIGNATED POINT DESCRIBED IN THE ORIGINAL SIGN.

Figure 3-12-Continued.


DIRECTIONAL DISK



FORK LEFT


AXIAL ROUTE 205
TO REAR, STRAIGHT AHEAD


AXIAL ROUTE 205
TO REAR, TURN LEFT


DETOUR

LATERAL ROUTE 202 NORTHBOUND TRAFFIC TO FRONT, FORK RIGHT

CASUALTY EVACUATION ROUTE

(ALL MEDICAL UNITS EXCEPT TURKISH) (TURKISH MEDICAL UNITS)
Figure 3-1s-Continued
tional military command or a national authority, a standard system:of military route signs has been adopted by member governments. This system includes signs which the Geneva Convention already prescribes (para 3-16) and others not included in the Geneva Convention. Standard signs include hazard signs, regulatory signs, and guide signs. Examples are shown in figure 3-13.
a. Hazard Sign. This sign indicates a traffic hazard and is used only in areas under military authority. A hazard sign is square and is placed with one corner pointing downward. A purely military sign not included in the International (Geneva Convention) System or host country's system has a yellow background with the legend or symbol in black. If the sign is included in the International System or host country's system, the International or host country's sign is used to the same yellow background instead of the black symbol or legend.
b. Regulatory Sign. This sign is used to regulate and control traffic and to define the light line. A regulatory sign is square. It has a black background on which the legend is superimposed in white with the following exceptions: bridge classification signs, stop signs, no entry signs, blackout signs, and signs erected by the military for the control of civilians under specified conditions. Descriptions of the excepted regulatory signs are contained in STANAG No. 2010 and STANAG No. 2012 (Edition No. 2).
c. Guide Sign. A guide sign is used to indicate locations, distances, directions, routes, and similar information.
(1) A guide sign for a route is rectangular with the long axis vertical. The legend or symbol and route number are superimposed in white on a black background. Odd numbers are used for axial routes, and even numbers designate lateral routes.
(2) A directional disk is used as a supplement to other guide signs to indicate the direction of a route or as an appendage to any major-unit sign to indicate the route to that unit. The disk is less than 16 inches ( 0.41 m ) in diameter and has a black arrow, with or
without bar, on a white background. Eight equally spaced holes around its circumference allow the disk to be nailed with the arrow pointing in any direction. Battalions and lower units are not permitted to install directional disks.
(3) A guide sign for a casualty evacuation route is either rectangular or cross-shaped with symbols in red on a white background.
(4) A detour sign has a white arrow, barred or not, on a blue square. The sign is placed so that one corner of the square points downward.

## 3-18. Marking of Contaminated on Dangerous Land Areas

Roads and areas within NATO nations containing radiological, biological, or chemical contamination; minefields; boobytraps; or unexploded bombs will be marked by triangular signs in accordance with the details of the agreement of STANAG No. 2002. Examples are shown in figure 3-14.

## 3-19. NATO Markings for Military Vehicles

a. General. The armed forces of NATO have agreed to use the standard markings for vehicles described below. (SEATO Military Vehicle Markings are prescribed by CSTAG 20-27.) The markings listed are not necessarily used at all times, but when they are used, vehicles are marked in accordance with the following paragraphs. The rear of a trailer is marked in the same way as its prime mover; there is no need to mark the front of a trailer. When necessary for security reasons, vehicle marking may, by direction of the field commander or his superior authority, be covered or removed.
b. Registration Numbers. The marking of vehicles for registration is as required by the nation concerned. Registration markings consist of numbers or a combination of letters and numbers.
c. National Symbols. National symbols are used to identify the vehicles of each country. At a minimum, symbols are shown front and rear. Service symbols may be superimposed up-


BOOBY TRAPS

## CHEMICAL <br> MINEFIELDS



## UNEXPLODED BOMB

Figure 3-14. Markings of contaminated or dangerous land areas (STANAG No. 2002).
on the national distinguishing symbols or shown separately by an additional symbol.
d. Speed Limits. Speed limit markings are placed on vehicles as directed by the nation concerned.
e. Tactical Markings. Tactical markings serve in general as identification markings within units; they consist of stripes and geometrical figures or combinations thereof and may also include a name. Colors may be used. Markings should be large enough to make ground-to-ground identification of vehicles possible; they are used primarily for easy battlefield recognition. The design and position of these markings are prescribed by the field commander directing their use. They are removed when vehicles are permanently released from the jurisdiction of the commander who prescribed their use.
f. Ground-to-Air Recognition. Equipment for these markings consists of red and yellow fluorescent panels equipped with tie cords. Panel dimensions are approximately 6 feet by 2 feet 3 inches ( 1.80 m by 0.68 m ). Panels are draped on vehicles in a standard, unchanging pattern that differs from the displays prescribed for other recognition purposes (frontlines, targets, etc.). Theater commanders prescribe the arrangement of panels and the conditions under which they will be used.
g. Special. Military police vehicles and other traffic control vehicles are identified, front and rear, with the prescribed markings. Ambulances and other vehicles used exclusively for medical purposes are marked according to the rules of the Geneva Convention. Such markings consist of one red cross or crescent
on a square white background painted on the side body panels, roof of body, roof of driver's cab, and rear door (s) or panel.
h. Bomb Disposal Units. Vehicles of bomb disposal units have all fenders painted red.
i. Danger. A red flag flown from any vehicle indicates DANGER.
j. Priority Vehicles. Any vehicle which for any reason (special liaison officer, signal vehicles carrying priority dispatches, damage assessment personnel, etc.) requires priority over all other vehicles may be so marked by any commander having area responsibility. Such priority markings are valid only in the area of the commander concerned. The markings consist of equilateral triangles with red borders and symbols on white backgrounds on the front and rear of the vehicle (fig. 315). A single priority sign may be used if visible from both front and rear. The size of a priority sign should be as large as the dimensions of the vehicle permit. The symbol inside the triangle indicates the commander authorizing use of this priority sign. This sign must be removable in order to avoid misuse and is used only on direct orders of the commander concerned.

k. Organization of Columns.



Figure 3-15. Vehicle priority sign.
(1) A column of vehicles is a group of at least 10 vehicles moving under a single commander, over the same route, in the same direction.
(2) To facilitate control, large columns may be broken down to serials and march units.
(3) Each column and each organized element must include the following:
(a) A commander, whose place in the column may vary. The pace setter of the first element of a column leads it and regulates its speed.
(b) In the first vehicle, a subordinate commander known as the pace setter.
(c) In the last vehicle, a subordinate commander known as the trail officer. The trail officer of the last element deals with such problems as occur at the tail of the column.

## l. Identification of Columns.

(1) Each column will be identified in accordance with STANAG No. 2027, i.e., blue flag on leading vehicle, green flag on last vehicle. In addition, when movement is being carried out at night, the leading vehicle will show a blue light and the last vehicle will show a green light. The vehicle of the column commander displays a flag that is bisected by a diagonal line to form two triangles. The upper triangle is white; the lower is black. In areas where vehicles drive on the left side of the highway, the flags are mounted on the right side of the vehicle; otherwise, they are mounted on the left side.
(2) Each column will be identified by a number known as "movement number" or identification serial number" which is allocated at the same time as the "movement credit" by the authority organizing the movement ( $m$ below). This number will identify the column during the whole of the movement.
(3) The number will be placed on both sides and, if possible, on the front of all vehicles composing the column so as to be clearly visible. It will be composed of the following :
(a) Two figures indicating the day of
the month on which the movement is due to commence.
(b) Three or four letters indicating the authority organizing the movement. The first two letters will be the national symbols shown in STANAG No. 1059 (Edition No. 2).
(c) Two figures indicating the serial number allocated by the authority responsible for the movement. For example, 03-USV-08 will indicate that column No. 8, composed of $V$
corps vehicles, will be moved by United States authority on the third day of the current month.
(d) The elements of a column may be identified by adding a letter behind the movement number.

## m. Movement Credit.

(1) A movement credit is the time allocated to one or more vehicles to move over a supervised, dispatch, or reserved route.

(1) RIGHT TURN

(4) OPEN UP

(2) STOP

(5) close up

(3) LEFT TURN

(6) PASS AND KEEP GOING

Figure 3-16. Driver arm and hand signals.
(2) Besides the allocation of a movement number or identification serial number, a movement credit includes the indication of times at which the first and last vehicle of a column are scheduled to pass-
(a) The entry point-where the column enters the controlled route.
(b) The exit point-where the column leaves the controlled route.

## 3-20. Arm and Hand Signals

a. The safe operation of motor yehicles often depends upon the driver's knowing and using the arm and hand signals shown in figure 3-16.
$b$. The current concept of tactical operations requires that vehicle drivers be trained to operate their vehicles under blackout conditions and to recognize operational night hand signals (fig. 3-17). These signals provide a means of control at night or when radio silence and security requirements are at a maximum.
c. The arm and hand signals illustrated in figure 3-18 are the common means for transmitting visual messages within administrative and tactical units of the armed forces. They must be memorized and practiced until they become second nature. Visual signals are useless if not correctly and distinctly interpreted. The signals illustrated with a single-headed arrow indicate the signal is a single action which may be repeated until acknowledged or executed. Signals illustrated with a doubleheaded arrow are continuous until acknowledged or executed. For additional information see FM 21-60.

## 3-21. Basic March Formulas ${ }^{1}$

a. General. There are three basic march factors: distance ( $D$ ), rate ( $R$ ), and time ( $T$ ). When two are known, the third can be found by using the formula shown below. Corresponding units of measure must be used throughout.
$R=\frac{D}{T} \quad T=\frac{D}{R} \quad \underline{D}=\underline{R T}$
b. Rate Factors.

Rate $($ yards per minute $)=\frac{\text { length }(\text { yards })}{\text { past time }(\text { minutes })}$

[^48]Rate $($ meters per minute $)=\frac{\text { length (meters) }}{\text { pass time (minutes) }}$
Rate (miles in the


## c. Time Factors.

Pass time (minutes) $=\frac{\text { length (yards) }}{\text { rate (yards per minute) }}=$ length (meters)
rate (meters per minute)
Time lead (minutes) $=\frac{\text { lead (yards) }}{\text { rate (yards per minute) }}=$
$\frac{\text { lead (meters) }}{\text { (meters per minute) }}$
Time gap (minutes) $=\frac{\text { gap (yards) }}{\text { rate (yards per minute) }}=$
gap (meters)
rate (meters per minute)
Time space (hours) $=\frac{\text { road space (miles) }}{\text { rate (mih) }}=$ road space (kilometers)
rate (kmih)
Pass time (hours) $=\frac{\text { road distance (miles) }}{\text { rate (mih) }}=$ $\frac{\text { road distance (kilometers) }}{\text { rate (kmih) }}$ rate (kmih)
d. Distance Factors.

Length (yards) ${ }^{\prime}=$ rate (yards per minute) $\times$ pass time (minutes)
Length (meters) $=$ rate (meters per minute) $\times$ pass time (minutes)
Lead (yards) $=$ rate (yards per minute) $\times$ time lead (minutes)
Lead $($ meters $)=$ rate $($ meters per minute $) \times$ time lead (minutes)
Gap $($ yards $)=$ rate $($ yards per minute $) \times$ time gap (minutes)
Gap. (meters) $=$ rate $($ meters per minute) $\times$ time gap (minutes)
Road space $($ miles $)=$ rate $(m i h) \times$ time space (hours)
Road space $($ kilometers $)=$ rate $(k m i h) \times$ time space (hours)
Road distance $($ miles $)=$ rate $(m i h) \times$ time distance (hours)
Road distance $($ kilometers $)=$ rate $(\mathrm{kmih}) \times$ time distance (hours)
e. Time-Distance Factors (fig. 3-19). When the speed in miles or kilometers per hour is known, the time in minutes or the distance in miles or kilometers traveled can be quickly determined from a time-distance graph (fig.

(2) Turn right. The light is rotated in the direction of the turn.

(5) Move in reverse. Thè light is held at shoulder level and blinked several times toward the vehicle.

Figure 3-17. Night hand signals.

A. ATTENTION

E. MOUNT


1. INCREASE SPEED, OR DOURLE TIME, OR RUSH

M. MOVE AHEAD. OR JOIN ME: OR FOLLOW ME

Q. HALT; OR STOP

B. ASSEMBLE

F. DISMOUNT

I. DECREASE SIPEED (Vehicles)

N. MOVE IN- REVERSE

R. CLOSE UP AND STOP

C. READY

G. START ENGINE(S). OR PREPARE TO MOVE

O. EXTEND (From Turret, Ground, or Open Vehicle)

S. DISREGARD PREVIOUS COMMAND: OR AS YOU WERE

D. FORWARD. OR TO| THE REAR (Vehicles or individuals |turn simultaneously)


H, STOP ENGINE (S)

L. LEFT TURN: OR
COLUMN LEFT

P. CLOSE UP (From Turret,

Ground or Open Vehicle)


Figure 3-18.-Motor march arm and hand signals.

3-20). For example, if a convoy moves at a speed of 15 miles per hour ( 24.14 kmph ) for a 2 -hour period, the distance traveled can be determined by-
(1) Locating the oblique line marked 15 mph (24.14 kmph).
(2) Locating the horizontal line, extending from the left margin, representing the 2 hours traveled.
(3) Determining the point at which these two lines intersect and reading the distance in miles or kilometers from scale along the bottom (miles) or top (kilometers) margin of the
graph. For this example, the distance traveled would be 30 miles ( 48.27 km ).

## f. Conversions.

(1) The following factors may be converted into distance, rate, or by arithmetic:

Length + gap $=$ lead
Pass time (time length) + time gap $=$ time lead Distance (miles) $\times 1,760=$ distance (yards)
Distance (kilometers) $\times 1,000=$ distance (meters)
Time (hours) $\times 60=$ time (minutes)
Rate ( mih ) $\times 30=$ approximate yard per minute
Rate (kmih) $\times 17=$ approximate meters per minute
(2) These factors are substituted in the


Figure 3-19. Space and time factors.


Figure 3-20. Time-distance graph.
basic formulas in a through $d$ above. For example.

> Pass time (minutes) $=\frac{\text { miles } \times 1,760}{\operatorname{mih} \times 30}=$ $\frac{\text { kilometers } \times 1,000}{\text { kmih } \times 17}$
> Speed (yards per minute) $\quad \frac{\text { miles } \times 1,760}{\text { hours } \times 60}$
> Speed (meters per minute)
> $\frac{\text { kilometers } \times 1,000}{\text { hours } \times 60}$

## 3-22. Basic Lengths

The length of any column or element of a column is the length of roadway which it occupies, measured from front to rear inclusive. For planning purposes, the average length of one motor transport vehicle is 10 yards (approximately 9 meters).

## 3-23. Road-Movement Graph

a. Definïtion. A road-movement graph (fig. $3-21$ ) is a time-space diagram used in controlling both foot and road marches and in
preparing or checking road-movement tables. The graph helps the planner to foresee possible conflicts and discrepancies in planning.
b. Uses. Road-movement graphs may be used to indicate-
(1) Position of various mixed traffic on a route at a particular time.
(2) Scheduled passing of various elements of traffic at a particular point.
(3) Conflicts between various elements of traffic at junctions, intersections, bridges, and defiles.
(4) Deviations of columns from prescribed schedule.
(5) Reversing directions of march, either by simultaneous turn of all elements of a column or by circling about.
(6) Two-way traffic over a route and alternating traffic through defiles.
(7) Variations in actual running speeds and in the traffic flow and traffic density of a route.

## c. Construction.

(1) Analyze the route on the map. Note important points, such as cities, towns, road junctions, bottlenecks, etc., to be passed through and the distance between major points along the route.
(2) Select graph paper with enough squares to plot distance and time involved. Across bottom left to right, place scale of time. In left margin, from bottom to top, place scale of distance.
(3) If the origin and destination, rate of march, and time of departure of a movement are known, schedule the head of the column as follows:
(a) Assume that a unit is to march from Mount Royal ( 25 miles ( 40.2 km ) on the vertical scale), leaving a 0700 hours and proceeding at 15 miles in the hour ( 24.1 kmih ) to a point 5 miles ( 7.4 km ) beyond Tavistock. The distance is 60 miles ( 96.5 km ). At 15 miles in the hour, it will require 4 hours to cover the 60 miles.
(b) Place a dot at the point where the


Figure 3-21. Road-movement graph.
line representing the place of departure (Mount Royal at 25 miles ( 40.2 km ) on the vertical scale) intersects the line representing the hour of departure ( 0700 hours on horizontal scale).
(c) Place a second dot at the point where the line representing the destination (5 miles past Tavistock at the 85 -mile ( 136.7 km ) mark on the vertical scale) intersects that of hour of scheduled arival of the head of the column at the destination ( 1100 hours on the horizontal scale or 0700 plus 4 hours).
(4) Unless the unit is very small, usually it is desirable to show the schedule of the tail of the column as well as the head. After charting the schedule of the head, schedule the tail of the time length of the column is known or can be computed. Assuming that the time length of the column, including extra time allowance, is 30 minutes, a line drawn from the point representing the clearance of the column
at origin ( 0730 hrs ) and at the destination ( 1130 hrs ) will be shown the schedule of the tail of the column past all points en route.
(5) To determine what time the column must start to complete the movement and arrive at the destination at a certain hour, reverse the above procedures.
d. Analysis. Length of column, pass time (time length), rate of march, and other factors may be determined from the road-movement graph as follows:
(1) Length of column. A vertical line connecting the head and tail lines, measured by the scale of miles or kilometers, will show the planned length of the column on the road at the prescribed rate of march at any hour during the movement, provided that the extra time allowance, if any, converted to distance is subtracted from the measurement.
Example: When the head of the column is at

Stevens ( 45 miles ( 72.4 km ) on vertical scale), the tail will be at approximately the 38 -mile (61.1-km) mark.
(2) Pass time (time length). A horizontal line connecting the head and tail lines, measured by the scale of hours, will show the planned pass time of the column as it passes any point on the road.
Example: If the head of the column arrives at Tavistock at 1040 hours, the tail will not clear that point until half an hour later, at 1110 hours.
(3) Rate of march. The diagonal line of the graph indicates the rate of march. Example: The distance (mile or kilometer scale) between the intersection of the diagonal line with any two vertical lines spanning a 1-hour period (time scale) indicates the distance in that hour.

## e. Multiple Movements.

(1) A number of serials or columns over the same route can be scheduled by using a road-movement graph. The commander of a large unit or the highway regulation officer
can keep accurate records of the location of each serial by having information sent to him as each serial reaches or clears highway regulation points along the route of march. This information is indicated by filling in the space between the lines representing the scheduled head and tail of each column with color or tape. This enables the headquarters to see at a glance the location of each serial, to follow the progress of each movement, to correct situations which may cause congestion and delay, and to know where each serial can be reached in order to issue new orders if necessary.
(2) Colored pencils, crayons, ink, or adhesive tape may be used to indicate various schedules and the relative priority of movements or to plot movements in progress. For example, the head and tail schedule may be outlined by black lines, progress of each serial may be filled in with green, and failure to adhere to the schedule may be shown in red.
(3) Figure 3-22 shows the plotted progress of serials scheduled in figure 3-21. Note the changes and adjustments in schedules that had to be made. This is what happened-

mt royal


Figure 3-22. Deviations from schedules.
(a) Serial A. Went through as scheduled.
(b) Serial B. Change in orders required that serial $B$ continue on to Dundalk. It continued on schedule, and the head of the column arrived at its new destination at noon.
(c) Lateral movement. Because of a change or orders for serial B, arrangements had to be made to hold the lateral movement at McLean. It made its noon halt and crossed the route 3 hours behind its original schedule, not clearing until 1830 hours.
(d) Serial C. At 1200 hours it became obvious that if serial $C$ continued on schedule, it would conflict with the delayed lateral movement at about 1730 hours. Serial $C$ also had lost priority, because of the arrival of serial B and Dundalk with critically needed supplies. Therefore, serial $C$ was halted for 2 hours (from 1200 to 1400 hours). It continued at a slower rate of march until 1700 hours, when it was halted again to let serial $D$ pass.
(e) Serial $D(D-1, D-2, D-3)$. All elements went through on schedule.

## 3-24. Traffic Density

$a$. Traffic density is the average number of vehicles occupying a specified length of roadway at a given instant. Traffic density is expressed in vehicles per mile or kilometer and can be determined by the formulas shown below.
b. Any traffic density desired for dispersion or for maintaining the maximum capacity of a route may be arrived at by selecting an appropriate intervehicular gap and using the following formulas:

$$
\frac{1 \text { mile in yards }}{\text { Desired intervehicular gap in yards }}+\text { avg length }
$$ of 1 veh = vehicles per mile

$\frac{1 \text { kilometer in meters }}{\text { Desired intervehicular gap in meters }}+$ avg length of 1 veh = vehicles per kilometer
Example: If vehicles are dispersed every 100 yards ( 91.4 m ), density is-

$$
\begin{aligned}
& \frac{1,760}{100+10}=16 \text { vehicles per mile } \\
& \frac{1,000}{91.4+9}=10 \text { vehicles per kilometer }
\end{aligned}
$$

c. When the speed and speedometer multiplier are known, traffic density may be determined by using the following formulas:
$\frac{1 \text { mile in yards }}{\text { (Speed in mph } \times \text { speedometer multiplier) }}+$ avg length of 1 veh $=$ vehicles per mile

$$
\frac{1 \text { kilometer in meters }}{\frac{\text { (Speed in kmph } \times \text { speedometer multiplier) }}{\text { (Sper }}+\mathrm{avg}} \begin{aligned}
& \text { length of } 1 \text { veh }=\text { vehicles per kilometer }
\end{aligned}
$$

Example: If the speed of a column is 20 miles per hour ( 32.19 kilometers per hour) and speedometer multipliers of 2 for miles and 1.2 for kilometers are used, traffic density is-

$$
\begin{aligned}
& \frac{1,760}{(20 \times 2)+10}=35 \text { vehicles per mile } \\
& \frac{1,000}{(32.19 \times 1.2)+9}=21 \text { vehicles per kilometer }
\end{aligned}
$$

d. At a constant speed, traffic density can also be determined by counting the number of vehicles passing a given point in a period of time. Use the following formulas:
$\frac{\text { Vehicles per hour passing point }}{\text { Speed in miles per hour }}=$ vehicles per mile
$\frac{\text { Vehicles per hour passing point }}{\text { Speed in kilometers per hour }}=$ vehicles per kilometer
Example: If 500 vehicles pass a given point in $1 / 2$ hour at 20 miles per hour ( 32.19 kilometers per hour), traffic density is determined as follows:

500 vehicles per $1 / 2$ hour $=1,000$ vehicles per hour
$\frac{1,000}{20}=50$ vehicles per mile
$\frac{1,000}{32.19}=31$ vehicles per kilometer

## 3-25. Road-Movement Table

a. A road-movement table provides a convenient means of transmitting to subordinates information about schedules and other essential details. This is particularly so if the inclusion of such details in the body of the operation order would tend to complicate it or make it unduly long. Tables frequently require a wider distribution than normal operation orders because copies are issued to convoy operating personnel, traffic regulating personnel, and traffic control posts. For security reasons,
it may not be desirable to include dates or locations. Security classification is given in accordance with contents of the table; it is not necessarily the same as that of the operation order. If the table is issued by itself and not as an annex to a more detailed operation or administrative order, it must be signed and/or authenticated in the same manner as other orders.
b. The beginning of the table includes general information common to two or more
serials, e.g., security classification, maps, average speed, traffic density, halts, main routes to the start and release points, and information about other critical points. Information concerning the routes and critical points is normally described by grid references, codewords, etc., and, if necessary, may be numbered or lettered for ease of reference to the columns in the table. The remainder of the table includes information concerning each individual serial and is arranged in tabular form. A sample road movement table is shown below.
$\qquad$ to $\qquad$ (Formation/Unit) Operation Order No.

Maps

1. Average speed
2. Traffic density
3. Halts
4. Routes (between start points and release points may be indicated by code-red, green, etc.)
5. Critical points ${ }^{1}$
a. Start points
b. Release points
c. Other critical points
6. Main routes to start These routes and points may be depoints
7. Main routes from release points
scribed by grid references, codewords, etc., and if necessary, numbered or lettered for ease of reference in the columns below.

| Serial ${ }^{8}$ <br> (a) | Date <br> (b) | Unit formation <br> (c) | No. of vehicles(d) (d) | $\begin{gathered} \text { Load class } \\ \text { of } \\ \text { oeaviest } \\ \text { vehicles } \\ \text { (e) } \end{gathered}$ | From <br> (f) | To <br> (g) | Route <br> (h) | Route <br> to <br> start <br> point <br> (j) | Critical pointa ${ }^{\text {a }}$ |  |  | $\begin{gathered} \text { Route from } \\ \text { release } \\ \text { point } \\ (n) \end{gathered}$ | Remarks ${ }^{\text {a }}$ <br> (o) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  | Ref <br> (k) | $\begin{gathered} \text { Due } \\ \left(\begin{array}{c} \text { hrg } \\ (1) \end{array}\right. \end{gathered}$ | (clear |  |  |
| 1 | 23 Oct | 46 Trans Co 51 Trans Co (Lt Trk) | 90 | 21 | Marseille | Montelimar | N 113 <br> N 538 N 7 | City | Marseille | 0800 | 0818 | N 540 | Return to Marseille immediately after unloading as Serial 1A. |
|  |  |  |  |  |  |  |  |  | Salon | 0935 | 0935 |  |  |
|  |  |  |  |  |  |  |  |  | Plan-Orgon | 1016 | 1034 |  |  |
|  |  |  |  |  |  |  |  |  | Avignon | 1059 | 1117 |  |  |
|  |  |  |  |  |  |  |  |  | Orange | 1150 | 1208 |  |  |
|  |  |  |  |  |  |  |  |  | Pierralatte | 1250 | 1308 |  |  |
|  |  |  |  |  |  |  |  |  | Montelimar | 1330 | 1348 |  |  |
| 2 | 23 Oct | 67 Trans Co <br> 70 Trans Co (Lt Trk) | 120 | 21 | Marseille | Montelimar | N 113 <br> N 538 N 7 | City | Marseille | 0820 | 0851 | N 540 | Relieved from at tachment upon closing in Marseille. |
|  |  |  |  |  |  |  |  |  | Salon | 1003 | 1026 |  |  |
|  |  |  |  |  |  |  |  |  | Plan-Orgon | 1044 | 1107 |  |  |
|  |  |  |  |  |  |  |  |  | Avignon | 1127 | 1150 |  |  |
|  |  |  |  |  |  |  |  |  | Orange | 1218 | 1241 |  |  |
|  |  |  |  |  |  |  |  |  | Pierralatte | 1318 | 1341 |  |  |
|  |  |  |  |  |  |  |  |  | Montelimar | 1358 | 1421 |  |  |
| 3 | 23 Oct | 89 Trans Co 90 Trans Co (Med Trk) | 115 | 21 | Marseille | Montelimar | N 113 N 538 N 7 | N 8 | Marseille | 0901 | 0925 | N 540 | Halt in place south of Avignon. Resume march at 1335 hours. |
|  |  |  |  |  |  |  |  |  | Salon | 1036 | 1100 |  |  |
|  |  |  |  |  |  |  |  |  | Plan-Orgon | 1117 | 1141 |  |  |
|  |  |  |  |  |  |  |  |  | Avignon | 1201 | 1359 |  |  |
|  |  |  |  |  |  |  |  |  | Orange | 1426 | 1450 |  |  |
|  |  |  |  |  |  |  |  |  | Pierralatte | 1526 | 1550 |  |  |
|  |  |  |  |  |  |  |  |  | Montelimar | 1605 | 1629 |  |  |

[^49]c. A strip map (fig. 3-23) may also be published as an annex to an operation order. When a strip map is used, its details should correspond to the data in the road movement table and it should be distributed to the lowest practical level.


Figure 3-23. Sample strip map.

## 3-26. Convoy Commander's Checklist

If each item listed below is checked and acted upon carefully by the convoy commander before departure time, the chances of neglecting some important arrangement will be minimized.
a. Where is start point?

Release point?
b. What route is to be used?
c. Has reconnaissance been made and condition of route determined?
d. Can bridges and defiles safely accommodate all loaded and/or tracked vehicles?
$e$. Are critical points known and listed on strip maps?
$f$. Has the size of serials been determined?
$g$. Has the size of march units been determined?
$h$. What will be the rate of march?
i. What is the vehicle interval on open
 areas? At halt? $\qquad$
j. Type of column?
$k$. Has provision been made for refueling, if required
$l$. Has a suitable bivouac site been selected, if required?
$m$. Have suitable rest and mess halt areas been selected, if required?
$n$. Is road-movement table needed?

## Prepared?

Submitted?
o. Have convoy clearances been obtained? What date?
$p$. Is escort required and has it been requested?
$q$. Are spare trucks available for emergencies?
$r$. Are vehicles fully serviced, clean, and ready for loading?
s. Is load proper, neat, and balanced? $\qquad$
$t$. Are drivers properly briefed? $\qquad$
By whom, when?
Strip maps furnished?
$u$. Is convoy marked front and rear of each march unit?
$v$. Are guides in place? Have arrangements been made to post guides? $\qquad$
$w$. Are blackout lights functioning?
$x$. Are maintenance services alerted? $\qquad$
$y$. Is maintenance truck in rear? -...-.-.-Are medics in rear? ................ Plan for casualties?
z. Are all interested parties advised of ETA?
aa. Is officer at rear of convoy ready to take necessary corrective action such as investigating accidents and unusual incidents and changing loads? Who is trail officer?
$a b$. Is there an entrucking plan?
Who is responsible?
ac. Is there a detrucking plan?
Who is responsible?
ad. Has a plan been made for feeding personnel?
ae. Have times been established for entrucking or loading?
$a f$. Has time been established for formation of convoy?
ag. Have times been established for detrucking or unloading?
$a h$. Has time been established for releasing trucks?
Who is responsible?
ai. Is there a carefully conceived plan known to all personnel in the convoy that can be used in case of attack?
$a j$. Is a written operation order on hand, if required?
ak. Will a $\log$ of road movement be required at end of trip?
Are the necessary forms on hand?
al. Has weather forecast been obtained?
am. Do all personnel have proper clothing and equipment?
an. Is there a communications plan?

## 3-27. Convoy Commander's Report

The convoy commander prepares this report after a move has been completed and normally submits it to his immediate superior officer. The sample report below may be used as a guide. However, the report may be submitted in the form of a strip map, with an appropriate legend attached.

FORWARD LOAD
420 Trans Bn
(Trk) $\quad \begin{gathered}4401 \text { Trans } \\ \text { Co. (Lt } \\ \text { Trk) }\end{gathered}$
TIME :
Convoy departed SP _-.- 0621
Convoy departed 1st loading point --------------- 0800
Convoy arrived at 1st loading point --------------- 0630
Time at 1st loading point _... 1 hr 30 min
Arrived at highway regulation point (HRP) ......-.-. 1200
Departed HRP ------- 1205
Departed 1st unloading point -..------------ 1245
Arrived at 1st unloading
point
1212
Time at 1st unloading point _-..-- 33 min
SUPPLIES AND PERSONNEL:
Cargo (short tons) ---.-.-.--.-.-.-. 50.2


DISTANCE:*
Speedometer reading of lead vehicle (1st
loading point) ---.-...--------- 21,324
Speedometer reading of lead vehicle
(SP) -....-.-.-.-......-.-.-.-.-.-. 21,322
Total forward (no load) ................. 2
Speedometer reading of lead vehicle (1st
loading point ------.-.-------------21, 281
Total forward (loaded) -----------.-. 57
REMARKS:
SP—Company area, RJ 124/167
Weak bridge 6.4 miles east of 1 st loading point. Road generally in poor condition between SP and 1st unloading point.

## RETURN LOAD

TIME:
Departed 2d loading point ..... 1300
Arrived at 2d loading point (same as 1st unloading point) --.-.-.-. 1245

Time at 2d loading point ...-.-...-15 min

[^50]Departed 2d unloading point ..... 1415
Arrived at 2 unloading point ..... 1400
Time at 2d unloading point ..... 15 min
SUPPLIES AND PERSONNEL:
Cargo (short tons) ..... 10
Class of supplies ..... II and IV
Personnel ..... 120
DISTANCE:*
Speedometer reading of lead vehicle ..... (2d
unloading point) ..... 21,396
Speedometer reading of lead vehicle (2d
loading point) ..... 21,381
Total return (loaded) ..... 15
Speedometer reading of lead vehicle(SP)12,436Total return (no load)40
REMARKS:
Road in excellent condition between 2d load-ing point and SP.
ROUND-TRIP DATA
TIME:
Time returned to SP ..... 1654
Total round-trip time ..... 10 hr 33 min
Total travel time (including halts) ..... 8 hr
Total loading time ..... 1 hr 45 min
Total unloading time ..... 48 min
SUPPLIES AND PERSONNEL:
Cargo (short tons of Class I) ..... 50.2
(short tons of Class II and IV) ..... 10
Personnel ..... 120
DISTANCE:*
Total distance (loaded) ..... 72
Total distance (unloaded) ..... 42
Total round-trip distance ..... 114
REMARKS:*Distances shown are in miles (multiply by1.609 to convert to kilometers). Average rateof march $=14.2 \mathrm{mih}=22.9 \mathrm{kmih}$. Ton-miles:Forward-2,861; Return-150. Passenger-miles: Forward-0; Return-1,800.
s/Thomas A. Young(Signature-convey commander)
2d Lt, 4401 Trans Co (Lt Trk)

## 3-28. Convoy Clearance

A convoy clearance request usually is required from a unit or organization that is planning a move by convoy. The information required varies according to local SOP and regulations. The sample outline below shows the information usually required by any authority that issues road clearances. When available, DD Form 1265 should be used. In a field army, the traffic headquarters normally determines routes to be used and issues road clearances.

From: S3 1429 TTBn
Phone: Barkersville 1429
Time and date: 261530 Oct 61
Authority for movement: MO 341, HQ TALOG, dated 19 Oct 61

Convoy No: 12B
Unit name or serial No.: 4406 T Car Co
Personnel: 4 Off 98 EM
Total number of vehicles: 51 trks, 31 tlrs
Type and number of vehicles: thirty-eight $1 / 4$-ton trks, twenty-five $1 / 4$-ton tlrs, one $8 / 4$-ton trk, four $11 / 2$-ton trks, eight $21 / 2$-ton trks, six 1-ton tlrs

## No. of serials: 3

Vehicles by type and number in serials (do not show control, mess, or maintenance vehicles) :
(1) Two $21 / 2$-ton trks, twelve $1 / 4$-ton trks, one $1 / 2$-ton trk, two 1 -ton tlrs, eight $1 / 2$-ton tlrs
(2) Same as 1st serial
(3) Same as 1st serial

Vehicle Distance: $\frac{60}{\text { (yards) }} \frac{55}{\text { (meters) }}$
Average length of vehicles and/or combinations: $\frac{10}{\text { (yards) }} \frac{9}{\text { (meters) }}$
Gap between serials:

$$
\text { Distance } \frac{2935}{(\text { yards })} \frac{2684}{(\text { meters })} \text { Time } \frac{5}{(\mathrm{~min})}
$$

Length of serials:

$$
\text { Distance } \frac{990}{(\text { yards })} \frac{905}{(\text { meters })} \text { Time } \frac{1.69}{(\mathrm{~min})}
$$

Total length of convoy:

$$
\text { Distance } \frac{8840}{\text { (yards) }} \frac{8043}{(\text { meters })} \text { Time } \frac{15}{(\mathrm{~min})}
$$

Cargo and tonnage ${ }^{2}: 36$ tons of baggage and organizational equipment.

Outsized or overweight loads: None
SP: Barkersville
Scheduled time and date of departure: 290700 Oct 61

Proposed route: Barkersville, RJ 261, Kennedy, Kleburg, Exeter

Destination: Exeter
Estimated time and date of arrival: 291900 Oct 61

Rate of march: $\quad \frac{20}{\text { (mih) }} \frac{32}{\text { (kmih) }}$
Scheduled halts: 15 min RJ 261; 1 hr Kennedy; 15 min Kelburg

Scheduled bivouacs: Arrive NA Depart: NA
POL points (determined by staff transportation officer) : NA

Highway regulation (determined by staff transportation officer): Advised Sgt Harris in office of staff transportation officer, 261015 Oct 61. Clearance granted by Lt Brown, office of staff transportation officer, 261230 Oct 61. Critical points:

| Name of Point | ETA | ETD |
| :---: | :---: | :---: |
| RJ 261 | 0900 | 0915 |
| Kennedy | 1215 | 1315 |
| Kleburg | 1615 | 1630 |
| Exeter | 1900 |  |

## Remarks ${ }^{3}$ :

1. POL points not needed. Convoy will be refueled by tankers during halt at Kennedy.
2. Unit commander will insure strict compliance with all SOP and with all highway regulation and control procedures issued by competent authority.
s/George A. Harkins
(Signature)
GEORGE A. HARKINS
Capt, S3 1429 TTBn
(Grade, title, and organization)
[^51]
## 3-29. Traffic Headquarters

a. Mission. The traffic headquarters coordinates the actual use of a road net to meet operational requirements. The traffic headquarters is normally established at division or higher levels.
b. Functions. The normal functions of a traffic headquarters include-
(1) Maintaining a situation map of the road net showing current data on road conditions.
(2) Implementing priorities established by the commander of highway movements.
(3) Receiving requests for highway routings and schedules from units within its area of jurisdiction.
(4) Consolidating itineraries and road movement tables and issuing movement credits as necessary.
(5) Receiving, coordinating, and disseminating information on highway movements into its area of jurisdiction.
(6) Coordinating movements terminating outside its area of jurisdiction with other headquarters.
c. Organization. The traffic headquarters is normally organized in the combat service support element supporting the tactical command. It is established under control of the G4. A highway planning officer is charged with operating the traffic headquarters.

## 3-30. Highway Schedule Request

This request is submitted by a unit desiring to use certain parts of the highway at specified times. Clearances are normally issued by post transportation officers, and highway regulation is not required. A sample request that shows the information usually required is given below.

1. FOR (UNIT): 4401st Trans Company (Light Truck)
2. ORIGIN: Fort Eustis, Va. DESTINATION: Camp A.P. Hill, Va.
3. DESTINATION INSTALLATION: Moss Neck area
4. VEHICLES BY TYPE:

| Wheeled |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Smaller <br> than <br> $21 / 2$-ton | $21 / 2$-ton | 5 -ton | Larger <br> than <br> 5 -ton | Tracked | Total |
| 5 | 45 | None | 1 | None | 51 |

REMARKS: Vehicle larger than 5-ton is a truck, 6-ton $6 \times 6$ wrecker
5. LIMITATIONS (SPECIAL SCHEDULING) : (a) LGTH: NA (b) WIDTH: NA (c) HGT: NA (d) WT: NA
6. (a) No. SERIALS: 3 (b) INTERVAL: $5 \min$ (c) No. MARCH UNITS: 9 (d) INTERVAL: 2 min within serials)
(e) TIME LENGTH: 28 min (f) RATE OF MARCH: 20 mih (g) TYPE OF CARGO: None (training mission)
h) TONS: None
7. CONVOY COMMANDER: 1st Lt James E. Brown
8. ROUTE AND SCHEDULE:

| (a) Critical points | (b) Arrive | (c) Clear | (d) Route | (e) MP <br> escort <br> required | (f) Remarks |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Main Gate, Ft Eustis, Va. | 210600 May 62 | 210628 May 62 | Rts 60, 238, 168, North | Yes |  |
| RJ Routes 168 and 30 | 210700 May 62 | 210728 May 62 | Rts 30 and 33, East | No |  |
| RJ Routes 33 and 17 | 210800 May 62 | 210828 May 62 | Rt 17, North | No |  |
| 9. PERSONNEL, IF LOGISTICAL SUPPORT REQUIRED: (a) OFF None (b) EM |  |  |  |  |  |
| None (c) OTHER None |  |  |  |  |  |
| 10. SUPPORT REQUIRED: None |  |  |  |  |  |

REQUESTED BY: Maj John P. Doe
DATE: 16 May 1962 TIME: 0800
MOVEMENT No: 23-2-62
ORGANIZATION: 23d Transportation Group (Truck)
RECEIVED BY: Lt Brown (Transportation Office)

## 3-31. Vehicle Loading

a. Responsibility. The driver is responsible for his vehicle being loaded properly.
b. Rules for Loading (fig. 3-24).
(1) Place heavy supplies at the bottom of the load and distribute evenly over cargo floor.
(2) Place the load so that it will not shift; distribute the weight equally.
(3) Do not distribute load loosely or build it up too high. High, loosely distributed
loads cause swaying, make the vehicle difficult to handle, and increase the danger of losing the cargo or overturning the vehicle.
(4) If the truck has an open body, put a tarpaulin, when practicable, over the cargo to protect it against sun, dust, rain, or pilferage.
(5) If possible, place barrels and drums on their sides-parallel with the length of the truck and brace and pyramid them. If the possibility of leakage does not permit this placement, set the drums' upright. This latter
arrangement does not permit the loading of as many drums in the same space.
(6) Combine boxed, crated, and packaged cargo, as far as possible, with like items or items of combining shapes.
(7) Load sacked cargo separately, or so as not to risk its being punctured by oddshaped or sharp-edged items; stack it in overlapping layers to prevent shifting.

## 3-32. Vehicle Capacities and Capabilities

The figures below should be used for planning purposes only. They are based upon experience gained in the field and are averages for the various makes and models of the equipment listed. Weather, roads, terrain, and tactical situation must also be considered.


WRONG


RIGHT

The right vehicle for the right job.


This overloads trailer rear wheels, brakes will not brake properly, rubber scuffs away. Distribute the load over the full trailer floor.

WRONG



WRONG
This overloads one spring and set of tires. Brakes lock on the light side, cause skids.


RIGHT
Nothing overloaded, frame will not twist and loosen crossmember rivets.


RIGHT

This overloads and shortens tire life, bends the truck rear-axle housing, Applying the trailer brakes may lock the wheels and cause flat spots

Figure s-24. How to load a truck.


Tires, axles, frame, etc., $\exists$ re designed to carry a load distributed as above.


Distribute trailer loads equally between the rear tires and the fifth wheel. This transfers the load to the tractor.


WRONG
This will bend the frame, overload front tires, making steering harder.


RIGHT
Place heavy part of load near rear axle for proper tire loading and to keep frame from bending.


Seta concentrated load just ahead of the rear axle with, if possible, the longest side on the floor.

## RIGHT

This kind of weight distribution bends the frame, overloads rear tires, and makes steering almost impossible.

Figure 3-24-Continued.
a. Local and Line Hauls.

| Type of equipment | Avg load veh trip | Loading and unloading time (hr) trip | Local hauls ${ }^{1}$ |  |  | Line hauls ${ }^{2}$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Avgdistanceforward |  | $\begin{aligned} & \text { Rovind } \\ & \text { trips } \\ & \text { per veh } \\ & \text { per day } \end{aligned}$ | Distance <br> in the <br> $h r$ |  | Avg daily distance capability |  |
|  |  |  | Mi | Km |  | Mi | Km | Mi | Km |
|  |  |  |  |  |  |  |  |  |  |
| 2112T, 6x6 | 4 tons | $21 / 2$ | 15 | 24 | 4 | 15 | 24 | 125 | 201 |
| 5T, 6x6 | 6 tons | $21 / 2$ | 15 | 24 | 4 | 15 | 24 | 125 | 201 |
| Semitrailer: |  |  |  |  |  |  |  |  |  |
| 12T, S\&P | 12 tons | $21 / 2$ | 15 | 24 | 4 | 15 | 24 | 125 | 201 |
| Gas tank, 12T, 4W | 5,000 gal. | 21/2 | 15 | 24 | 4 | 15 | 24 | 125 | 201 |
| Refrig, 71⁄2T, 2W | 6 tons | 21/2 | 15 | 24 | 4 | 15 | 24 | 125 | 201 |
| Low-bed wrecker, 12T, 4W | 1 missile | $21 / 2$ | 15 | 24 | 4 | 15 | 24 | 125 | 201 |
| Tank trans, 50T | 50 tons | $21 / 2$ | 15 | 24 | 4 | 11 | 18 | 90 | 145 |

## b. Payload Capacities.

| Type of equipment | Maximum cargo loads Off road Highway |  | Men w/indiv equip- ment ment |
| :---: | :---: | :---: | :---: |
| Truck, cargo: |  |  |  |
| 21⁄2T, 6x6 | 21/2 tons | 5 tons | 16 |
| 5T, 6x6 _---- | 5 tons | 10 tons | 18 |
| Semitrailer: |  |  |  |
| 12T, S\&P _-- | 12 tons ${ }^{\text {b }}$ | 18 tons | $50^{\circ}$ |
| 12T, Van, 4W | 12 tons | 13 tons | NA |
| Gas tank, 12T, 4W. | 3,000 gal. | 5,000 gal. | NA |
| $\begin{aligned} & \text { Refrg, } 71 / 2 \mathrm{~T} \text {, } \\ & 2 \mathrm{~W} . \end{aligned}$ | 6 tons ${ }^{\text {b }}$ | 71/2 tons | NA |
| Low-bed wrecker, 12T, 4W. | 1 missile | 1 missile | NA |
| Tank trans, 50T. | 40 tons ${ }^{\text {b }}$ | 50 tons | NA |

a Does not include driver. For distance greater than 75 miles, the figure should be reduced.
bot generally used for this type of operation.
c Recommended for emergency use only.
c. Vehicle Availability. In advance highway
transport planning, availability means the average number, or percent, of vehicles in a unit that can be operated continuously for 20 hours during each 24 -hour period. The table below gives planned availability figures. Availability figures are greater than those shown in the table for a longer daily operation or for a specific task such as a short one-lift haul. The planning figure must not be confused with actual availability, which is obtained from vehicle records and reports.

|  |  | Vehicle availability |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Unit | Task vehicles assigned | Advance planning ${ }^{1}$ | Target ${ }^{2}$ (24-hour day ) | Spot tasks |
| Trans light trk co _ | 60 | 45 | 50 | 57 |
| Trans med trk co | 60 | 45 | 50 | 57 |
| Trans hvy trk co | 24 | 18 | 20 | 23 |
| Trk pools | Any | $75 \%$ | 83\% | 95\% |
|  | number |  |  |  |

${ }^{1}$ Also used when involved in particularly rigorous operations remote from adequate maintenance, or when actual operating conditions cannot be determined.
2 With well-trained and disciplined personnel, good operating conditions, and adequate maintenance support.
d. Capabilities of Truck Companies.


[^52]
a Some $21 / 2$-ton. $6 \times 6$, cargo trucks have fender wells which project into the cargo space. In such cases, a level platform for the storage of a unitized cargo can be obtained by fitting a frame of 2 by 4 or 4 by 4 timbers flat in the cargo bed between the fender wells.
b May be loaded by crane.
c Increase by one for 12 -ton stake and platform trailer.

## 3-34. Motor Vehicle Shipments of Hazardous Cargo

a. The following measures must be enforced to prevent fire:
(1) Smoking must be prohibited within 50 feet ( 15 m ) of a vehicle loaded with explosives or flammable liquids. Open flames such as those produced by striking matches and using cigarette lighters, torches, etc., must be prohibited within 100 feet ( 30 m ) of any motor vehicle loaded with explosives or gasoline.
(2) Two fire extinguishers, properly filled, should be provided, one inside the cab and one outside, on the driver's side.
(3) All personnel should be instructed in the proper use of fire extinguishers and, where practicable, the instruction should be supplemented by demonstrations.
(4) If a truck catches on fire, all trucks should be moved away from the vicinity of the fire and all traffic stopped. Every effort should be made to warn inhabitants living in the vicinity of the danger.
(5) When loading or unloading trucks, explosives must not be placed in the vicinity of the exhaust.
(6) Ignition and lighting systems should be properly insulated and inspected frequently to insure that danger from short circuits is eliminated.
(7) Every effort should be made to prevent leaks in gasoline tanks, fuel lines, and carburetors. When a leak is discovered, the
truck should be unloaded and moved to a safe distance before repairs are made.
(8) Oil and grease thrown from parts should not be allowed to accumulate on the truck body, engine, or other places where a fire hazard would result.
b. Motor vehicles transporting explosives or gasoline must not be driven past fires of any kind until it has been ascertained that the fire can be bypassed safely.
c. Advance reconnaissance and contact with civilian traffic officials are essential. Whenever possible, routes selected should avoid heavy traffic and large cities.
d. Loitering should not be permitted in the vicinity of a vehicle in convoy.
e. When a truck breaks down, it should be moved off the road or as far to the side as possible and, pending the arrival of an empty truck or repair party, left in charge of a guard.
f. Fuzes and detonating devices must not be carried in the same truck with other explosives (fixed and semifixed ammunition are exceptions).
$g$. The interior of the truck body should be lined so that every portion of the lining with which a container may come in contact is of wood or other nonsparking material.
$h$. Loads should be braced and stayed to prevent shifting.
i. A truck loaded with explosives or gasoline must never be towed or pushed except when a
disabled truck must be moved to the side of the road.
j. Hourly halts should be made to inspect loads and vehicles.
$k$. Motor vehicles transporting explosives on public roads or highways must be marked with placards bearing the word EXPLOSIVES in letters at least 8 inches ( 21 cm ) high. The placards must be prominently located on each side, and on the front and rear of the truck.
$l$. A motor vehicle transporting explosives or gasoline must not be left unattended upon any public street or highway.
$m$. The vehicle motor must not be running when explosives or gasoline are being loaded or unloaded.
$n$. When a truck has an open body, a tarpaulin must be used to protect the cargo from rain or the direct rays of the sun.
$o$. The entire cargo of explosives or ammunition must be transported within the body of the truck. The truck tailboard or tailgate must be closed and secured.
p. Cargo such as dynamite and certain other explosives must be protected from intense cold, which can cause the explosive to deteriorate or become dangerous. Freezing characteristics of the cargo must be determined be-
fore transporting such cargo in temperatures below $32^{\circ} \mathrm{F}$. If necessary, insulated vans must be used.
q. Motor vehicles transporting chemical agents and hazardous chemicals over public highways must conform with ICC regulations. In general, such vehicles will be placarded on the rear, front, and on each side with reflecting placards indicating the degree of hazard. For detailed information see AR 55-355 and appropriate carrier tariffs.

## 3-35. Vehicle Missile-Carrying Capabilities

The missile-carrying capabilities of certain types of vehicles normally found in highway units are given in $a$ and $b$ table below. In each case, either weight or volume is the limiting factor. To achieve the loads indicated, it may be necessary to raise or remove the tops of some trucks and trailers. The loads given do not exceed width dimensions of the vehicles, except in some cases for low-bed and flat-bed trailers. Some of the special equipment used to transport one complete round or the major components thereof is listed in $c$, table below. In the tables, column $A$ indicates the number of packaged missiles or indicated component that one vehicle can transport. Column B shows the number of vehicles required to transport one packaged missile or indicated component.
a. Transportation Light Truck Company (TOE 55-17).

b. Transportation Medium Truck Company (TOE 55-18).

c. Special Transport Equipment. ${ }^{2}$

Trailer, rocket, XM449 -------------------- $\quad 1 \quad 1$
Truck, 21/2T, 6x6, M45E3, with
launcher, XM398E1 $\qquad$
Semitrailer (Sergeant warhead and

and fin ----------------------1

Truck-mounted launcher, M386 (Honest
John rocket) $\qquad$
--- $---\quad---\quad--\quad---\quad--\quad 1$

Erector-launcher, GM Transportable
(Pershing)

[^53]
## 3-36. Computing Truck Unit Requirements

a. One-Lift Hauls. To determine the number of truck companies required to move a given number of tons in one lift, use the following formula:

Tons per veh $\times$ veh availability per Co $=$ truck
companies required
Example. Determine number of light truck companies required to move 2,700 tons in 1 lift.
Assuming: $4=$ tons per $21 / 2$-ton, $6 \times 6$ truck $45=$ vehicle availability per company

Substitute in formula:

$$
\frac{2,700}{4 \times 45}=15 \text { companies }
$$

b. Sustained Forward Hauls (Continuous Operation Using Relays). In sustained forward hauls, trucks return for additional loads, and it is necessary to consider turnaround time and the daily operating time. To determine the number of truck companies required to move a given forward tonnage daily, use the formula below.

Daily forward tonnage $\times$ turnaround time in hours
Tons per veh $\times$ veh available per Co $\times$ operating time in hours (daily) $=$ truck companies required
Example. Determine the number of medium truck companies equipped with semitrailers, 12 -ton, stake and platform, required to move an average tonnage of 4,800 short tons daily for a round-trip distance of 435 miles.
Assuming: $12=$ tons per vehicle
$45=$ vehicle availability per company
$20=$ hours operating time daily
$10=$ miles in the hour
$1=$ hour for each relay terminal operation (average 1 terminal per 125 miles)
First, compute turnaround time:

$$
\begin{gathered}
\mathrm{TT}=\frac{\text { round-trip distance }}{\text { rate of march }}+\text { delays }=\frac{435}{10} \\
+2=45.5 \text { hours }
\end{gathered}
$$

Then substitute in the formula:

$$
\frac{4,800 \times 45.5}{12 \times 45 \times 20}=20.2 \text { or } 21 \text { companies }
$$

c. Sustained Hauls (Continuous Operation). In sustained forward hauls using only trucks, not semitrailers in relays, it is necessary to consider operating turnaround (including loading and unloading) and the daily operating time. To determine the number of truck companies required to move a given forward tonnage daily, use the following formula:

Daily forward tonnage $\times$ operating turnaround Tons per veh $\times$ veh available per Co $\times$ operating time in hours (daily) $=$ truck companies required
Example. Determine the number of light truck companies, equipped with $21 / 2$-ton trucks, required to move an average tonnage of 5,000 short tons daily for a round-trip distance of 52 kilometers.

Assuming: $4=$ tons per vehicle

$$
\begin{aligned}
45 & =\text { vehicle availability per com- } \\
& \text { pany } \\
20 & =\text { hours operating time daily } \\
2.5 & =\text { hours for loading and un- } \\
& \text { loading } \\
16 & =\text { kilometers in the hour }
\end{aligned}
$$

First, compute operating turnaround time:

$$
\begin{gathered}
\mathrm{TT}=\frac{\text { round trip distance }}{\text { rate of march }}+\text { delays }=\frac{52}{16} \\
+2.5=5.75 \text { hours }
\end{gathered}
$$

Then, substitute in the formula:

$$
\frac{5,000 \times 5.75}{4 \times 45 \times 20}=7.9 \text { or } 8 \text { companies }
$$

## 3-37. Motor Movement in Snow

| Depth of snow <br> (inches) | Special measures required for movement |
| :---: | :--- |
| 3 | None. |

## 3-38. Time Elements in Supply Operations

The time elements given below represent an approximated average under combat conditions and should be used as a guide only when actual experience figures are not available.

Class 1
Unloading rations for one division at class I distributing point and preparing for distribution to battalions or units of similar size 100
Distributing class I supplies to battalion or unit of similar size by higher echelon at one distributing point
Distributing class I supplies to separate battalion or unit of similar size by higher echelon

15
Preparing 1 day's class I supplies for issue at battalion or battalion class I distributing point

30
Physically distributing battalion supply agencies 1 day's class $I$ supplies (transfer or loads) to kitchen
Unloading kitchen equipment from trucks, setting up, and being prepared to begin cooking (or vice versa)

## Daylight $_{\text {Minutes }}^{\text {Darkness }}$

## 3-39. Water Supply

a. Water Requirements. Values given are for planning purposes in temperate zones. For extremes of heat or cold, requirements vary considerably from these values.

| Truck | Terrain | Gallons per day |
| :---: | :--- | :--- |
| $21 / 2-t o n, ~ 6 \times 6 \ldots-$ | Level, rolling $\ldots \ldots$ |  |

b. Vehicle Carrying Capacities. A full 5 -gallon water can weighs 50 pounds; the volume of the can is 1.4 cubic feet.

| Vehicle | Carrying eapacity (full 5-gal. cans) Off highway On highway |  |
| :---: | :---: | :---: |
| $1 / 4$ ton trailer | 10 | 20 |
| 11/2-ton trailer | 60 | 120 |
| 21/2-ton truck, M35 | 100 | 200 |
| 21/2-ton truck, M135 | 100 | 200 |
| 5 -ton truck, M54 | 200 | 370 |
| 12-ton semitrailer, M127 | 480 | 593 |

## 3-40. Highway Capability Estimates

a. Definitions. The following definitions are applicable to this discussion of capacity and capability:
(1) Traffic volume. The number of vehicles, considering road conditions, vehicle type, and resulting rate of march attainable, that can pass one point in one direction using one lane in a specific period of time, expressed in vehicles per hour (VPH) or vehicles per day (VPD).
(2) Basic capacity. The maximum number of vehicles that can pass over a highway during a 24 -hour period, based upon a safe operating vehicle speed and interval, considering vehicle and pavement types.
(3) Operational capacity. The maximum number of vehicles that can pass over a highway in a 24 -hour period, derived from estimates of basic capacity with allowances for driver characteristics, unforeseen operational developments, vehicle casualties, driver changes, and essential preventive maintenance en route.
(4) Practical daily capacity. The maximum number of vehicles that can pass over a highway per day, considering highway characteristics and operating conditions.
(5) Capability. The maximum number of short tons of payload per day which can be moved over a highway, considering type of roadway, maintenance, hills, curves, weather, other traffic, types of vehicles used, and other limiting factors.
b. General. The capacity of a highway to support a normal or a maximum vehicular movement is determined by a number of factors: vehicle types and average loads, traffic data, type and width of surface and shoulders, base type and thickness, subsoil type and condition, curves and gradients, moisture and temperature, number of traffic lanes, and operational factors (tables 3-1-3-7). No one highway movement is apt to be affected by all of these basic factors. Conditions dictate which factors must be used to estimate the capability of a highway. Tonnage movement which exceeds the capacity of any part of the road net should not be planned unless reconstruction or heavy maintenance to increase the capacity of the inadequate highway section or bridge is also planned; otherwise, the load must be distributed on alternate routes. If an alternate route is not available or if the tonnage is not reduced, the planner can expect the highway or bridge to deteriorate rapidly and any sustained operation to be disrupted. In addition, maintenance vehicles and personnel may limit capacity by interference with the flow of traffic. A workable method for determining the tonnage capability of a highway is explained in $c, d$, and $e$ below. Sufficient vehicle types (foreign or domestic) have been included to provide a basis for estimating the capability of any highway. This method is based on the assumption that the highway bridges (dimensions and supporting characteristics) are adequate, or will be improved to carry the estimated loads. Capabilities in table 3-8 may be used when specific and detailed highway information is not available. Capacity of a specific road may be quickly estimated without use of tables or other aids by determining traffic volume as described in $c$ below.
c. Basic Factors. Simple estimation of traffic volume and resulting road capacity in vehicles or tons per given period of time:
(1) Rate of march is the primary controlling factor in this method of determining traffic volume; therefore, extreme care must be used in selecting a realistic rate of march. Traffic volume may be determined by using the following formula:
(a) Meters:
$\begin{aligned} & \text { Traffic volume in } \\ & \text { vehicles per hour }\end{aligned}=1000 \times \frac{\text { Rate of march (KMIH) }}{\text { Intervehicular gap (meters) }}$
(b) Miles and yards:
$\begin{aligned} & \text { Traffic volume in } \\ & \text { vehicles per hour }\end{aligned}=1760 \times \frac{\text { Rate of march (MIH) }}{\text { Intervehicular gap (yards) }}$
(2) To determine traffic volume in vehicles per day, multiply the result of the above formula by the anticipated number of operating hours per day.
(3) To determine road capacity in vehicles, multiply traffic volume by the number of usable lanes in one direction.
(4) To determine road capacity in tons, multiply road capacity in vehicles by the average payload in tons of the vehicle to be used.
(5) Example. Rate of march $=20 \mathrm{KMIH}$ Intervehicular gap $=100$ meters
Usable traffic lanes in each direction $=2$
Hours of operation per day $=24$
Average payload per vehicle $=3$ STON
Traffic volume $=1000 \times \frac{20 \mathrm{KMIH}}{100 \text { meters }}$
$=200 \mathrm{VPH}$ or $4,800 \mathrm{VPD}$.
Road capacity in vehicles per day $=4,800$ VPD (volume) $\times 2$ lanes $=9,600$ VPD
Road capacity in tons per day $=9,600$ VPD (capacity) $\times 3$ STON per vehicle $=28,800$ STON
d. Basic Factors.
(1) Surface type (table 3-1). The types of road surfaces and basic and operational capacities are shown in table 3-1. If the vehicle in question does not correspond exactly to one in the table, the analyst should select the basic or operational capacity for the vehicle that is most similar to the vehicle in question.

Table 3-1. Highway daily capacity: Basic and operational.


[^54](2) Surface and shoulder width (table 3-2). For a two-way movement, the ideal single highway is 24 feet wide and has shoulders at least 12 feet wide. The shoulder factor should be considered only for maintaining maximum capacity, not for increasing capacity. If there are no shoulders or if they are
less than 12 feet wide ( 7 feet for one-way movement), a reduction factor should be used. Table 3-3 is used if the widths of the surface and shoulder are not given separately and the width of the traveled way only is known. This may occur in connection with gravel or earth roads.

Table 3-2. Surface and shoulder width factors

| Type of movement | $\begin{gathered} \text { Number of } \\ \text { lanes } \end{gathered}$ | Surface |  |  | Shoulder |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Factor |  |  | Factor |  |
|  |  | $\begin{aligned} & \text { Width } \\ & (f t) \end{aligned}$ | Divided highway | $\begin{aligned} & \text { Undivided } \\ & \text { highway } \end{aligned}$ | Width | Divided highway | Undivided highway |
| One-way | 1 | 8 | ------ | 0.44 | 0 | ----.-.- | 0.74 |
|  | 1 | 9 | ---- | 0.51 | 1 | -------- | 0.79 |
|  | 1 | 10 | --- | 0.58 | 2 | ----- | 0.85 |
|  | 1 | 11 | ----- | 0.64 | 3 | -- | 0.93 |
|  | 1 | 12 | -- | 0.68 | 4 | -..- | 0.97 |
|  | 1 | 12-18 ${ }^{\text {a }}$ | ----- | 0.68 | 5 | ------- | 0.98 |
|  | 1 | $>18$ | ----- | ( ${ }^{\text {b }}$ | 6 | ---- | 0.99 |
|  | 1 | ---.-. | ------ | --...- | 7 | ------- | 1.00 |
|  | 1 | ------ |  |  | $>7$ | -------- | 1.00 |
| Two-way | 2 | 18 | ----. | 0.75 | 0 | ------. | 0.70 |
|  | 2 | 19 | -- | 0.80 | 1 | -------- | 0.75 |
|  | 2 | 20 | ------- | 0.85 | 2 | -------- | 0.80 |
|  | 2 | 21 | -- | 0.90 | 3 | -------- | 0.85 |
|  | 2 | 22 | ------ | 0.95 | 4 | -------- | 0.90 |
|  | 2 | 23 |  | 0.98 | 5 | -- | 0.94 |
|  | 2 or $3^{\text {c }}$ | 24 | --- | 1.00 | 6 | -------- | 0.97 |
|  | 2 or 3 | 24-35 | --1- | 1.00 | 7 | - | 0.98 |
|  | 2 or 3 | $>35$ |  | 1.00 | 8 | -------- | 0.98 |
|  | 2 or 3 | ----- |  |  | 9 | -------- | 0.99 |
|  | 2 or 3 | ------ |  |  | 10 | -------- | 0.99 |
|  | 2 or 3 | --.-.- |  |  | 11 | -------- | 0.99 |
|  | 2 or 3 | ----- |  |  | 12 |  | 1.00 |
|  | 2 or 3 | ------ |  |  | $>12$ |  | 1.00 |
|  | 4 | 36 | 2.0 | 1.8 | 0-2 | 0.80 | 0.80 |
|  | 4 | 42 | 2.2 | 2.0 | 2-7 | 0.90 | 0.90 |
|  | 4 | 48 | 2.5 | 2.2 | 7-12 | 1.00 | 1.00 |
|  | 4 | ------ | --- | -- | $>12$ | 1.00 | 1.00 |

[^55]Table 3-3. Combined surface and shoulder factors when only width of traveled way is known

Factor
Width of traveled way

(feet) $\quad$| One-way movement |
| :---: |$\quad$ Two-way movement

| Width | of traveled way (feet) | Factor |  |
| :---: | :---: | :---: | :---: |
|  |  | One-way movement | Two-way movement |
|  | 25 | -..------.-....- | 0.71 |
|  | 26 | -------.-.-. | 0.73 |
|  | 27 | --.------..-. -- | 0.75 |
|  | 28 | ------------- | 0.77 |
|  | 29 | --.----------- | 0.79 |
|  | 30 | -.-.--------- | 0.80 |
|  | 31 | ------------- | 0.82 |
|  | 32 | -..---------- | 0.835 |
|  | 33 | - - - ----. | 0.84 |
|  | 34 | --.------.-.-- | 0.85 |
|  | 35 | ..-- ----.-.-. | 0.86 |
|  | 36 | -.-.------.-. | 0.87 |
|  | 37 | ------------- | 0.87 |
|  | 38 | ------------- | 0.87 |
|  | 39 | ------------- | 0.87 |
|  | 40 | ------------- | 0.87 |
|  | 41 | ------------- | 0.875 |
|  | 42 | ------------- | 0.88 |
|  | 43 | -------------- | 0.90 |

Factor
of traveled way
(feet)
44
45
46
47
48
49
50
(3) Curve and gradient (table 3-4). Curves and gradients affect the capacity of roads. Radius of simple curvature is measured from the center of the circle to the middle of the road. Gradient, or slope percentage, is the vertical rise to the horizontal distance traveled. The ruling grade of a road is the gradient used in determining the capacity of roads.

Table 3-4. Curve and Gradient Factors*

| Curve Radius of curvatureFactors |  |  |  |  |  |  | Gradient |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  | Factors |  |  |  |  |  |  |
| Curve radius $(f t)$ | 3T trk | 57 trk | $\begin{aligned} & 10 T \text { atle } \\ & \text { or } t r k \end{aligned}$ | $8 \mathrm{~F}_{\text {stlr }}$ | 50T atlr | $\underset{\text { veh }}{A d_{m i n}}$ | Percent | $3 T$ trk | sTtre | $\begin{aligned} & \text { 10T atlir } \\ & \text { or trle } \end{aligned}$ | 18 T stlr | 507 stlr | $\underset{v e h}{A d \min }$ |
| <50 | 0.40 | 0.40 | 0.20 | . 20 | . 20 | . 65 | $<2$ | 1.00 | 1.00 | 1.00 | 1.00 |  | 1.00 |
| 50 | 0.40 | 0.40 | 0.20 | . 20 | . 20 | . 65 | 2 | 1.00 | 1.00 | 1.00 | 1.00 | . 98 | 1.00 |
| 63 | 0.50 | 0.51 | 0,29 | . 25 | . 23 | . 78 | 21/8 | 1.00 | 1.00 | 1.00 | 1.00 | . 97 | 1.00 |
| 75 | 0.60 | 0.63 | 0.38 | . 30 | . 27 | . 85 | $21 / 4$ | 1.00 | 1.00 | 1.00 | 1.00 | . 95 | 1.00 |
| 88 | 0.70 | 0.71 | 0.44 | . 35 | . 31 | . 91 | 23/8 | 1.00 | 1.00 | 1.00 | . 99 | . 94 | 1.00 |
| 100 | 0.75 | 0.78 | 0.50 | . 41 | . 35 | . 94 | $21 / 2$ | 1.00 | 1.00 | . 99 | . 98 | . 93 | 1.00 |
| 113 | 0.78 | 0.83 | 0.55 | . 46 | . 40 | . 97 | 2\%\% | 1.00 | 1.00 | . 98 | . 97 | . 92 | 1.00 |
| 125 | 0.82 | 0.88 | 0.61 | . 54 | . 46 | . 98 | $23 / 4$ | 1.00 | 1.00 | . 98 | . 96 | . 89 | 1.00 |
| 138 | 0.85 | 0.91 | 0.66 | . 60 | . 52 | . 99 | 27/8 | 1.00 | 1.00 | . 97 | . 94 | . 88 | 1.00 |
| 150 | 0.88 | 0.94 | 0.71 | . 65 | . 57 | 1.00 | 3 | . 99 | 1.00 | . 95 | . 93 | . 86 | 1.00 |
| 163 | 0.90 | 0.96 | 0.75 | . 71 | . 62 | 1.00 | $31 / 4$ | . 98 | 1.00 | . 93 | . 91 | . 83 | 1.00 |
| 175 | 0.92 | 0.98 | 0.78 | . 74 | . 67 | 1.00 | $31 / 2$ | . 98 | 1.00 | . 91 | . 88 | . 81 | 1.00 |
| 188 | 0.94 | 0.99 | 0.82 | . 78 | . 71 | 1.00 | $33 / 4$ | . 97 | 1.00 | . 88 | . 85 | . 78 | 1.00 |
| 200 | 0.95 | 0.99 | 0.86 | . 82 | . 75 | 1.00 | 4 | . 95 | . 99 | . 86 | . 82 | . 75 | 1.00 |
| 213 | 0.97 | 1.00 | 0.88 | . 85 | . 78 | 1.00 | $41 / 4$ | . 94 | . 99 | . 83 | . 78 | . 71 | 1.00 |
| 225 | 0.98 | 1.00 | 0.91 | . 88 | . 81 | 1.00 | $41 / 2$ | . 93 | . 98 | . 78 | . 74 | . 67 | 1.00 |
| 238 | 0.98 | 1.00 | 0.93 | . 91 | . 83 | 1.00 | 43/4 | . 90 | . 96 | . 75 | . 71 | . 63 | 1.00 |
| 250 | 0.99 | 1.00 | 0.95 | . 93 | . 86 | 1.00 | 5 | . 88 | . 94 | . 70 | . 65 | . 57 | 1.00 |
| 263 | 0.99 | 1.00 | 0.96 | . 94 | . 87 | 1.00 | $51 / 2$ | . 85 | . 91 | . 65 | . 60 | . 52 | . 99 |
| 275 | 1.00 | 1.00 | 0.98 | . 96 | . 89 | 1.00 | 6 | . 83 | . 88 | . 60 | . 54 | . 46 | . 98 |
| 288 | 1.00 | 1.00 | 0.98 | . 97 | . 91 | 1.00 | 61/2 | . 78 | . 83 | . 55 | . 47 | . 40 | . 97 |
| 300 | 1.00 | 1.00 | 0.99 | . 98 | . 93 | 1.00 | 7 | . 75 | . 78 | . 50 | . 41 | . 35 | . 94 |
| 313 | 1.00 | 1.00 | 0.99 | . 99 | . 94 | 1.00 | 8 | . 70 | . 71 | . 44 | . 36 | . 31 | . 91 |
| 325 | 1.00 | 1.00 | 1.00 | 1.00 | . 95 | 1.00 | 9 | . 60 | . 63 | . 38 | . 30 | . 27 | . 85 |
| 338 | 1.00 | 1.00 | 1.00 | 1.00 | . 96 | 1.00 | 10 | . 50 | . 52 | . 29 | . 25 | . 23 | . 78 |
| 350 | 1.00 | 1.00 | 1.00 | 1.00 | . 98 | 1.00 | 11 | . 40 | . 40 | . 20 | . 20 | . 20 | . 65 |
| $>350$ | 1.00 | 1.00 | 1.00 | 1.00 |  | 1.00 | $>11$ | . 40 | . 40 | . 20 | . 20 | . 20 | . 65 |

${ }^{*}$ Both factors should not be used : apply only the factor which gives the minimum capacity.
(4) Moisture and temperature (table $3-5$ ). Moisture and temperature affect the capacity of road surfaces. The type of soil upon which the roadway is constructed becomes increasingly important as surface rigidity decreases. Heavy concentrations of, or long exposures to, moisture affect the subsoil of even the highest type of pavement, while both the surface and the subsoil of low type or unimproved roads are immediately affected. The degree of moisture can be determined by
studying data on soil conditions and on seasonal weather variations. Tables 3-5 and 3-7 are guides for determining the effects of moisture and temperature on the capacity of a highway to withstand sustained and maximum vehicular movement. Reports of good, fair, and poor surface conditions must be evaluated by the analyst, who should compare them with other reports, photographs, and information about the road network.

${ }_{2}^{2}$ Factors are based upon the assumption that the road has been properly constructed, and thickness of base is adequate.
${ }^{2}$ This type of subsoil normally is not found under high-type pavements: consequently, factors are not shown. However, where high-type pavements have been constructed over silt subsoil in northern areas, capacities are reduced during certain times of the year due to subsoil weakening. The extent of reduction will depend upon the judgment of the analyst.


Interpolation should be used to obtain factor if fractions of an inch are encountered.
(5) Number of traffic lanes.
(a) One lane. Since roads less than 18 feet wide should be used for one-way movement only, the whole adjusted sustained capacity is in one direction. If a one-way movement is to be maintained over a period of time, some provision must be made for the return of empty trucks, either by alternate routes or by a reduction in the hours of forward operation. The one-way factors shown in table 3-2 consider one forward lane only, although a 17 -foot road with good shoulders also has limited usefulness for return of empties.
(b) Two lanes. Roads over 18 feet in width can support one-way or two-way movement. Since the capacities shown in table 3-1 are for all traffic, the adjusted capacity will be in terms of total traffic moving in both directions for two-way movement. Therefore, half of this total two-way movement represents the highway capacity in one direction.
(c) Multilane. A multilane, divided highway of a given width can support a greater volume of traffic than can an undivided highway of the same width because all traffic on any one lane is moving in the same direction. Since total traffic may move in one or both directions, the adjusted capacity may be determined in the manner described in (b) above. The greater inherent capacities of multilane systems are allowed for in table 3-2.
(6) Operational factors.
(a) Turning and cross movements. Although the turning and cross movements factors vary between 1.0 and 0.5 , depending on the size and nature of the overall operation, the average factor of 0.85 may be used when estimating highway capacity.
(b) Hours of running time. Running time usually is determined by the hours of daylight or darkness. In no case should the running time for sustained movement be more than 18 hours a day. When a one-way movement is planned over a route with no alternate, the running time selected must include time for returning empties and for turning around.
(c) Weather and other factors. Certain operational factors such as the weather, tactical situation, and movements of unknown vehicles, cannot be accurately assessed beforehand.
(7) Base thickness. Factors applicable to base thickness may be required. For the transportation planner, normally this is not necessary, since the thickness of base in road construction is usually adequate. Should the base not be adequate, thereby producing a factor other than unity, the quantities in table 3-6 can be used.

## e. Making the Estimate.

(1) General. Since conditions dictate the factors which must be used when estimating a highway's capacity, the analyst must consider each problem separately. In some situtions, a factor of 1.0 will apply; in such cases, the highway capacity is not affected. Methods and examples of estimating highway capacity to support normal and maximum movements are given below.
(2) Methods.
(a) Normal movement. To estimate sustained highway capability, determine surface type and multiply the operational capacity in number of trucks (table $3-1$ ) successively by each of the following factors that is applicable: width of surface and shoulder,

Table 3-7. Number of Days Surfaces Can Support a Maximum Movement without Road Maintenance

| Surface type | Vehicle type <br> (highway tonnage ratinge) <br> Dry | Type and condition of subsoil ${ }^{1}$ |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Sand and/or gravel |  |  | Clay |  |  | Freeze \& thaw | Silt ${ }^{2}$ |  |  |  |
|  |  | Moist | Wet | Freeze \& thaw | Dry | Moist | Wet |  | Dry | Moist | Wet | Freeze \& thaw |
| Cement concrete, bituminous concrete. | 3 T trk (avg for 2-axle) -_ 30 | 30 | 20 | 20 | 30 | 30 | 10 | 10 | ----- | ----- | ----- | ----- |
|  | 5 T trk _--------------30 | 30 | 20 | 20 | 30 | 30 | 10 | 10 | ----- | ----- | ----- | ----- |
|  | 10T trk or stlr _-_-_-_ 30 | 30 | 20 | 20 | 30 | 30 | 10 | 10 | ---- | ----- | ---- | ----- |
|  | 18 T stlr ---------------30 | 30 | 20 | 20 | 30 | 30 | 10 | 10 | ----- | ----- | ----- | ----- |
|  | 50T stlr _------------- 30 | 30 | 20 | 20 | 30 | 30 | 10 | 10 | ---- | ----- | ----- | ----- |
|  | Admin veh _------------ 90 | 90 | 50 | 50 | 90 | 90 | 50 | 50 | ---- | ----- | ----- | ----- |
| Intermediate bituminous. | 3 T trk (avg for 2-axle) -- 15 | 15 | 5 | 5 | 15 | 15 | 2 | 2 | ----- | ----- | ----- | ----- |
|  | 5T trk _-_------------- 15 | 15 | 5 | 5 | 15 | 15 | 2 | 2 | ----- | ----- | ----- | ----- |
|  | 10T trk or stlr | 15 | 5 | 5 | 15 | 15 | 2 | 2 | ----- | ----- | ----- | ----- |
|  | 18T stlr --------------15 | 15 | 5 | 5 | 15 | 15 | 2 | 2 | ----- | ----- |  | ----- |
|  | 50T stlr ---------------15 | 15 | 5 | 5 | 15 | 15 | 2 | 2 |  | ----- | ----- | ----- |
|  | Admin veh _----------- 50 | 50 | 20 | 20 | 50 | 50 | 10 | 10 | ----- |  | ---- |  |
| Bituminous surface treatment. | 3T trk (avg for 2-axle) -_ 10 | 10 | 3 | 3 | 10 | 10 | 1 | 1 | 2 | 2 | 0.50 | 0.50 |
|  |  | 10 | 3 | 3 | 10 | 10 | 1 | 1 | 2 | 2 | 0.50 | 0.50 |
|  | 10 T trk or stlr _-.------- 10 | 10 | 3 | 3 | 10 | 10 | 0.75 | 0.75 | 2 | 2 | 0.25 | 0.25 |
|  | 18 T stlr ----------------10 | 10 | 3 | 3 | 10 | 10 | 0.75 | 0.75 | 2 | 2 | 0.25 | 0.25 |
|  | 50 T stlr --------------- 10 | 10 | 3 | 3 | 10 | 10 | 0.75 | 0.75 | 2 | 2 | 0.25 | 0.25 |
|  | Admin veh -----------20 20 | 20 | 10 | 10 | 20 | 20 | 10 | 10 | 5 | 5 | 2 | 2 |
| Waterbound macadam, gravel, crushed stone. | 3 T trk (avg for 2-axle) | 5 | 1 | 1 | 5 | 5 | 0.62 | 0.62 | 0.50 | 0.50 | $<0.25$ | $<0.25$ |
|  |  | 5 | 1 | 1 | 5 | 5 | 0.62 | 0.62 | 0.50 | 0.50 | $<0.25$ | $<0.25$ |
|  | 10T trk or stlr _----------5 | 5 | 0.5 | 0.5 | 5 | 5 | 0.37 | 0.37 | 0.50 | 0.50 | <0.25 | $<0.25$ |
|  | 18T stlr --------------- 5 | 5 | 0.5 | 0.5 | 5 | 5 | 0.37 | 0.37 | 0.50 | 0.50 | <0.25 | $<0.25$ |
|  | 50 T stlr |  |  |  | 5 | 5 | 0.37 | 0.37 | 0.50 | 0.50 | $<0.25$ | $<0.25$ |
|  | Admin veh ------------------10 | 10 | 2 | 2 | 10 | 10 | 1.5 | 1.5 | 1 | 1 | $<0.25$ | <0.25 |
| Improved earth | 3T trk (avg for 2-axle) -- 5 | 5 | $<0.25$ | <0.25 | 5 | 5 | $<0.25$ | $<0.25$ | 0.25 | 0.25 | $<0.25$ | $<0.25$ |
|  | 5T trk -------------- 5 | 5 | $<0.25$ | $<0.25$ | 5 | 5 | $<0.25$ | $<0.25$ | 0.25 | 0.25 | $<0.25$ | $<0.25$ |
|  | 10T trk or stlr ----------5 | 5 | <0.25 | <0.25 | 5 | 5 | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ |
|  | 18 T stlr ------------------ 5 | 5 | <0.25 | $<0.25$ | 5 | 5 | $<0.25$ | $<0.25$ | <0.25 | <0.25 | $<0.25$ | <0.25 |
|  | 50T stlr | -- | - | --- | 5 | 5 | <0.25 | $<0.25$ | 0.25 | 0.25 | $<0.25$ | <0.25 |
|  | Admin veh ----------------10 | 10 | $<0.25$ | $<0.25$ | 10 | 10 | 10 | 10 | 0.25 | 0.25 | $<0.25$ | <0.25 |
| Unimproved earth | 3 T trk (avg for 2-axle) .- 5 | 5 | $<0.25$ | $<0.25$ | 5 | 5 | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ | <0.25 |
|  | 5 T trk _---------------- 5 | 5 | $<0.25$ | $<0.25$ | 5 | 5 | $<0.25$ | $<0.25$ | <0.25 | $<0.25$ | <0.25 | $<0.25$ |
|  | 10T trk or stlr _-_-_-_-- 5 | 5 | $<0.25$ | $<0.25$ | 5 | 5 | $<0.25$ | $<0.25$ | <0.25 | $<0.25$ | $<0.25$ | $<0.25$ |
|  | 18 T stlr | 5 | $<0.25$ | $<0.25$ | 5 | 5 | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ |
|  | 50 T stlr | - | ----- | ----- | 5 | 5 | $<0.25$ | $<0.25$ | <0.25 | $<0.25$ | $<0.25$ | $<0.25$ |
|  |  | 10 | $<0.25$ | $<0.25$ | 10 | 10 | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ | <0.25 | $<0.25$ |

[^56]curve and gradient, moisture and temperature, base thickness, and operational factors. The product is for a 24 -hour day. It should then be adjusted in one of two ways as follows:

1. Adjust the figure to reflect the actual working hours in the day by multiplying it by the following fraction:
$\frac{\text { Working hours in day }}{24}$
2. If making a strategic estimate for which definite information as to method of operation is not known, the figure should be adjusted to reflect daylight hours only by multiplying it by the following fraction:

$$
\frac{\text { Daylight hours in day }}{24}
$$

Adjust the figure further to show movement in one direction only by dividing by 2 if movement is two-way. If movement is one-way, no further reduction is necessary since the alltraffic capacity represents loaded movement in one direction. Convert to tonnage capability.
(b) Maximum movement. To estimate the capability of a highway to support a maximum movement with no road maintenance, multiply the basic daily capacity successively by the surface and shoulder width factors, the curve and gradient factor, the turning and cross movement factor, and the base thickness factor, if applicable. The other factors are not used as multipliers in making a maximum estimate, since this type of operation calls for maximum tonnage within a short time, with no requirement for sustained movement. Adjustments of the figure thus obtained are made in the same manner as for the normal movement described in (a) above, except that the working day in 20 hours. Owing to the influence of the surface on such movements when no road maintenance is performed, high type surfaces can sustain movements for longer periods than low type surfaces (table 3-7).
(c) Highway capability checklist. In order to eliminate or reduce the possibility of omitting important considerations when estimating highway capability, the following checklist may be used as a guide.
(a) Technical planning information. 1. Point-to-point distance.
2. Surface type and width.
3. Vehicle type and average load.
4. Shoulder type and width.
5. Base type and thickness.
6. Alinement (curvature and gradient).
7. Subsoil type and condition.
8. Traffic and bridge data.
(b) Planning guide factors.

1. Operational or basic capacity (vehicles per day).
2. Surface and shoulder width.
3. Curve and gradient.
4. Pavement deterioration (moisture and temperature).
5. Base thickness.
6. Operational factors.
(c) Planning estimate.
7. Practical daily capacity (vehicles per day).
8. Capability (short tons per day).
(4) Examples. (Slide-rule calculations are sufficiently accurate for these estimates.)
(a) Bituminous-surface treatment.
9. Problem. What is the sustained capability of a bituminous-surface treated highway where-

Surface is 12 to 20 feet wide and has clay subsoil.

Shoulder width is 6 to 7 feet.
Ruling gradient is 10 percent.
Minimum curve radius is 100 feet.
It is the dry season.
Alternate routes are available for the return of empty trucks.

Operations are 12 hours per day.
Cargo trucks averaging 3 tons are used.
2. Solution. The operational capacity for 3-ton cargo vehicles on bituminous-surface treatment is 16,900 vehicles per day (table 3-1). Inasmuch as surface widths vary from 12 to 20 feet, the estimate must be for a oneway movement. The returning empty trucks will use alternate routes. The surface width factor (table 3-2) is 0.68 for a 12 -foot surface; the shoulder factor is 0.99 . The curve and
gradient factor for 10 -percent grades is 0.5 (table 3-4). The moisture factor is 0.6 for bituminous-surface treatment in dry weather with clay subsoil (table 3-5). The average factor for turning and cross movement is 0.85 . Therefore, the calculation for this estimate is $16,900 \times 0.68 \times 0.99 \times 0.5 \times 0.6 \times 0.85$, or 2,910 vehicles per day. Multiplying the number of vehicles by 3 (the average payload in short tons carried by each vehicle) gives a highway capability of 8,730 short tons per 24 -hour day for a sustained period. Since the operation is only for 12 hours per day, the net capability is half of 8,370 , or 4,365 short tons per day. It should be noted that this problem involves a 12-hour, one direction movement because alternate routes are available for the returning empties. Had no alternate routes been available, the running time, which must include time for changing direction and returning empties, might have been 8 hours forward, 8 hours returning, and 2 hours for transition. This makes a total of 18 hours per day, which is the recommended maximum for sustained movement.
(b) Gravel surface.

1. Problem. What is the sustained capability of gravel surfaced road where-

Surface is 18 feet wide with a clay base.

Shoulder width is 2 feet.
Ruling gradient is 10 percent.
Minimum curve radius is 200 feet. It is the wet season.
No alternate routes are available. Operations are 14 hours per day. Three-ton cargo trucks are used.
2. Solution. The operational capacity of a gravel surface to support 3 -ton cargo trucks is 6,700 vehicles per day (table 3-1). A two-way movement is planned because the surface is 18 feet wide and no alternate routes are available. According to table 3-2, the sur-face-width factor is 0.75 ; the shoulder-width factor is 0.8 . The curve and gradient factor is 0.5 (table 3-4). Table 3-5 shows the moisture factor to be 0.10 for a wet gravel road with clay subsoil. The factor of 0.85 is used for turning and cross movement. The calculation
for this estimate is $6,700 \times 0.75 \times 0.8 \times 0.5 \times$ $0.10 \times 0.85$, or 171 vehicles per day with vehicles traveling in both directions. Therefore, 171 divided by 2 will give 85 vehicles for a one-direction movement. Then $85 \times 3$ (average number of tons carried by each vehicle) equals a capability of 255 short tons per 24 -hour day. Using a 14 -hour working day, the net capability is $14 \times 255$, or 149 short tons per day $\overline{24}$ for sustained operations.
(c) Four-lone, divided highway.

1. Problem. What is the sustained capability of a four-lane, divided highway where-

Surface is cement concrete with clay subsoil.

Width of each two-lane section is 24 feet.

Shoulders are 8 feet wide. Ruling gradient is 4 percent. Minimum curve radius is 1,000 feet.

The weather is dry. Operations are 12 hours per day. Three-ton cargo trucks are used.
2. Solution. Use the operational capacity of 16,900 vehicles per day for a cement concrete surface as the basic figure for the computation (table 3-1). The surface width factor for a 4-lane, divided highway with two 24 -foot surfaces is 2.5 and the shoulder width factor is 1.0 (table 3-2). The curve and gradient factor (table 3-4) is 0.95 for 4-percent grades. The moisture factor for cement concrete with clay subsoil in dry condition is 1.0 (table 3-5). The average factor for turning and cross movement is 0.85 . Thus, the calculation for sustained movements on this section of highway is- $16,900 \times 2.5 \times 1.0 \times 0.95 \times 1.0 \times$ 0.85 , or 34,117 vehicles. This figure represents the number of vehicles per 24-hour day that is the practical total capacity of the highway. Since returning empty trucks will use the highway also, the cargo movement forward will be one-half of the capacity. Therefore, the traffic in one direction will be 17,050 vehicles per day. Because operations are for only 12 hours per day, 17,050 must be divided by 2 which
gives a net capacity in one direction of 8,525 vehicles per day. The sustained capability in tonnage will be $8,525 \times 3$, or 25,575 short tons per day.
(d) Maximum movement over fourlane, divided highway.

1. Problem. What is the maximum movement capability of the four-lane, divided highway described in (c) above?
2. Solution. Procedure is the same as that outlined in (c) above, except that basic capacity is used instead of operational capacity (table 3-1), the moisture factor is not considered, and running time is increased to 20 hours per day. The computation is $21,100 \times$ $2.5 \times 1.0 \times 0.95 \times 0.85$, or 42,600 vehicles per 24 -hour day traveling in both directions. Since operations are for 20 hours per day and only forward traffic is desired, $42,600 \times 20 / 24 \div 2$ would give 17,700 vehicles per day forward. The net short term tonnage capability is then
$17,700 \times 3$, or 53,100 short tons per day. This capability for cement concrete is dry weather could be maintained on a maximum basis for 30 days (table 3-7), giving a total projected capability on a maximum or "crash" basis of $1,593,000$ short tons.
f. Making the Estimate with Limited Informtaion. Table 3-8 may be used as a guide in the absence of more accurate data for estimating the supply support tonnage capabilities of highways under varied conditions, assuming operations are sustained, adequate road maintenance is provided, and each road bears two-way traffic. In using the "Reductions" portion of table 3-8, multiply the daily forward tonnage successively by each of the three factors that is applicable (narrow roadway, one of the next three concerning terrain, and seasonal bad weather). It should be noted that the seasonal bad weather factor applies only when the estimate is for a sustained period.

Table 3-8. Making the Estimate with Limited Information

| Type of road | Daily tonnageforward |  |  | Reductions applicable to various conditions |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Optimum dispatch only | $\begin{gathered} \text { Supply } \\ \text { (traffic } \\ \text { (COMMZ) } \end{gathered}$ |  | Narrow | Rolling terrain | $\begin{gathered} \text { Hilly } \\ \text { wilth } \\ \text { curves } \end{gathered}$ | Mountainows | $\begin{gathered} \text { Seasonal } \\ \text { bad } \\ \text { weather } \end{gathered}$ |
| Concrete | 60,000 | 36,000 | 8,400 | 0.75 | 0.90 | 0.70 | 0.40 | 0.80 |
| Bituminous | 45,000 | 27,000 | 7,300 | 0.75 | 0.90 | 0.70 | 0.40 | 0.70 |
| Bituminous treated | 30,000 | 18,000 | 5,800 | 0.75 | 0.80 | 0.60 | 0.35 | 0.60 |
| Gravel | 10,150 | 6,090 | 3,400 | 0.75 | 0.80 | 0.50 | 0.30 | 0.40 |
| Earth | 4,900 | 2,940 | 1,600 | 0.75 | 0.75 | 0.40 | 0.20 | 0.10 |

## Section IV. MAINTENANCE

## 3-41. Organization

| Category | Definition | Scope | $\underset{b y}{P e r f o r m e d ~}$ | Responaibility of |
| :---: | :---: | :---: | :---: | :---: |
| Organizational | That maintenance normally authorized for, performed by, and the responsibility of a using unit on equipment in its possession, This maintenance consists of functions and repairs within the capabilities of authorized personnel skills, tools, and test equipment as prescribed in unit's TOE or TD. <br> (Formerly known as 1 st and | Care taken of, and maintenance performed on, equipment to keep it in a serviceable condition in accordance with applicable DA publications such as TM's, TB's, LO's, and ESC. These functions consist of: inspections, servicing, adjustments, lubrication, scheduled services, minor repairs, proper operation, records, and | Operator of crew, and organizational mechanics. | Unit commander. |

Direct support -- Maintenance normally authorized for, performed by, and the responsibility of designated maintenance activities. Direct support maintenance units provide support where feasible by on-site repair, replacement of assemblies and components, delivery of parts to the user, and technical assistance. Normally, TOE and TD of direct support organizations will specify this unit as having a maintenance mission and provide using units with on-site repairs.
(Formerly known as 3d echelon maintenance).

General support - Maintenance normally performed by semimobile units in support of the supply system or, when required, to support direct support units in the maintenance and repair for return to user.

## Depot

Maintenance normally performed by permanent installations using extensive equipment.

## Scope

equipment serviceablity criteria. All repair parts replacements and levels will be in accordance with PLL and levels as prescribed by TOE and TD.

Provide for replacement of major parts, components, assemblies, or end items. Arrange for the evacuation of unserviceable equipment from user to an activity where repairs can be accomplished, or to a collection or salvage facility. Assist in the performance of maintenance inspections of equipment and of organizational maintenance operations of the user to ascertain the condition of equipment and the effectiveness of organizational mainte-' nance. Provides repair parts support, technical advice to units supported, maintenance float items, and inspection personnel.

Provide for the repair of end items and assemblies for return to the supply system or maintenance float. The performance of maintenance is accomplished through use of maintetenance standards. This includes the overhaul and repair of end items and components for return to stock. Provide inspection personnel.

Provide for overhaul and repair of economically repairable materiel, augment the procurement program in satisfying overall Army requirements and, when required, provide for repair of materiel beyond the capability of general support maintenance organizations, and the maintenance of depot stocks in a ready-for-issue condition. When

## Performed <br> rforr $b y$

$\underset{\substack{\text { Responsibility } \\ \text { of }}}{ }$

Units having Army commander, DSU responsibility (mainteence mission)
division commander, installation commander.

Scope
required, will rebuild items to fulfill military assistance programs. This level required maintenance to be performed using manufacturers standards and/or maintenance standards established for this category.

## 3-42. Recommended Tire Pressures and Maximum Loads

The table below may be used as a guide for determining inflation pressures and maximum loads for tires. Pressures and loads shown are averages for the different makes of tires. If available, figures from the identification plate or technical manual for a particular vehicle should take precedence, if they differ from those listed below. To obtain better flotation (bearing surface) in soft sand, snow, or mud, tire pressure may be reduced, but pressure below 10 pounds per square inch is not recommended. In extreme cold, tire pressure should be increased 10 percent. Proper pressure should be restored as soon as practicable.

| Tire size |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Passenger cars | Trucks. buses, and trailers | Number of plies | Recommended pressure (psi) | Recommended maximum load (lb) |
| 5.50-16 | ------ | 4 | 30 | 810 |
| 5.90-15 | ------ | 4 | 24 | 745 |
| *6.00-13 | ------ | 4 | 27 | 750 |
| 6.00-16 | ---.-- | 4 | 28 | 915 |
| ----- | 6.00-16 | 6 | 45 | 1,140 |
| 6.25-16 | --..-- | 4 | 28 | 985 |
| 6.40-15 | ---.-- | 4 | 24 | 830 |
| *6.50-13 | ----- - | 4 | 27 | 825 |
| 6.50-16 | ----- | 4 | 28 | 1,050 |
| ------ | 6.50-16 | 6 | 45 | 1,290 |
| ------ | 6.50-20 | 6 | 50 | 1,700 |
| ------ | 6.50-20 | 8 | 65 | 1,950 |
| 6.70-15 |  | 4 | 26 | 910 |
| *6.95-14 | -----. | 4 | 28 | 900 |
| *7.00-13 |  | 4 | 27 | 925 |
| *7.00-14 | ------ | 4 | 30 | 1,075 |
| .-.-. - | 7.50-15 | 6 | 45 | 1,380 |
|  | 7.50-15 | 8 | 55 | 1,555 |
| 7.00-16 |  | 4 | 26 | 1,145 |
| ----- | 7.00-16 | 6 | 45 | 1,440 |
| ----- | 7.00-20 | 8 | 55 | 2,000 |
| ----- | 7.00-22 | 6 | 50 | 1,870 |
| $7.10-15$ | --- - - | 4 | 26 | 990 |
| *7.50-14 | -----. | 4 | 24 | 1,085 |


| size |  |  | Recompressure (psi) | $\begin{aligned} & \text { Recom- } \\ & \text { mended } \\ & \text { maximum } \\ & \text { load (lb) } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: |
| Passenger | Trucks, buses. and trailers | $\begin{gathered} \text { Number } \\ \text { of } \\ \text { plies } \end{gathered}$ |  |  |
| ------ | 7.50-15 | 8 | 55 | 1,780 |
| ------ | 7.50-15 | 10 | 80 | 3,310 |
|  | 7.50-15 | 12 | 95 | 3,660 |
| 7.50-16 | --.--- | 4 | 24 | 1,235 |
|  | 7.50-16 | 6 | 45 | 1,650 |
| ------ | 7.50-16 | 8 | 55 | 1,860 |
| ----- | 7.50-17 | 8 | 60 | 2,100 |
|  | 7.50-18 | 8 | 60 | 2,200 |
|  | 7.50-20 | 8 | 60 | 2,375 |
| 7.60-15 | ----. | 4 | 26 | 1,090 |
| *8.00-14 |  | 4 | 24 | 1,175 |
| 8.00-15 |  | 4 | 26 | 1,395 |
|  | 8.00-22 | 8 | 65 | 2,740 |
| 8.20-15 | ------ | 4 | 24 | 1,415 |
|  | 8.25-15 | 14 | 100 | 4,450 |
| 8.25-16 | -..--- | 6 | 34 | 1,690 |
|  | 8.25-20 | 10 | 65 | 2,900 |
| *8.50-14 | ------ | 4 | 24 | 1,265 |
| *9.00-14 | ------ | 4 | 24 | 1,355 |
| ------ | 9.00-15 | 12 | 75 | 4,510 |
| -.---- | 9.00-16 | 8 | 45 | 2,250 |
| ------ | 9.00-20 | 8 | 45 | 2,775 |
| ------ | 9.00-20 | 10 | 65 | 3,250 |
| .-.-.- | 9.00-22 | 10 | 70 | 3,330 |
|  | 9.00-22 | 12 | 85 | 3,730 |
| *9.50-14 | ----- | 4 | 24 | 1,465 |
| ------ | 9.75-20 | 12 | 70 | 3,900 |
| ------ | 9.75-22 | 12 | 70 | 4,200 |
| ------ | 9.75-24 | 12 | 70 | 4,400 |
| ------ | 10.00-15 | 14 | 85 | 5,480 |
| ------ | 10.00-20 | 12 | 70 | 4,000 |
| ------ | 10.00-22 | 10 | 70 | 3,960 |
| ------ | 10.00-22 | 12 | 70 | 4,275 |
| ------ | 10.00-24 | 12 | 70 | 4,550 |
| ---.. | 10.50-20 | 12 | 75 | 4,700 |
| ------ | 10.50-22 | 12 | 75 | 5,000 |
| ------ | 10.50-24 | 12 | 75 | 5,200 |
|  | 11.00-20 | 12 | 70 | 4,500 |
|  | 11.00-22 | 12 | 70 | 4,750 |
|  | 11.25-20 | 14 | 80 | 5,450 |
| ------ | 11.25-24 | 14 | 80 | 6,050 |
|  | 12.00-20 | 14 | 75 | 5,275 |
|  | 12.00-22 | 12 | 75 | 5,150 |


| Tire size |  |  | Recom-mendedpressure(pai) | $\begin{gathered} \text { Recom- } \\ \text { mended } \\ \text { maximum } \\ \text { load (lb) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: |
| Passenger carg | Trucks. buses, and trailers | $\begin{gathered} \text { Number } \\ \text { of } \\ \text { plies } \end{gathered}$ |  |  |
| ------ | 12.00-24 | 14 | 75 | 5,925 |
| ------ | 12.75-20 | 16 | 90 | 7,200 |
|  | 12.75-24 | 16 | 90 | 8,000 |
|  | 13.50-20 | 16 | 95 | 8,200 |
|  | 13.50-24 | 16 | 95 | 9,100 |
|  | 14.00-20 | 12 | 45 | 5,450 |
|  | 14.00-24 | 20 | 90 | 9,150 |
|  | 16.00-25 | 20 | 60 | 9,475 |
|  | 18.00-24 | 16 | 40 | 13,590 |

*Tubeless tires.

## 3-43. Vehicle and Motor Checklist

a. General.
(1) Is the general appearance of the motor pool satisfactory?
(2) Are "no smoking" signs posted in fuel dispensing areas?
(3) Is fuel dispensing area equipped with fire extinguishers of proper type and are they accessible?
(4) Are fuel dispensing personnel familiar with the operation of fire extinguishers?
(5) Have fire extinguishers been inspected at prescribed intervals?
(6) Are speed limits posted?
(7) Are parking areas designated?
(8) Is a traffic plan designated?
(9) Are vehicles checked for proper dispatch before departing from motor pool?
(10) Are covered metal containers provided for oily rags?
(11) Are containers available for the disposal of waste oil and solvents?
(12) Are containers available for ordinary waste?
(13) Are separate facilities available for the storage of paint and flammables; are "no smoking" signs posted?
b. Maintenance Shop and Records.
(1) Are tools and equipment properly
cleaned, serviced, and secured when not in use?
(2) Are regulations enforced regarding flammable materials?
(3) Are all preventive maintenance inspections properly supervised?
(4) Are equipment lubrication orders on hand and in use?
(5) Are appropriate technical manuals and bulletins on hand and readily available?
(6) Are technical manuals used in the performance of preventive maintenance inspections and services?
(7) Are adequate road tests performed on each vehicle as a part of preventive maintenance and inspection services?
(8) During scheduled preventive maintenance inspections, does the unit diagnose deficiencies correctly and initiate proper corrective action?
(9) Are vehicles requiring maintenance beyond the capability of unit promptly evacuated to a support maintenance facility?
(10) Are authorized tools on hand and in a serviceable condition?
(11) Are unserviceable tools turned in?
(12) Are air compressors and auxiliary engines properly serviced and maintained? --
(13) Are lubricants properly stored, identified, and secured from contamination?
(14) Are repair parts utilized discriminately as substantiated by the condition of parts which have been replaced?
(15) Is welding, cutting, and grinding equipment properly maintained?
(16) Are protective goggles worn by personnel when operating welding, cutting, and grinding equipment?
(17) Is training of maintenance personnel adequate?
(18) Are all vehicles, auxiliary engines, and trailers entered on the roster?
(19) Are all vehicles scheduled for preventive maintenance services indicated by U.S. Army registration number?
(20) Are all entries for scheduled services made in pencil on advance basis and inked over when preventive maintenance service is completed?
(21) Are the proper symbols or letters used in posting the preventive maintenance roster?
(22) Are the preventive maintenance services properly distributed throughout the month?
(23) Are all forms on hand or on requisition that are needed to properly implement the Army system of maintenance?
(24) Are vehicle and equipment operational records properly filled out?
(25) Is the proper form used for preventive maintenance checks and services? Are these forms retained for the required period?
(26) Are all vehicles dispatched entered on the organizational control record for equipment? Are appropriate entries made in each column of the record?
(27) Do all drivers have the required U.S. Government motor vehicle operator's identification card? Are these cards properly made out?
(28) Is there an equipment logbook for each vehicle?
(29) Are all authorized publications on hand and available for ready reference?
(30) Are scheduled maintenance services being performed?
(31) Does the maintenance shop maintain an equipment modification record?
(32) Is the ordnance section of the organization and/or installation property book properly maintained and up to date?
(33) Do registration numbers of vehicles, serial numbers of other major items, and quantities of all major items on hand agree with those in organizational property book?
(34) Do quantities of major items shown as authorized in organizational property book agree with appropriate TOE, TA, or other competent authorizations?
(35) Are invalidated property issue slips maintained in a suspense file until validated copies are received from issuing agency?
(36) Are exchange tags used for repair parts?
(37) Are repair parts on hand within authorized allowances?
(38) Is the interchangeability of repair parts employed where possible?
(39) Are repair parts properly stored, tagged, and preserved?
(40) Are used repair parts accounted for by major items registration or serial number?
(41) Are stock number changes posted to date in supply records and catalogs?
(42) Have parts required for inoperable equipment been requested?
(43) Is followup made on outstanding requests for repair parts?
(44) Are all required supply publications on hand?
(45) Is strict supply economy practiced in the use of repair parts and supplies?
(46) Are supply personnel adequately trained in use of supply publication procedures?
(47) Are unserviceable recoverable parts and assemblies promptly returned to supporting unit?
(48) Is a jacket file of hand receipts maintained for property loaned to another unit, organization, activity, or individual?

## c. Vehicle Inspection.

(1) Is the general appearance of the vehicle satisfactory?
(2) Are registration and unit markings in accordance with current directives?
(3) Are engine compartments clean?
(4) Are cab compartments clean?
(5) Is cargo space clean?
(6) Is vehicle free of rust?
(7) Are door glasses present, unbroken, and clean?
(8) Do door glass regulators operate properly?
(9) Do door latches operate properly?
(10) Do lights operate properly?
(11) Is condition of canvas, upholstery, and fastenings satisfactory?
(12) Are footbrakes adjusted for proper free travel? $\qquad$
(13) Are handbrakes adjusted properly?
(14) Is battery electrolyte at proper level?
(15) Is engine oil clean and at proper level?
(16) Is cooling system filled to proper level?
(17) Is there a copy of the operator's reporting form for a motor vehicle accident in each vehicle?
(18) Is there an accident identification card in each vehicle?
(19) Are all on-equipment materiel

OEM) tools present and in good condition?
(20) Does the driver seem adequately trained?
(21) Is the driver properly licensed? $\qquad$
(22) Is there a copy of the vehicle technical manual and lubrication order in each vehicle?

## 3-44. Safe Operating Distances Between Vehicles

The chart below shows average values which may be used in determining safe gaps between vehicles at various speeds on average hardsurfaced roads. Since well-trained drivers can reduce the distance traveled during the perception and reaction periods, the planner should consider the physical condition and state of training of drivers for a particular operation, keeping in mind that rain, snow, or ice presents special conditions. Braking distances are based on the assumption that the vehicles are loaded and have good brakes, tires, and traction. Total distances have been determined from the standpoint of safety only; the tactical situation may require larger or smaller gaps. In the absence of definite information, the following rule-of-thumb method may be used to determine the gap between vehicles in a convoy; speedometer reading (mph) $\times 2=$ gap in yards, or speedometer reading (kmph) $\times 1.2=$ gap in meters. (This method should be used only for speeds indicated by asterisks.)

| mph | Speed |  | Perception |  | Average distance required for stopping Reaction Braking |  |  |  |  |  | Meters |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $k m p h$ | $f t / \mathrm{sec}$ | Feet | Meters | Feet | Meters | Feet | Meters | Feet |  |  |
|  | Passenger vehicles ${ }^{2}$ |  |  |  |  |  |  |  |  |  |  |
| 20* | 32.2 | 29.3 | 22 | 6.7 | 22 | 6.7 | 25 | 7.6 | 69 | 23 | 21.0 |
| 25* | 40.3 | 36.7 | 28 | 8.5 | 28 | 8.5 | 35 | 10.7 | 91 | 30 | 27.7 |
| 30* | 48.3 | 44.0 | 33 | 10.0 | 33 | 10.0 | 48 | 14.6 | 114 | 38 | 34.6 |
| 35* | 56.3 | 51.3 | 39 | 11.9 | 39 | 11.9 | 67 | 20.4 | 145 | 48 | 44.2 |
| 40* | 64.4 | 58.7 | 44 | 13.4 | 44 | 13.4 | 90 | 27.4 | 178 | 59 | 54.2 |
| 45* | 72.4 | 66.0 | 50 | 15.3 | 50 | 15.3 | 117 | 35.7 | 217 | 73 | 66.3 |
| 50* | 80.5 | 73.4 | 55 | 16.8 | 55 | 16.8 | 148 | 45.2 | 258 | 86 | 78.8 |
| 55 | 88.5 | 80.7 | 61 | 18.6 | 61 | 18.6 | 185 | 56.4 | 307 | 102 | 93.6 |
| 60 | 96.6 | 88.0 | 66 | 20.1 | 66 | 20.1 | 228 | 69.6 | 360 | 120 | 109.8 |
| 65 | 104.6 | 95.4 | 72 | 21.9 | 72 | 21.9 | 275 | 83.9 | 419 | 140 | 127.7 |
| 70 | 112.6 | 102.7 | 77 | 23.5 | 77 | 23.5 | 332 | 102.5 | 486 | 162 | 149.5 |



Single-unit, 2-axle vehicles with gross weight of 10,000 pounds or more

| $20^{*}$ | 32.2 | 29.3 | 22 | 6.7 | 22 | 6.7 | 40 | 12.2 | 84 | 28 | 25.6 |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $25^{*}$ | 40.3 | 36.7 | 28 | 8.5 | 28 | 8.5 | 64 | 19.5 | 120 | 40 | 36.5 |
| 30 | 48.3 | 44.0 | 33 | 10.0 | 33 | 10.0 | 92 | 28.0 | 158 | 53 | 48.0 |
| 35 | 56.3 | 51.3 | 39 | 11.9 | 39 | 11.9 | 126 | 38.4 | 204 | 68 | 62.2 |
| 40 | 64.4 | 58.7 | 44 | 13.4 | 44 | 13.4 | 165 | 50.3 | 253 | 84 | 77.1 |
| $\mathbf{4 5}$ | 72.4 | 66.0 | 50 | 15.3 | 50 | 15.3 | 208 | 63.4 | 308 | 103 | 94.0 |
| 50 | 80.5 | 73.4 | 55 | 16.8 | 55 | 16.8 | 256 | 78.1 | 366 | 122 | 111.7 |
| 55 | 88.5 | 80.7 | 61 | 18.6 | 61 | 18.6 | 310 | 94.5 | 432 | 144 | 131.7 |
| 60 | 96.6 | 88.0 | 66 | 20.1 | 66 | 20.1 | 372 | 113.5 | 504 | 168 | 153.7 |

Single-unit vehicles with more than 2 axles and combination of vehicles (tractor truck, semitrailer, and trailer) with gross weight of 10,000 pounds or more

|  |  |  |  |  |  |  |  |  |  |  |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $20^{*}$ | 32.2 | 29.3 | 22 | 6.7 | 22 | 6.7 | 50 | 15.3 | 94 | 32 | 28.7 |
| 25 | 40.3 | 36.7 | 28 | 8.5 | 28 | 8.5 | 80 | 24.4 | 136 | 45 | 41.4 |
| 30 | 48.3 | 44.0 | 33 | 10.0 | 33 | 10.0 | 115 | 35.1 | 181 | 60 | 55.1 |
| 35 | 56.3 | 51.3 | 39 | 11.9 | 39 | 11.9 | 157 | 47.9 | 235 | 78 | 71.7 |
| 40 | 64.4 | 58.7 | 44 | 13.4 | 44 | 13.4 | 205 | 62.5 | 293 | 98 | 89.3 |
| 45 | 72.4 | 66.0 | 50 | 15.3 | 50 | 15.3 | 260 | 79.3 | 360 | 120 | 109.9 |
| 50 | 80.5 | 73.4 | 55 | 16.8 | 55 | 16.8 | 320 | 97.6 | 430 | 143 | 131.2 |
| 55 | 88.5 | 80.7 | 61 | 18.6 | 61 | 18.6 | 388 | 118.3 | 510 | 170 | 155.5 |
| 60 | 96.6 | 88.0 | 66 | 20.1 | 66 | 20.1 | 465 | 141.9 | 597 | 199 | 182.1 |

[^57] chart.

Section V. MISCELLANEOUS

## 3-45. Anchoring Methods <br> (fig. 3-25)

a. Holdfasts. Natural anchorage should be used whenever possible. Sound wooden pickets, 3 inches in diameter and driven at least 3 feet into dry, undisturbed earth, should withstand the following pulls:

| Picket | Pounds |
| :---: | :---: |
| Single | 700 |
| 1-1 holdfast combination | 1,400 |
| 1-1-1 holdfast combination | 1,800 |
| 2-1 holdfast combination | 2,000 |


| Picket | Pounds |
| :--- | :--- |
| 3-2-1 holdfast combination | 4,000 |
| For wet earth, the holding power should be multiplied |  |
| by the following factors: |  |
| Clay and gravel mixture |  |
| River clay or sand |  |

River clay or sand
0.5
b. Deadman. The deadman is a log, railroad tie, or similar object sunk into the ground in such a manner as to afford anchorage for a line. The holding power of a deadman depends upon the bearing area and holding power of the earth. To determine the necessary bearing


PICKET HOLDFAST


3-2-1 COMBINATION PICKET HOLDFAST


Figure 3-25. Picket holdfast and deadman.
surface, divide the total stress by the values given in the chart below for the depth and cable inclination selected.

| Mean depth of deadman in ordinary earth | Inclination of pull (vertical to horizontal) and safe resistance in pounds per square foot |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Vertical | 1 to 1 | 1 to 2 | 1 to 3 | 1 to 4 |
| 3 feet | 600 | 950 | 1,300 | 1,450 | 1,500 |
| 4 feet | 1,050 | 1,750 | 2,200 | 2,600 | 2,700 |
| 5 feet | 1,700 | 2,800 | 3,600 | 4,000 | 4,100 |
| 6 feet | 2,400 | 3,800 | 5,100 | 5,800 | 6,000 |
| 7 feet | 3,200 | 5,100 | 7,000 | 8,000 | 8,400 |

c. Installation of Deadman. To obtain the best results when installing a deadman, the following procedure should be used?
(1) Position. The best position for the deadman is behind a natural crest or mound where as much surface of undisturbed earth
as possible may be used. It should be placed far enough away from the vehicle being winched or towed so that it will not interfere when the vehicle clears the obstacle. If the deadman is too close to the vehicle, an upward pull may cause the anchorage to become dislodged.
(2) Digging. Dig a trench deep enough to place the top of the deadman a foot or so below the ground surface, depending on the density of the soil, and long and wide enough to hold the deadman. Undercut the bank in the direction of pull at an angle of about $15^{\circ}$ from the vertical. Clear the bottom of the hole at a right angle to this bank. To help strengthen the top edge of the hole in the direction of pull, drive two stakes on each side of the cable at a slightly greater angle to the vertical than the angle made by the bank and flush with the slanted bank near the top. Cut a trench for the cable from the hole through the crest of the hill or mound. This should be slightly deeper than the bottom of the hole at the beginning and should continue out in an ascending slope.
(3) Cable attachment. Attach the cable or chain so that the largest area of the deadman is against the forward bank, and so that any tendency of the deadman to rotate acts downward and not upward.

## 3-46. Improved, Unmounted A-Frame

An improvised A-frame (fig. 3-26) is a field expedient that provides both a lift and a tow. It is useful for lifting a vehicie out of or over a ditch or hole, and for recovering a badly mired heavy vehicle. It can be made with 2 poles, approximately 12 feet long, and chains, cables, or ropes. The chains are used for lashing the poles together and for towlines. The poles are locked together to form shears. The legs of the shears are placed in two holes that are dug about 6 inches deep and 6 feet apart; a line is strung across the top of the A-frame between the power source and the vehicle to be moved. The legs of the A-frame must be placed far enough away from the vehicle that is to be moved to keep them from damaging it when it is lifted up and forward. After the front wheels have been lifted out of the ditch,


Figure 8-26. A-frame.
the vehicle must be moved slightly forward and the ditch filled or bridged to allow the rear wheels to cross.

## 3-47. Winch

## a. Using the Winch.

(1) When used properly, the winch installed on Army vehicles furnishes great lifting and pulling power. Improper use or careless handling, however, results in inefficient performance and possible breakdown of the winch mechanism.
(2) A vehicle may be taken across an obstacle with the assistance of its own winch by attaching the winch cable to a deadman or tree. The power of the drive wheels should be used whenever possible to assist the winch. Transmission gears should be so selected that the speed of the vehicle's wheels as they move over the ground will be the same as that of the winch cable as it is wound on the winch drum.
(3) After the vehicle with winch has crossed an obstacle with the assistance of its own winch, it may be used to help other vehicles without winches over the obstacle by either straight towing or winching operations. The winch cable may be extended and attached to the other vehicle, the winch mechanism locked, and the truck used as a towing vehicle; or the winch truck may be halted and blocked, and the winch alone used.
(4) When pulling a vehicle with the winch of another, the towed vehicle should assist with its maximum traction. The best power combination generally results if the winch is operated in the highest gear that will give sufficient power and the truck being winched is pulling in lowest gear.
(5) When the winch is used on a difficult pull, the winch truck may be held in place by using the brakes and wheel blocks, or by anchoring to a tree or deadman. When the


Figure s-27. Use of winch and snatch block.
load is not too heavy, traction devices will assist in holding the vehicle in place. A snatch block may be used to increase the mechanical advantage of the winch when pulls are too heavy for the winch alone (fig. 3-27).
(6) Overturned vehicles cannot always be righted by manpower alone. When necessary, a rigging similar to that shown in figure 3-28 may be used. Parking brakes on the overturned vehicle should be applied before the vehicle is righted. Any towing or winching method may be used to pull on the rope. A holding bridle, placed opposite to the bridle shown in the figure, should be used to prevent the vehicle from being damaged by settling too rapidly. Also, to prevent damage to bridles and the body of the vehicle, padding (rags and/or small boards) should be used between points of contact.
b. Safety Precautions.
(1) Certain precautions are necessary in the proper use of the winch cable. Whenever the winch cable is slipped over abrasive surfaces (concrete, asphalt, etc.), it should be protected by placing pieces of wood under it. Power must be applied to the cable gradually. Kinks and twists must always be removed. Cables should not be tied in knots, except for emergency repair. They should not be rigged around an angle in such a manner as to bend
them. Vehicles with metal tires should not be permitted to run over the cable.
(2) Most winches have a shearpin which is designed to break off under any strain which might snap the cable. Nevertheless, when a steel cable is tightened, it may break and snap back with enough force to kill or seriously injure a man. Personnel should stand clear before the cable is tightened. Makeshift shearpins should not be used
(3) The cable should be wound evenly on the drum when in use under load and when being rewound after use. To wind the cable evenly, at least a light load is necessary to prevent kinking. Otherwise, the cable may - become tangled or damaged, resulting in sharp burrs which can cause serious injury.
(4) Personnel handling winch cables should always wear work gloves, preferably with leather palms, to protect themselves from cuts and scratches caused by broken strands in the cable.

## 3-48. Chespaling Mats: Expedient Surface for Muddy or Soft Areas

a. Chespaling mats (fig. 3-29) are useful in providing a temporary hard surface in soft sand, mud, or swampy areas. They may be made of small saplings or bamboo rods approximately 6 feet long and about $11 / 2$ inches


Figure 3-28. Using a winch to right an overturned vehicle.


Figure 3-29. Chespaling mats.
in diameter. The saplings or rods are placed about 3 inches apart and wired together with the chicken-wire mesh or smooth wire strands. If saplings are used, they should be kept wet to preserve springiness in the wood and to prevent them from splitting or breaking. A 12 -foot mat of this type weighs about 75 pounds.
b. To construct a chespaling road, two mats are laid lengthwise with a 1-foot overlap in the center. If more mats are added, 1 -foot overlap is made on the ends. Pickets may be used to hold the mats down on curves. A mat road of this type should remain serviceable for 3 to 4 months, depending upon weather conditions and the condition of the surface over which it is laid. Approximately 1,500 vehicles may pass over such a road before replacement is needed.


Figure s-so. Forklift mounted on $6 x 6$ truck.
a. Other type of expedient road surfaces for use in soft areas (swamp or snow) are shown in FM 31-70 and TM 5-337.

## 3-49. Truck-Mounted Forklift

The truck-mounted forklift is particularly suitable for transferring palletized cargo and fuel
drums. To mount the forklift truck, bolt it to the rear of the bed of a $6 \times 6$ truck (fig. 3.30 ). Place a counterweight of about 750 pounds at the forward end of the cargo floor. Remove the finger lift of the forklift truck and install an overhead 5 -foot arm with a hook at its outer end.

| Product | Packaging | $\begin{gathered} \text { Weight } \\ (l b) \\ \text { (l) } \end{gathered}$ | Cubic ft |  | Conversion factors |  | Gallone per |  |  |  | Packages per |  |  | Capacity of vehicles for carrving filled containers : |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Actual | $\begin{aligned} & \text { Plan- } \\ & \text { ning } \end{aligned}$ | $\underset{\text { tol. }}{\text { Gal. }}$ | ${ }_{t o}^{L b}$ | STON | LTON |  |  | STON | LTON |  |  | railer |  | Truc |  |  | Semitra |  |
|  |  |  |  | factor | $l b$ |  | STON |  |  |  | STON | LTON | MTON | $1-$ ton | ${ }_{\text {ton }}^{11 / 6}$ | 11/6 | ${ }_{n}^{\text {biton }}$ | Cargo | ton | ton | ${ }_{\text {con }}^{\text {25- }}$ ton |
| A viationgasoline | Bulk |  |  | -- | 5.90 | . 169 | 339 | 380 |  | 9.04 |  |  |  |  |  |  |  |  |  |  |  |
|  | 50-gal. drum ${ }^{\text {a }}$ - | 373 | 9.03 | 11 | 6.91 | . 145 | 289 | 324 | 188 | --- | 5.36 | 6 | 3.48 | 5 | 8 | 8 | 13 | 26 | 53 | 64 | 134 |
|  | 55-gal. drum ${ }^{4}$ - | 389 | 8.8 | 11 | 7.20 | . 139 | 278 | 311 | 193 | --- | 5.14 | 5.76 | 3.57 | 5 | 7 | 7 | 12 | 25 | 51 | 62 | 128 |
|  | $55-\mathrm{gal}$. drum ${ }^{5}$ - | 364 | 9.2 | 11 | 6.90 | . 145 | 290 | 325 | 181 |  | 5.49 | 6.15 | 3.42 | 5 | 8 | 8 | 13 | 27 | 51 | 66 | 137 |
|  | 5-gal. can ${ }^{0}-{ }^{\text {- }}$ | 40.5 | . 81 | 1 | 8.0 | . 125 | 250 | 280 | 200 |  | 49.4 | 55.3 | 40.0 | 49 | 74 | 74 | 124 | 248 | 495 | 594 | 137 1,239 |
| $91 \mathrm{~A}$ <br> gasoline | Bulk |  |  | -- | 6.11 | . 164 | 327 | 367 |  | 8.73 |  |  |  |  |  |  |  |  |  |  |  |
|  | 55-gal. drum ${ }^{\text {\% }}$ | 384 | 9.03 | 11 | 7.11 | . 141 | 281 | 315 | 188 | --- | 5.21 | 5.83 | 3.48 | 5 | 7 | 7 | 13 | 26 | 52 | 62 | 130 |
|  | 55-gal. drum ${ }^{4}$ - | 400 | 8.8 | 11 | 7.41 | . 135 | 270 | 302 | 193 | -- - | 5.0 | 5.60 | 3.57 | 5 | 7 | 7 | 12 | 25 | 50 | 60 | 125 |
|  | 55-gal. drum ${ }^{\text {a }}$ - | 376 | 9.2 | 11 | 7.09 | . 141 | 282 | 316 | 181 | - - | 5.32 | 5.96 | 3.42 | 5 | 8 | 8 | 13 | 26 | 53 | 64 | 133 |
|  | 5-gal. can ${ }^{0}$..- | 41.6 | . 81 | 1 | 8.32 | . 120 | 240 | 269 | 200 |  | 48.1 | 53.8 | 40.0 | 48 | 72 | 72 | 120 | 240 | 480 | 576 | 1,200 |
| Kerosene | Bulk ------- |  |  | -- | 6.80 | . 147 | 294 | 329 |  | 7.84 |  |  |  |  |  |  |  |  |  |  |  |
|  | 55-gal. drum ${ }^{3}$ - | 421 | 9.03 | 11 | 7.80 | . 128 | 256 | 287 | 188 |  | 4.75 | 5.32 | 3.48 | 4 | 7 | 7 | 12 | 23 | 47 | 57 | 119 |
|  | 55-gal. drum ${ }^{4}$ - | 437 | 8.8 | 11 | 8.09 | . 124 | 247 | 277 | 193 |  | 4.58 | 5.13 | 3.57 | 4 | 6 | 6 | 11 | 22 | 46 | 55 | 114 |
|  | 55-gal. drum ${ }^{\text {b }}$ - | 351 | 9.2 | 11 | 6.62 | . 151 | 302 | 338 | 181 |  | 5.70 | 6.38 | 3.42 | 5 | 8 | 8 | 14 | 28 | 57 | 68 | 114 |
|  | 5-gal. can ${ }^{\text {² }}$-- | 45 | . 81 | 1 | 9.0 | . 111 | 222 | 249 | 200 |  | 44.4 | 49.8 | 40.0 | 44 | 66 | 66 | 111 | 222 | 445 | 534 | 1,110 |
| Diesel fuel | Bulk |  | --- | .- | 6.99 | . 145 | 286 | 321 |  | 7.63 |  |  |  |  |  |  |  |  |  |  |  |
|  | 55-gal. drum ${ }^{3}$ - | 432 | 9.03 | 11 | 8.0 | . 125 | 250 | 280 | 188 | -- | 4.63 | 6.19 | 3.48 | 4 | 6 | 6 | 11 | 23 | 46 | 55 | 116 |
|  | 55-gal. drum ${ }^{4}$ - | 448 | 8.8 | 11 | 8.30 | . 120 | 241 | 270 | 193 | -- - | 4.46 | 5.00 | 3.57 | 4 | 6 | 6 | 11 | 22 | 45 | 53 | 112 |
|  | 55-gal. drum ${ }^{5}$ - | 430 | 9.2 | 11 | 8.11 | . 123 | 247 | 276 | 181 | --- | 4.65 | 5.21 | 3.42 | 4 | 7 | 7 | 11 | 23 | 46 | 55 | 112 |
|  | 5-gal. can ${ }^{\text {a }}$-- | 46 | . 81 | 1 | 9.20 | . 109 | 317 | 244 | 206 |  | 43.5 | 48.7 | 40.0 | 43 | 65 | 65 | 109 |  |  | 55 | 116 |
| Lubricating oils | Bulk |  | -- | -- | 7.60 | . 132 | 263 | 295 |  | 7.02 |  |  |  |  |  |  |  |  |  | 522 | 1,090 |
|  | 55-gal. drum ${ }^{3}$ - | 472 | 9.03 | 11 | 8.58 | . 117 | 233 | 261 | 191 |  | 4.24 | 4.75 | 3.48 | 4 | 6 | 6 |  |  | 42 |  | 106 |
|  | $55-\mathrm{gal}$. drum ${ }^{\text {4 }}$ | 488 | 8.8 | 11 | 8.87 | . 113 | 226 | 253 | 196 | --- | 4.10 | 4.59 | 3.57 | 4 | 6 | 6 | 10 | 20 | 42 | 49 | 106 |
|  | 55-gal. drum ${ }^{\text {b }}$ - | 462 | 9.2 | 11 | 8.56 | . 117 | 234 | 262 | 185 | -- - | 4.33 | 4.85 | 3.42 | 4 | 6 | 6 | 10 | 21 | 43 | 52 | 108 |
|  | 5 -gal. can ${ }^{0}$--Case of 1-qt cans | 49 | 0.81 | 1 | 9.80 | . 102 | 204 | 229 | 181 | --- | 40.8 | 45.7 | 40.0 | 40 | 61 | 61 | 102 | 204 | 410 | 489 | 1,020 |
|  | (12/case) <br> Case of 1-qt cans | 35 | . 88 | 1 | --- | --- | --- | -- | --- | --- | 58.0 | 64.9 | 40 | 57 | 85 | 85 | 143 | 286 | 572 | 687 | 1,430 |
|  | (24/case) Case of 5-qt cans | 60 | 1.6 | 2 | --- | --- | --- | --- | --- |  | 33.4 | 37.3 | 20 | 33 , | 50 | 50 | 83 | 166 | 333 | 400 | 835 |
|  | (6/case) | 77 | 1.9 | 2 | --- | --- | --- | -- |  |  | 26.0 | 29.1 | 20 | 26 | 39 | 39 | 65 | 130 | 260 | 312 | 660 |


${ }^{2}$ Bulk petroleum products are measured In U.S. gallons or barrels. One barrel equals 42 U.S. gallons.
${ }^{2}$ Based upon authorized off-highway loads In short tons. When overloads are autborized, these quantities may be increased to the cubic capacity of the vehicle or to 100 percent overweight, whichever limit is reached first.
${ }^{3}$ 18-gage standard, welghs 54 pounds empty, holds 54 gallons of llght products and 55 gallons of heavy products. Federal Specificatlon PPP-D-729, Amendment 1.
4 16 -gage standard, weighs 70 pounds empty, holds 54 gallons of llght products and 55 gallons of heavy products. Federal Specification PPP-D-729, Amendment 1 .
${ }^{5} 18$-gage limited standard, weighs 52 pounds empty, holds 53 gallons of light products and 54 gallons of heavy products. Federal Specification PPP-D-729.

- For planning purposes, weight of gasoline may be taken as 42 pounda and weight of lubricating oil for engines at 50 pounds per 5 -gallon can, including weight of can. An empty 5 -gallon can weighs approximately 11 pounds.


## 3-51. Volume of Barracks Bags

The volume of barracks bags packed to capacity averages 4.4 cubic feet. The following capacities can be used for planning purposes. Quantities are based upon cargo space of vehicles, and can be increased by loading above sideboards for vehicles without closed top. Figures are based upon the assumption that the weight of the bags does not average over 50 pounds each. Should this weight be exceeded, appropriate adjustments must be made.


## 3-52. Vehicle Size and Weight Limits

The charts below may be used as planning guides. Size and weight limits are changed periodically as a result of road and bridge construction. Planners must check with local military and/or civilian agencies to verify local limits and methods of clearance or exemption before putting vehicles on the road.
a. United States.

Compiled December, 1965, by National Highway Users Conference, National Press Bldg., Washington, D.C. 20004 as an addendum to NHUC Motor Vehicle Law Reporting Service No. 1.

Size restrictions
Gross weight limits
(in thousands of pounds)
Length (feet)
pneumatic tires only


A. Gross weight determined by table of axle spacing and/or sum of axle weight limits.
B. Gross weight determined by bridge formula. See last page.
C. Weight limits fixed by state law.
D. Buses permitted length of 40 ft . in Colo., Ind., Iowa, Mich., Mont., N. H., Pa., S. D., Tenn., Va., Wisc.; 3 axle buses permitted 40 ft. in Calif., La., Misa, N. C., N. Y., Ohio:
buses permitted 45 ft . in Okla.. 42 ft . in Del.
E. Plus weight on front axle.
F. Semi-trailers 40 ft . in Alaska, Calif., Ohio.
G. 'Bus width 102 in. Colo., 104 in . Wisc.
H. Vehicles over 35 ft . in length, except bus
I. Semi-trailer length not restrlcted ln Ariz., Fla., Min
J. Full trailers not permitted in Ala., Conn., Ky. ; reatricted to $\mathbf{8 , 0 0 0} \mathrm{lbs}$. and 38 ft . length in Mass., 3,500 lba. in Tenn.
K. Auto transporter length 55 ft . In Minn., 60 ft . in Mil, Ind., Iowa (algo double bottoms), Kans., Mo., Mlch., S. C. : 65 ft . in Idaho on desigrated highways,
L. Auto transporter height $181 / \mathbf{f} \mathbf{f t}$. in N. Y., W. Va.; 14 ft . in Wash.
M. Limit on Interstate System only.
N. Subject only to axle limits.
O. On desisnated highways
P. Effective February 5, 1986.

NP-Not permitted.
NR-Not restricted.
NS-Not specified
b. Canada.

| Province | Height (ft) | Width (ft) | Vehicle length ( $f t$ ) |  | Axle load limits (a) |  | Vehicle gross veight limits (lb) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Single unit | Tractor and trailer | Single axie | $\begin{gathered} \text { s-axle } \\ \text { tandem } \end{gathered}$ |  |
| British Columbia | 13.5 | 8 | 35 | 50 | 18,000 | 32,000 | 76,000 |
| Alberta | 13.5 | 8 | 35 | 60 | 18,000 | 32,000 | 72,00 |
| Saskatchewan | 13.5 | 8 | 35 | 50 | 18,000 | 28,000 | 64,000 |
| Manitoba | 13.5 | 8 | 40 | 60 | 18,000 | 32,000 | 72,000 |
| Ontario | 13.5 | 8 | 33 | 50 | 18,000 | 30,000 | 70,000 |
| Quebec | 12.5 | 8 | 35 | 60 | 16,000 | 24,000 | 50,000 |
| New Brunswick | 12.5 | 8 | 35 | 60 | 18,000 | 30,000 | 70,000 |
| Nova Scotia | 12 | 8 | 36 | 65 | 18,000 | 26,000 | 56,000 |
| Prince Edward Island | 14.5 | 8 | 35 | 85 | 18,000 | 30,000 | 54,000 |
| Newfoundland | No inform | n availabl |  |  |  |  |  |
| Yukon Territory | No inform | n availabl |  |  |  |  |  |
| Northwest Territories | No inform | n availabl |  |  |  |  |  |

c. Europe.

| Country |  |  | Length (ft) |  |  | Axle load limits (lb) |  | Gross weight limita (lb) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Width } \\ (f t) \end{gathered}$ | Height (ft) | Sinole unit | Truck tractor semitrailer | $\begin{gathered} \text { Other } \\ \text { com- } \\ \text { binations } \end{gathered}$ | Single | Tandem | $\begin{gathered} \text { g-axle } \\ \text { vehicle } \end{gathered}$ | s-axle vehicle | $\underset{\text { articulated }}{\text { f-axle }}$ vehicle | 5-axle vehicle | Vehicle with trailer |
| Austria | $7.87{ }^{\circ}$ | 12.5 | 36.09 | 45.93 | 59.05 | 17,637 | 28,660 ${ }^{\text {b }}$ | 28,660 | 39,684 | 44,092 | 55,113 ${ }^{\text {c }}$ | 72,752 |
| Belgium | 8.20 | 13.12 | 39.37 | 45.93 | 72.18 | 38,660 | 44,092 ${ }^{\text {d }}$ | 41,887 | $\begin{aligned} & 57,302 \cdot \text { to } \\ & 70,547 \end{aligned}$ | 70,548 | 70,548 | 70,548 |
| Denmark | 8.20 | 7.81 | 39.37 | 45.93 | 59.05 | 17,637 | 31,967 | $\left({ }^{1}\right)$ | ( ${ }^{\text {P }}$ ) | ( ${ }^{1}$ ) | $\left({ }^{\text {P }}\right.$ ) | $\left({ }^{( }\right)$ |
| Finland | 7.87 | 12.5 | 36.09 | 45.93 | 59.05 | 14,110 | 22,046 | ${ }^{8}$ ) | $\left({ }^{\text {c }}\right.$ ) | ${ }^{(8)}$ | ( ${ }^{\text {( })}$ | ${ }^{(8)}$ |
| France | 8.20 | 12.25 | 36.09 | 45.93 | $59.05{ }^{\text {b }}$ | 22,860 | 46,297 | 41,887 ${ }^{\text {' }}$ | 77,161 ${ }^{\text {J }}$ | 77,161 ${ }^{\text {' }}$ | 77,161 ${ }^{\text {' }}$ | 77,161 ${ }^{1}$ |
| Great Britain | 8.09 | 15.0 * | 29.99 | 35.0 | --- | 20,150 | 24,625 | 31,305 | 44,753 | 53,792 | 71,650 | 71,650 |
| Italy ------ | 8.20 | 13.1 | 36.09 | 45.93 | 59.05 | 22,046 | 31,967 | 30,864 | $\begin{aligned} & 39,863 \text { to } \\ & 61,729 \end{aligned}$ | 61,729 | $\begin{aligned} & 70,547 \text { to } \\ & 79,366 \end{aligned}$ | $\begin{aligned} & 70,547 \text { to } \\ & 79,366 \end{aligned}$ |
| Luxembourg | 8.20 | 13.1 | $36.09{ }^{1}$ | 45.93 | 65.62 | 28,660 | 41,887 ${ }^{\text {b }}$ | 41,887 | 57,320 | 77,162 | $\begin{aligned} & 77,162 \text { to } \\ & 88,185 \end{aligned}$ | $\begin{aligned} & 77,162 \text { to } \\ & 88,185 \end{aligned}$ |
| Netherlands | 8.20 | 12.5 | 36.09 | 45.93 | 59.05 | 17,637 ${ }^{\text {m }}$ | 35,273 |  | ---- |  | ---- |  |
| Norway ${ }^{\text {n }}$ | 7.22 ${ }^{\circ}$ | ---- |  |  |  | 4,409 ${ }^{\circ}$ | 4,409 | ----- |  | ---- |  | ---- |
| Poland | 8.20 | 13.1 |  |  | ---- | 17,637 | 30,864 | 30,864 ${ }^{\text { }}$ | 44,093 ${ }^{\text {p }}$ | 57,320 ${ }^{\text {P }}$ | ---- |  |
| Portugal | 8.04 | 13.1 | 32.81 | 39.37 | 45.93 | 22,046 | 36,376 | 33,069 | 44,092 | 44,092 | 44,092 | 77,162 |
| Spain | 8.24 | 14.6 | 39.37 | $32.81{ }^{4}$ | $32.81{ }^{\text {¢ }}$ | $\begin{aligned} & 22,046 \text { to } \\ & 26,456 \end{aligned}$ | $\begin{aligned} & 33,069 \text { to } \\ & 44,092 \end{aligned}$ | 33,069 | $\begin{aligned} & 33,069 \text { to } \\ & \mathbf{5 5 , 1 1 6} \end{aligned}$ | $\begin{aligned} & 33,069 \text { to } \\ & 59,525 \end{aligned}$ | $\begin{aligned} & 33,069 \text { to } \\ & 59,525 \end{aligned}$ | $\begin{aligned} & 33,069 \text { to } \\ & 59,525 \end{aligned}$ |
| Sweden | $\begin{aligned} & 7.71 \text { to } \\ & 8.20 \end{aligned}$ | ---- | ---- |  | ---- | $\begin{aligned} & 13,228 \text { to } \\ & 17,637 \end{aligned}$ | $\begin{aligned} & 17,637 \text { to } \\ & 26,456 \end{aligned}$ | ( ${ }^{\text {r }}$ | (') | ( ${ }^{\text {r }}$ | ( ${ }^{\text {r }}$ | ( ${ }^{\text {r }}$ |
| Switzerland | $\begin{aligned} & 7.55^{\circ} \text { to } \\ & 8.20 \end{aligned}$ | 13.1 | 32.81 | 45.93 | 59.05 | 22,046 | ---- | 35,273 | 46,297 | 57,320 | 57,320 | 57,320 |
| West Germany ' | 8.20 | 13.1 | 36.09 | 49.2 | 54.13 | $\begin{aligned} & 17,637{ }^{\mathrm{V}} \text { to } \\ & 22,050 \end{aligned}$ | $\begin{aligned} & \text { o } 26,455 \text { ' to } \\ & 35,280 \end{aligned}$ | 26,455 | 52,840 | 52,920 | 77,180 | 88,200 |

a For buses, 98.42 in . For bus trailers, 96.45 in . For other trailers, 92.52 in .
b Maximum $22,046 \mathrm{lb}$ per axle.
c For truck or bus with trailer, $72,752 \mathrm{lb}$.
d Maximum 28,660 lb per axle.

- For 8 -axle truck, $57,320 \mathrm{lb}$. For tractor track $\operatorname{semitrailer,~72,750~ib.~}$
${ }^{1}$ Maximum weight depends on the distance between the center axles.
F Weight of $22,406 \mathrm{lb}$ pius 308.64 lb for every 3.94 in . of the distance between the
foremost and rearmost axles of a vebicle or the combination of vebicles exceeding 6.56 ft .
${ }^{h}$ With special considerations in urban and suburban traffic, 65.62 in.
1 The weight per 39.37 in . between the outer axles cannot be greater than $11,023 \mathrm{lb}$.
\& For 3 -axle trailer, 57.320 lb ; for tractor truck semitrailer, $77,161 \mathrm{lb}$.
Only for buses.
${ }^{1}$ Can be increased to 39.37 ft if the back projection is not larger than slx-tenths of the wheelbase or 14.48 ft .
$m$ In axles with four single wheels (dual wheels are considered as one) $35,273 \mathrm{lb}$.
n Exemptions granted for certain roads to 7.71 ft wide and $15,432 \mathrm{lb}$ per axle.
- Exemptions from restrictions on vehicle width and axle weight are granted upon application. They permit 86.61 in . width and $8,818 \mathrm{lb}$ axle welght. 88.58 in . width and
$11,023 \mathrm{lb}$ axle weight, and 95.52 in . width and $13,228 \mathrm{lb}$ axle weight. respectively, and refer to a great number of specifically lndicated roads. Exemptions up to an axle weight of $15,432 \mathrm{lb}$ can be granted on certain main roads.
p Axle spacing, 118.11 in .
- In special cases, 45.98 ft .
${ }^{r}$ Gross weight iimit dependent on axde distance.

| Axle diotance (ft) | Gross weight limite (lb) |
| :---: | :---: |
| 16.41 ---- | -.....-_26,455 to 35,274 |
| 32.81 ......- | -...-39,683 to 48,502 |
| 49.22 ...-.--- | -_-.-...-52,911 to 61,729 |
| 65.62 | ...-68,343 to 77,162 |

: On secondary streets, 86.61 in . On special roads for foreign buses, 94.42 in . Trucks 94.48 in .
 to 1-1-58.
u Driving axle $22,046 \mathrm{lb}$, others $17,637 \mathrm{lb}$.
v Axle distance less than $4.27 \mathrm{ft}, 31,967 \mathrm{lb}$. Greater axle distance, $35,274 \mathrm{lb}$.

## 3-53. Preparaifon of Vehicles for Air Movement

a. Units which must be ready for immediate movement by air should make preparations well in advance to avoid delays in the loading of vehicles into the transporting aircraft. Essential items of information that must be available are-
(1) Weight of vehicle (with load),
(2) Dimensions of vehicle.
(3) Center of gravity of loaded vehicle.
$b$. The dimensions of the vehicle may be obtained from the vehicle technical manual. Since unit equipment will be loaded on vehicles for air shipment in accordance with a prescribed loading plan, the center of gravity will have to be computed for each vehicle. Actual weighing and computation may be made during loading plan tests. After a vehicle has been loaded in accordance with the unit loading plan, its center of gravity should be marked on the exterior of the vehicle with crayon or waterproof tape.
c. Figure 3-31 illustrates method of determining the weight and center of gravity location of single- and multi-unit vehicles.

3-5a. Vehicle Weight and Dimension Card The NATO Armed Forces have agreed to adopt for the transportation of their vehicles the card as shown in figure 3-32.
$a$. The front will be printed in white on a black background. (When printed forms are not immediately available, a substitute card printed and completed in black on a white background.)
b. The border of the front will be gummed so as to facilitate affixing to windshields.
$c$. The card is to be printed in both the official NATO languages (English and French) and in the language of the country of origin if other than English or French.
d. The size of the card is $91 / 2$ inches ( 24 cm ) $\times 71 / 4$ inches ( 18 cm ).
$e$. The method by which the card will be employed is shown on the reverse of each card (fig. 3.32).

## 3-55. Transparicion Morom Pool bayour and Faribioites

The basic layout of motor pools may vary depending on space and existing conditions. The typical motor pool should include the facilities shown in $a$ through $i$ below.

Note. In cases of new construction, the use of a single structure is advocated. This promotes subtantial economies in construction costs and operations.
a. Office. The motor pool office should be located in the motor pool operations area.
b. Dispatch Office. All vehicular operations are controlled through this office. If at all possible, it whould be located at the exit of the motor pool, thereby allowing the dispatcher to visibly check vehicles leaving the parking area.
c. Driver's Room. The driver's room is conveniently located in the vicinity of the dispatch office but, for reasons of orderly operation, separate from the main dispatch office.
d. Emergency Repair Facility. This facility performs minor and emergency repairs that are not serious enough to warrant removal of the vehicle from operation. It is usually located in a section of the general repair shop or at the POL point.
e. Vehicle Washing Facilities. Such facilities should be available for use under all weather conditions. Facilities should be so located that drainage away from parking areas and buildings is provided. The use of automatic washing facilities should be considered when feasible.
f. Preventive Maintenance and General Repair Shop. The number of vehicles serviced will be a deciding factor in the type of shop used. The primary function of the shop should be to accomplish regularly scheduled preventive maintenance, lubrication, and general repair activities.
g. Allied Trade Shops. Shops for spot painting, minor body work, carpentry, and welding are set up at the motor pool. Because of the fire hazard existing in some trade shops, further segregation of this facility is often required. For example, painting and welding activities should not be performed in close proximity.


$$
X=\frac{L w_{2}}{W}
$$

## WHERE

$X=$ Distance from front axle so unit center-of-gravity location
$\mathbf{L}=\mathbf{W h c e l b a s e}$
$w_{1}=$ Front axle load
$w_{1}=$ Rear axle load
$\mathbf{W}=$ Total weight of unit

## TO LOCATE CARGO UNIT CENTER OF GRAVITY, DETERMINE $X$



1. Determine axle loads by weighing all axles ( $w_{1}$ and $w_{2}$ ).

## Nofe

Vehicle must be level when weighing.
2. Determine cotal weight of unit (W) by adding axle loads ( $w$, and $w_{1}$ ).
3. Determine wheelbase (L).
4. Determine rear axle moment about front axic by multiplying rear axle load ( $w_{\mathbf{\prime}}$ ) by wheelbase (L).
5. Determine center-of-gravity distance from front axle ( X ) by dividing rear axle moment by total weight (W).


REAR AXLE MOMENT

## VEHICLES

Figure 3-31. Determining cargo unit weight and center of gravity.

$$
X=\frac{L_{1} w_{2}+L w_{3}}{W}
$$

## WHERE

$\mathbf{X}=$ Distance from front axie to unit center-of gravity location
$W_{1}=$ Front axie load
$L_{1}=$ Tractor wheelbase
$w_{2}=$ Tractor rear axic load
$L_{2}=$ Trailer wheelbase
$w_{3}=$ Trailer axie load
$L=$ Tocal wheelbase of unit
$W=$ Total weight of unit


TO LOCATE CARGO UNIT CENTER OF GRAVITY, DETERMINE $X$

1. Determine axcle loads by weighing all axies ( $w_{1}$, $w_{2}$, and $\left.w_{3}\right)$.

## Note

Vehicle must be level when weighing.
2. Determine total weight of unit ( $W$ ) by adding all axle loads.
3. Determine cractor wheelbase ( $L_{1}$ ) and trailer wheelbase ( $L_{2}$ ).
4. Derermine total wheelbase of unit (L).
5. Determine tractor rear axle moment about front axie by multiplying tractor wheelbase ( $L_{1}$ ) by tractor rear axle load ( $\mathrm{w}_{\mathbf{2}}$ ).
6. Determine trailer axie moment by multiplyìng cotal wheelbase (L) by crailer axie load (ws).
7. Determine tocal moment about front axie by adding trailer axle moment and tractor rear axle moment.
8. Determine center-of-gravity distance from front axie $(\mathrm{X})$ by dividing total moment by total weight (W).

## Notes

As an aid co load planning, it may be desirable to know relationship of vehicle center of gravity to vehicle extremities. To determine distance from front bumper to center of gravity, add distance between front bumper and front axle to value determined in step 8 . To determine distance berween aft end of vehicle and center of gravity, suberact value determined in step 8 from distance between froat axle and aft end of vehicle.


PROBLEM: Determine center-of-gravity location.

## SOLUTION:

1. $w_{1}=9,580$ pounds
$w_{2}=20,850$ pounds
$w_{s}=13.730$ pounds
2. $w=9,580+20,850+13,730=44,160$
pounds
3. $L_{1}=185$ inches $L_{2}=225$ inches
4. $L=185+225=410$ inches
5. $185 \times 20,850=3,857,250$
6. $410 \times 13,730=5.629,300$
7. $3,857,250+5,629,300=9,486,550$
8. $9,486,550+44,160=214.8$

## CONCIUSIONs

Cargo unit center of gravity is locatod 214.8 inches aft of front axle.

## MULTIPLE-UNIT VEhICLES

Figure 3-81-Continued.

```
(Example--Front)
```

VEHICLE WEIGHT AND DIMENSION CARD
FICHE DE DIMENSIONS ET DE POIDS DU VEHICULE

```
(3d language/3ème langue)
```

State unit of measure used. Préciser 1'unité de mesure utilisee. _ _ _ (3d language/3ème langue).

## WEIGHT

POIDS
_ _ _ (3d language/3ème langue)

LENGTH
LONGUEUR
_ _ _ (3d language/3ème langue)

## BREADTH

LARGEUR
_ _ (3d language/3ème langue)

## HEIGHT

HAUTEUR
_ _ _ (3d language/3ème langue)

## GROUND PRESSURE OR MAXIMUM AXLE LOAD

PRESSION UNITAIRE OU POIDS DE L'ESSIEU LE PLUS CHARGE
_ _ _ (3d 1anguage/3ème langue)

Figure 3-32. Vehicle weight and dimension card.
h. Supply and Parts Room. This facility is centrally located within the main shop building to provide easy access to parts and tools. Parts, bins, tool racks, and an appropriate issue counter should be provided.
i. Public Address System. A public address
system facilitates control of the motor pool or parking area. Interoffice communication between the dispatch office and key locations within the pool area eliminates many unnecessary, time-consuming trips and contributes to more orderly execution of assigned duties.
(Example--Back)
Directions for Use
Mode d'emploi

1. This card is designed to display vehicle laden weight and dimensions to all concerned with loading it on any means of transport, e.g., to an aircraft, ship, etc.
2. Cette fiche est destinèe á indiquer le poids on charge et les dimensions d'un véhicule à tous ceux qui peuvent être responsables de son chargement sur n'importe quel mode de transport, par example: avion, navire, etc.

3. Accurate weight and dimensions will be printed in chalk by the unit or depot preparing a vehicle for movement. This card will then be fixed inside the windscreen on the passenger's side. On tanks or other vehicles without windscreens, this card will be fixed on a suitable surface on the opposite side of the vehicle from the driver's seat, where it can be easily seen. If possible, it should be protected from inclement weather.
4. Le poids et les dimensions exacts serent indiqués à la craie, en lettres majuscules, par $l^{\prime} u n i t e ́ ~ o u ~ l e ~ d e ́ p o ̂ t ~ p r e ́ p a r a n t ~ l e ~ v e ́ h i c u l e ~$ en vue de son transport. Cette fiche sers ensuite apposee à l'interieur du pare-brise, du côté du passager. Dans le cas des chars ou autres véhicules sans pare-brise, la fiche sera apposée sur une surface appropriee sur le côté du véhicule opposé à celui du siège du conducteur et dans une position facilement visible. Si possible, le fiche doit être à $l^{\prime}$ abri des intempéries.
5. $\ldots \ldots$ (3d language/3ème langue)
6. This is a NATO form and whoever "chalks in" the weights and dimensions should use his country's normal system of weight and measurement.
7. Cette fiche est un formulaire OTAN et la personne chargee d'inscrire la craie le poids et les dimensions du véhicule doit utiliser le système normal de poids et mesures de son propre pays.
8. $\quad \ldots \ldots$ (3d language/3ème langue)

Figure 3-32-Continued.


Figure 3-3s. Motor paol parking plan.

## CHAPTER 4

## RAIL

## Section I. ORGANIZATION

## 4-1. Organization of Transportation Railway Service (TRS)

## (fig. 4-1)

General headquarters, transportation railway service.

Headquarters and headquarters company,
transportation railway
brigade.

Headquarters and headquarters company, transportation railway group.

Mission
To direct the operation and maintenance of railways used for military pourposes in a large theater of operations.

To command and provide operational planning, supervision, coordination, and control of the activties of transportation railway groups.
To command, administer, and supervise the overanions of railway battalions and attached units.

To operate and maintain a railraod division in a theater of operations.

To a theater support com mend or to a theater army logistical command or general headquarters, transportation railway service.
To a theater support command or to a theater army logistical command or field army. Normally assigned to headquarters and headquarters commany, transportation railway command or may operate separately under the supervision of the appropriate staff transportation officer.
To a Assignment mend army logistical command.

To transportation railway group.

Transportation railway battalion.

55-225

Capability
Provides:
a. Overall supervision and direction of all railroads of any theater of operations, and
b. Command of all troops assigned to transportation railway service.
Provides command and supervision of two or more transportation railway groups, TOE 55-202.

Provides command and supervision for from two to six transportation railway battalions and transportaion railway maintenance units as required.

During phase I operations (complete military operation of the railroad) :
a. Operates 40 locomotives per day in road and yard service over approximately 90 to 150 miles of railraod;
b. Operates a railway classification yard for the formation of trains;
Headquarters and head-
quarters company,
transportation railway
battalion.

To exercise command, control and administration of organic and attached units of the transportation railway battalion.

To a theater support command organic to the transportation railway battalion.

Transportation railway engineering company.

Transportation railway company.

To maintain and repair railway track, bridges, buildings, and railway signals and communications within a railway division.
To inspect, service, and make running repairs to diesel-electric locomotives and rolling stock.

## Capability

c. Inspects, conditions, and per. forms up to general support maintenance on approximately 40 locomotives and 800 railroad cars; performs running inspections of approximately 2,000 railroad cars per day; and repairs tools and mechanical equipment of all companies within the battalion;
d. Inspects and maintains approximately 90 to 150 miles of railway right-of-way; and
$e$. Inspects and repairs wire communications used for train movements; provides organizational maintenance on organic equipment.
a. Provides command, staff planning, administration, control, and supervision of operations of the transportation railway battalion and assigned and attached units;
b. Dispatches all trains operated by the battalion and supervises M-line operators; and
c. Operates railway stations and signal towers which are the responsibility of the battalion.
Performs maintenance and repair of track, railway signals, electrical communications, bridges, and structures of a railway division on a 24-hour basis.
a. Services and makes running repairs to approximately 40 dieselelectric locomotives and 800 railway cars on an around-theclock basis;
b. Performs running inspection for 2,000 railway cars daily; and
c. Performs light repairs to tools and limited repairs to special


## Capability

c. Inspects and, as necessary, adjusts or secures loads on cars passing through the yard.
To perform general support of diesel-electric locomotives and rolling stock in areas where static facilities are inadequate or nonexistent.

To headquarters and hea quarters company, transportation railway group or to a transportation railway battalion or comparable unit.
erforms the following functions on a 24-hour basis:
a. Inspecting and performing field maintenance on 20 diesel-electrir locomotives and 100 railway cars; and
b. Assembling railway equipment

Team EI, railway workshop $\quad 55-500$ -mobile.

*Assigned as required
Figure 4-1. Organization of the transportation railway service.

## Section II. EQUIPMENT

## 4-2. Whyte Classification System of Locomotives

The locomotives described in this section are classified according to the Whyte system, which classifies locomotives according to the arrangement of their wheels. A series of numerals separated by hyphens is used to designate the total number of wheels on the axle of each type of locomotive truck-the front (leading) truck, driving wheel group, and rear (trailing) truck, respectively. The figures always describe the locomotive's wheels from front to rear; the wheels of the locomotive tender are not counted in the classification of 2-8-2 indicates one pair of leading wheels, four pairs of coupled driving wheels, and one pair of trailing wheels. The absence of any of the three types of wheels is always denoted
by a zero; thus a 2-8-0 locomotive has no trailing wheels. Diesel locomotives may also be classified by this system; figures such as 0-6-6-0 indicate no leading or trailing wheels and two sets of three driving axles each, or a total of 12 driving wheels. The classification commonly used in Europe and other parts of the world, however, classifies a diesel or electric locomotive by letters and figures. A diesel $0-4-4-0$ is classified $\mathrm{B}-\mathrm{B}$; a $0-6-6-0$ is designated C-C, etc. Idler wheels (those which exert no tractive effort) and leading and trailing wheels are designated with numbers. A singleunit locomotive with two six-wheel trucks in which the center wheel is an idler would be designated as A1A-A1A. An electric locomotive four-wheel leading and trailing trucks and six driving wheels would be designated 2-C/C-2.

## 4-3. Characteristics of Railway Equipment

## a. Locomotives.

(1) Steam.

(2) Diesel-electric.


a For diesel-electric power, the continuous TE is approximately half of the starting TE. ${ }^{5}$ Reduced to 800 if equipped with Clarkson vapor heater.
(3) Gasoline-mechanical and diesel-me-
chanical.

| Type | Gage | $\begin{aligned} & \text { Weioht } \\ & \text { (lb) } \end{aligned}$ | Drawbar pull (b) | Horsepower <br> (total engine) | Curvature, $\min$ radius (ft) |  | Puel capacity |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 10-ton, single-engine, 0-4-0, domestic service | 561/2 | 20,000 |  | 100 |  |  | (diesel) |
| 5-ton, single-engine, 0-4-0, foreign and domestic service | 36 | 11,000 | $\begin{aligned} & 2.7 \mathrm{mph}-2,50012 \\ & \mathrm{mph}-875 \end{aligned}$ | 100 34 | 75 20 | 30 15 | (diesel) (gasoline) |


| Type | Ga | Capacity |  | Inoide dimension |  |  | Door dimensione | $\begin{gathered} \text { Tare } \\ \text { waight } \\ \text { (STON) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | (in.) | (b) | (ouft) | Length | Width | Height |  |  |
| , foreign service | 36, 39 \%/8, 42 | 60,000 | 1,588 | $34^{\prime} 51 / 2^{\prime \prime}$ | $7^{\prime} \% 4^{\prime \prime}$ | $6^{\prime} 4^{\prime \prime}$ | 7'101/4" wide | 13.6 |
| 8W, domestic service |  |  |  |  |  |  | $6^{\prime} 1-16^{\prime \prime}$ high |  |
| 8W, domestic service | 661/2 | 100,000 | 3,975 | 40'6" | 9'2" |  | $6^{\prime}$ wide, clear opening | 23 |
| 8W, broad gage, foreign service | 561⁄2, 60, 63, 66 | 80,000 | 2,520 | $40^{\prime \prime} 6^{\prime \prime}$ | $8^{\prime} 6^{\prime \prime}$ | 6'5\%" | $8^{\prime}$ high, clear opening $8^{\prime} 31 / 4^{\prime \prime}$ high | 18.5 |
| c. Open-Top Car |  |  |  |  |  |  | 6'834" ${ }^{\prime \prime}$ wide |  |

(1) Flatcars.

| 8W, Type | Gage (in.) | Normal capacity (lb) ${ }^{\circ}$ | Platform length ${ }^{\circ}$ | Platform width ${ }^{\circ}$ | Platform height above rail | $\begin{gathered} \text { Tare } \\ \text { weight } \\ \text { (STON) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 8W, narrow gage, foreign service 12W, domestic service --- | 36, 39\%, 42 | 60,000 | $34^{\prime \prime} 81 / 2^{\prime \prime}$ | $7{ }^{\prime 2} 2^{\prime \prime}$ | $3^{\prime \prime} 7^{\prime \prime}$ | 10.9 |
| 8 W , domestic service | $561 / 2$ | 200,000 | $54^{\prime}$ | 10'61/2" | 4'114" | 35 |
| 12 W , broad gage, foreign service, 80 -ton | 561/2 $661 / 2,60,63,66$ | 140,000 | 49'111/2" | $10^{\prime} 31 /{ }^{\prime \prime}$ | 3'81/2" | 27 |
| 12 W , domestic service (passenger train service) | $561 / 2,60,63,66$ $561 / 2$ | 160,000 200,000 | 46'4' ${ }^{\prime \prime}$ | 9'8' | 4'2\%/8" | 35.3 |
| 8 W , domestic service ----------------------1) | $561 / 2$ $561 / 2$ | 200,000 100,000 | 543'3 | $10^{\prime} 61 / /^{\prime \prime}$ $10^{\prime \prime} 6^{\prime \prime}$ | ${ }^{4} 5 \% \%^{\prime \prime}$ |  |
| 8W, broad gage, foreign service | 561/2, 60, 63,66 | 100,000 80,000 | 40'9" | 10'61/4" | 3'8 $3^{\prime \prime} 15-16^{\prime \prime}$ | 25.5 |
| 8W, broad gage, depressed center, foreign service | $561 / 2,60,63,66$ | 140,000 | $50^{\prime \prime} 7^{\prime \prime}$ | $9^{\prime} 8^{\prime \prime}$ |  | 41.5 |

[^58](2) Gondolas.

| Type | Gage (in.) | Capacity |  | Inside dimensions |  |  | Tare weight (STON) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | (lb) | (ouft) | Lenoth | Width | Height |  |
| High side, 8W, narrow gage, foreign service | 36, 39 \%, 42 | 60,000 | 940 | 34'5' | $6^{\prime} 101 / 2^{\prime \prime}$ | $4^{\prime}$ | 13 |
| Low side, 8 W , narrow gage, foreign service | 36, 393/8, 42 | 60,000 | 356 | $34^{\prime} 6^{\prime \prime}$ | 6'101/2" | $1^{\prime} 6^{\prime \prime}$ | 12.1 |
| High side, 8 W , broad gage, foreign service | $561 / 2$ | 80,000 | 1,680 | $40^{\prime}$ | $8{ }^{8} 3$ 3/4" | $4^{\prime}$ | 18 |
| Low side, 8 W , broad gage, foreign service | 561/2, 60, 63, 66 | 80,000 | 500 | 40'41/2" | $8^{\prime} 314^{\prime \prime}$ | $1^{\prime} 6^{\prime \prime}$ | 16 |
| Low side, 8W, drop ends, domestic service | $561 / 2$ | 100,000 | 1,184 | 41'6" | $9^{\prime} 61 / 8^{\prime \prime}$ | $3^{\prime}$ | 23 |
| High side, std gage, domestic service .-... | 561/2 | 100,000 | 1,580 | $41^{\prime} 6^{\prime \prime}$ | $9^{\prime} 6^{\prime \prime}$ | $4^{\prime} 6^{\prime \prime}$ | 25 |

(3) Hopper car.

| Type |  | $\begin{aligned} & \text { Gage } \\ & \text { (in.) } \end{aligned}$ | $\begin{gathered} \text { Normal } \\ \text { capacity } \\ \text { (lb) } \end{gathered}$ | Inside dimensions |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Length |  | Width | Height |
| 8 W , domestic service |  |  | 561/2 | 100,000 | $33^{\prime}$ | $9^{\prime} 51 / 2^{\prime \prime}$ | $9^{\prime \prime} 7^{\prime \prime}$ |

## d. Tank Cars.

| Type | Gaga (in.) | Length over tank heads <br> heade | $\begin{gathered} \text { Normal } \\ \text { capacity } \\ (\text { gal. })^{2} \end{gathered}$ | Inside diameter (in.) |  | $\begin{gathered} \text { Tare } \\ \text { iveight } \\ \text { (STON) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Tank ${ }^{2}$ | Dome |  |
| Nickel-clad, ICC-103-AW, 8W, domestic service | 561/2 | 31'11" | 7,500 | 78, approx | 45 |  |
| ICC-103, ICC-103-W, 8W, domestic service | $561 / 2$ | 34', approx | 10,000 | 87, approx | 5938 , approx |  |
| Caustic soda, ICC-103-W, 8 W , domestic service | $561 / 2$ | 34', approx | 10,000 | 88, approx | 64 |  |
| Petroleum, 8W, narrow gage, foreign service | 36, $383 / 8,42$ | 38,47/8' | 6,000 | 621/2 | 54 | 16 |
| Petroleum, 8W, broad gage, foreign service. | $561 / 2,60,63,66$ | 38'53/8" | 10,000 | $80 \%$ | 661/2 | 19 |
| Nitric acid, ICC-103-W, 8W, domestic service | 561/2 | 33'71/2" | 7,800 | 78, approx | 35 \% |  |
| Phosphorus, ICC-103-W, 8W, domestic service | 561/2 | 34'81/4" | 8,000 | 78, approx | 64 |  |
| Petroleum, std gage, domestic service ------ | 561/2 |  | 10,000 |  |  | 23 |

[^59]
## e. Refrigerator Cars.

| Type | Gage (in.) | $\begin{aligned} & \text { Normal } \\ & \text { capacity } \\ & \text { (b) } \end{aligned}$ | Length inside end lining | Width inside side lining | Ice capacity $(l b)$ | Dimensions of doors |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 8W, disassembled, foreign service | 561/2 | 80,000 | 38'911/2 | $6^{\prime} 11^{\prime \prime}$ | 11,000 | $4^{\prime}$ wide <br> $7{ }^{\prime}$ high |
| 8W, disassembled, broad gage, foreign service ---- | 5612, 60, 63, 66 | 80,000 | $32^{1} 12^{\prime \prime}$ | 7'8', approx | 11,000 | $4^{\prime}$ wide $7{ }^{7}$ high |
| 8W, mechanical, foreign service | 561/2, 60, 63, 66 | 80,000 | 40'9", equipment compartment | 7'6', approx | None | $6^{\prime}$ wide <br> $7{ }^{7}$ high |

f. Special-Purpose Cars.

| Type | Weight (lb) |  | Over end sills |  | Height <br> above rail | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Light | Loaded | Length | Width |  |  |
| Car, amb unit, 8W, domestic service _-- $561 / 2$ | 157,000 | 167,300 | 78'11" | $10^{\prime}$ | $13^{\prime \prime} 6^{\prime \prime}$ | Capacity: 27 patients, 6 |
| Car, kitchen, troop/amb train, 8 W , domestic service $\qquad$ $561 / 2$ | 100,160 |  |  |  |  | corpsmen, 1 nurse, 1 doctor. |
| Car, kitchen, dining and storage, | 100,160 |  | *54'2 1 /2" | $9^{\prime} 53 / 4{ }^{\prime \prime}$ | 13'6" | Width, side door openings: $6^{\prime}$. |
| amb train, 8 W , foreign service .-.--- $561 / 2,60$, 63, 66 | $\begin{gathered} 111,400 \\ \text { avg } \end{gathered}$ | ------ | $63^{1} / 4^{\prime \prime}$ | $9^{\prime}$ | $13^{\prime}$ | Seat capacity: 24. |
| Car, ward, amb train $-\ldots-\ldots-\ldots \frac{1}{2}, 60$ 63,66 | 111,400, avg | ------ | $63^{1 / 4} 4^{\prime \prime}$ | 9' | 13' | Berth capacity: 30. |
|  | 111,400 , avg | -- | 63'1/4" | $9^{\prime}$ | $13{ }^{\prime}$ | Berth capacity: 15 EM's, 4 doctors, 2 nurses. |

${ }^{\text {4 }}$ Includes couplers.
g. Cranes.

| Type | Gage (in.) | Weight (lb) | Boom length (ft) | Boom height (down) |
| :---: | :---: | :---: | :---: | :---: |
| Wrecking, steam, 75-ton, broad gage, foreign service | 561/2, 60, 63, 66 | 191,000 | 25, 2-piece, |  |
| Locomotive, diesel-mechanical, 25-ton, broad gage, domestic and foreign service |  |  |  |  |
| Locomotive, diesel-mechanical, 40-ton, broad gage, foreign service | 561/2, 60, 63, 66 | $210,000$ | 50, 2-piece, straight 50, 2-piece, straight | $13^{\prime} 6^{\prime \prime}$ max. |
| Locomotive, diesel-mechanical, 25-ton, narrow gage, foreign servi | 36, $393 / 8$, 42 | 161,000 | 40, 2-piece, straight | $10^{\prime} 10^{\prime \prime}$ |

## 4-4. Dimensions, Weight, and Capacities of Typical U.S. Freight Cars

There are no standard dimensions for commercial cars. The figures given are for types in common use. The 40-ton stock car comes in many lengths, varying from $35^{\prime} 7^{\prime \prime}$ to $41^{\prime} 10^{\prime \prime}$. All types have similar variations in capacity and dimensions.
Type

| Flat | 40 | -- | ---- | ------- | 18 | 40 | 9 | ---- |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 50 | ---- | ---- | ---- | 20 | 45 | 9 | ---- |
|  | 70 | ---- | ---- |  | 25 | $50^{\circ}$ | 9 |  |
| Gondola | 50 | ---- | ---- | 1,570 | 22 | 40 | 9.9 | 4 |
|  | 70 | ----- | ---- | 1,920 | 25 | 48 | 10 | 4 |
| Refrigerator | ${ }^{3} 30$ | ---- | ---- | 2,570 | 28 | 40.5 | 8.2 | 7.2 |
|  | ${ }^{5} 40$ | ---- | --- | 2,570 | 30 | 40.5 | 8.2 | 7.5 |
| Stock | 30 | ---- | 20 | 2,625 | 20 | 36 | 8.5 | 8.5 |
|  | 40 | ---- | 20 | 3,003 | 22 | 40.6 | 8.6 | 8.6 |
| Tank | ${ }^{\text {c } 40}$ | ---- | ---- | --.---- | 20 | 33 | ${ }^{86.6}$ | ---- |
|  | ${ }^{4} 50$ | ---- | ---- | ------ | 24 | 33 | ${ }^{6} 7.2$ | ---- |

[^60]4-5. Dimensions, Weight, and Capacisies of Predominant Types of West German Freight Cars

| Type of car | Number <br> of axles |  | $\begin{gathered} \text { Tare } \\ \text { weight } \\ \text { (STON) } \end{gathered}$ | Capaci Cubic feet level full |  | Length | Inside dimensio Width | Height | Door dim Width | ensions <br> Height | Height of floor above top of rail |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Boxcar, G-10 | 2 |  | 11.4 | 1,500 | 16.5 | 25'113/4" | $8^{\prime}$ | $7{ }^{\prime}{ }^{9 / 18^{\prime \prime}}$ | $4^{\prime} 111 / 16^{\prime \prime}$ | $6^{\prime} 6^{11} / 16^{\prime \prime}$ | $4^{1} / 16^{\prime \prime}$ |
| Boxcar, GLMHS-50 | 2 |  | 13.4 | 2,500 | 23.1 | 36995/16" | $8^{\prime} 11^{1 / 16^{\prime \prime}}$ | 9 9/8" | $6^{6} 6^{11 / 16^{\prime \prime}}$ | $6^{\prime} 6^{11} / 16^{\prime \prime}$ | $4^{6 / 16} 6^{\prime \prime}$ |
| Boxcar, GM-30 | 2 |  | 12.7 | 1,700 | 23.1 | 24'10" | $8^{\prime} 10^{\prime \prime}$ | 31'4' | $5^{\prime} 6^{\prime \prime}$ | $6^{1}$ | Not available |
| Boxcar, GMS-54 | 2 |  | 12.6 | 2,100 | 23.1 | $30^{\prime} 5^{11 / 11^{\prime \prime}}$ | $8^{\prime} 8^{11 / 16^{\prime \prime}}$ | 8'9 1/2" | $5^{\prime} 100^{13} / 18^{\prime \prime}$ | $6^{\prime 7} 71 /{ }^{\prime \prime}$ | $4^{1} 1 / 16^{\prime \prime}$ |
| Boxcar, KMMKS-51 | 2 |  | 12.5 | 1,420 | 30.8 | $28^{\prime} 8^{13} / 10^{\prime \prime}$ | $9 \times$ /8' | 5'61/8" | $5^{\prime} 10^{13} / 18^{\prime \prime}$ | $4^{\prime} 10$ 5/8' | $4^{\prime} 1^{7 / 16^{\prime \prime}}$ |
| Boxcar, KMM8KS-58 | 2 |  | 14.3 | 1,800 | 29.7 | 28'89/18' | $8^{\prime} 11^{1 / 166^{\prime \prime}}$ | $7{ }^{\prime} 1{ }^{5} 18^{\prime \prime}$ | $12^{\prime 3} \mathbf{4}^{\prime \prime}$ | $6^{\prime} 6^{11 / 16^{\prime \prime}}$ | $4^{\prime 11 / 16^{\prime \prime}}$ |
| Gondola, X-05 (low side) | 2 | Not | t available | 320 | 23.1 | 25'7" | 8'7' | $1^{\prime \prime}{ }^{\prime \prime}$ | --- | --- | Not available |
| Gondola, XLM-57 (low side) | 2 |  | 8.4 | 330 | 23.1 | 29'7" | $8^{\prime 6}{ }^{\prime \prime}$ | 1'4" | --- | --- | $4{ }^{\prime}$ |
| Gondola, OMM-37 (high side) | 2 |  | 9.7 | 1,210 | 24.6 | 27'7" | $9^{\prime}$ | $4^{\prime \prime} 10^{\prime \prime}$ | --- | --- | $4^{\prime}$ |
| Gondola, OMM-52 (high side) | 2 |  | 11.0 | 1,200 | 28.6 | 28' | $8{ }^{\prime}$ | $4^{\prime} 10^{\prime \prime}$ | --- | --- | $4{ }^{\prime}$ |
| Gondola, OMM-55 (high side) | 2 |  | 11.0 | 1,200 | 27.5 | 28'8 9/18 ${ }^{\prime \prime}$ | $9^{\prime} / 8^{\prime \prime}$ | $4^{\prime} 11^{1 / 186^{\prime \prime}}$ | 5'10 1/2" | --- | $4^{\prime} 7 / 8^{\prime \prime}$ |
| Gondola, OMM-53 (high side) | 2 |  | 12.1 | 1,200 | 27.5 | 28' | $8^{\prime} 9^{\prime \prime}$ | $4^{\prime} 10^{\prime \prime}$ | --- | --- | $4{ }^{\prime}$ |
| Gondola, OMM-33 (high side) | 2 |  | 11.5 | 1,260 | 27.0 | $28{ }^{7} 711^{\prime \prime}$ | $9^{7} / 16^{\prime \prime}$ | $5^{\prime} 1^{\prime \prime}$ | $4^{\prime} 11^{1 / 16 "}$ | --- | 4'\%" |
| Flatcar, R-10" | 2 |  | 10.6 | -..-- | 16.5 | $33^{2} 2^{5 / 10^{\prime \prime}}$ | $8^{\prime \prime}{ }^{\prime \prime}$ | $6^{\prime} 6^{11 / 18^{\prime \prime}}$ | --- | --- | $4{ }^{\prime}$ |
| Flatcar, RM-31 ${ }^{\text {a }}$ | 2 |  | 14.3 | ---- | 22.1 | $34^{\prime} 11^{9} / 16^{\prime \prime}$ | $8^{\prime} 6^{5 / 16^{\prime \prime}}$ | $6^{5} / 11^{\prime \prime}$ | --- | --- | $4^{\prime} 11{ }^{\prime \prime}$ |
| Flatcar, RMM-33 ${ }^{\text {a }}$ | 2 |  | 11.4 | ---- | 27.0 | 34183/8' | $9^{\prime} 21 / 4 \prime$ | $5^{\prime} 5^{11 / 10^{\prime \prime}}$ | --- | --- | $4.11 /{ }^{\prime \prime}$ |
| Flatcar, RLMMS-56 ${ }^{\text {a }}$ | 2 |  | 14.0 | ---- | 25.3 | $40^{\prime}$ | 8'11" | Not available | --- | -- | $4^{4}$ |
| Flatcar, SM-14* | 2 |  | 11.9 | ---- | 23.1 | 41'6' | 8'9" | Not available | --- | --- | Not available |
| Flatcar, SS-15 ${ }^{\text {n }}$ | 4 |  | 21.5 |  | 40.2 | $48^{\prime 2} 2^{\prime \prime}$ | $8^{\prime} 9^{\prime \prime}$ | Not available | --- | --- | Not available |
| Flatcar, SSLMA-44 | 4 |  | 22.7 | ---- | 44.1 | $59^{\prime 2}{ }^{7} / 16^{\prime \prime}$ | $9^{1} 1 / 4^{\prime \prime}$ | $4^{\prime} 10{ }^{1 / 4}{ }^{\prime \prime}$ | --- | --- | $4^{\prime} 53 / 4 \prime$ |
| Flatcar, SSLMAS-53 | 4 |  | 26.3 | ---- | 61.6 | $60^{\prime} 8^{5 / 16^{\prime \prime}}$ | $8^{\prime} 11^{13} / 18^{\prime \prime}$ | Not available | --- | --- | $4^{\prime} 6^{1 / 8}{ }^{\prime \prime}$ |
| Flatcar, SSKM-49 | 4 |  | 17.1 | ---- | 55.1 | $40.83 / 4{ }^{\prime \prime}$ | $8^{\prime} 5^{15} / 16^{\prime \prime}$ | Not available | --- | --- | $4^{\prime} 3^{9 / 16^{\prime \prime}}$ |
| Tank car | 2 |  | 14.0 | ( ${ }^{\text {b }}$ ) | -- | 21'2' | --- | -------- | --- | --- | 5 |
| Tank car | 4 |  | 26.4 | ( ${ }^{\text {c }}$ ) | --- | $33^{1 / 2}{ }^{\prime \prime}$ | --- |  | --- | --- | $5{ }^{\prime}$ |

[^61]$\underset{\sim}{f}$ 4-6. Dimensions, Weight, and Capacities of Predominant Types of Vietnamese Freight Cars

| Type of car | Number of axles | $\begin{gathered} \text { Tare } \\ \text { (veight } \\ \text { (STON) } \end{gathered}$ | Capacity |  | Inside dimensions (metera) |  |  | Door dimensione (meters) |  | Height of floor above top of rail (metere) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{aligned} & \text { Cubie } \\ & \text { meters } \end{aligned}$ | Pounds | Length | Wirth | Height | Width | Height |  |
| Boxcar, G | 2 | 6.0 | 22.95 | 22,045.8 | 5.414 | 2.120 | 2.0 | 1.45 | 1.9 | 1.0 |
| Boxcar, GG | 4 | 19.5 | 66.35 | 55,144.5 | 13.118 | 2.529 | 2.0 | 1.829 | 1.8 | 1.1 |
| Flatcar, M | 2 | 4.9 | ---- | 22,045.8 | ---- | ---- | - | --- | --- | 1.0 |
| Flatcar, MM | 4 | 13.0 | ---- | 55,144.5 | ---- | ---- | --- | ----- |  | 1.0 |
| Gondola, H | 2 | 5.2 | 12.1 | 22,045.8 | 5.47 | 2.2 | 1.03 | 1.45 | 1.03 | 1.0 |
| Gondola, HH | 4 | 13.65 | 29.98 | 55,114.5 | 11.0 | 2.5 | 1.09 | 1.45 | 1.09 | 1.0 |
| Tank car, MR | 2 | 5.6 | 10.0 | 22,045.8 | ---- | ---- | --- | ---- |  | 1.0 |
| Tank car, MMR | 4 | 18.5 | 30.0 | 45,908.0 | ---- | ---- | --- | ---- |  | 1.08 |

## 4-7. Dimensions, Weight, and Capacities of Predominant Types of Korean Freight Cars

| Type of ear | Number of axles | $\begin{gathered} \text { Tare } \\ \text { zeeight } \\ \text { (STON) } \end{gathered}$ | Capacity |  | Inside dimensiona (metera) |  |  | Door dimensione (meters) |  | Height of floor above top of rail (metere) |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | meters | Pounds | Length | Width | Height | Width | Height |  |  |
| Boxcar | 4 | 18.8 | 58.0 | 66,000 | 10.202 | 2.67 | 2.10 | 1.52 | $1.8{ }^{\text {a }}$ | Not | available |
| Flatcar | 4 | 17.0 | ---- | 99,000 | 10.5 | 3.05 | --- |  |  |  | 1.2 |
| Gondolas | 4 | 12.7 | 46.64 | 66,000 | 10.084 | 2.643 | 1.75 |  |  | Not | available |
| Tank cars, Juna | 4 | 20.5 | ( ${ }^{\text {b }}$ | 71,962 | 11.8 | 2.050 | Not available |  | -- | Not | available |

[^62]4-8. Capacity of Standard U.S. Passenger Cars

|  | $\begin{gathered} \text { Dayl } \\ \text { coach } \end{gathered}$ | Tourist sleeper | Standard sleeper ${ }^{2}$ |
| :---: | :---: | :---: | :---: |
| Length in feet | 65-75 | 65-75 | 65-80 |
| Number of sections | None | 13-16 | 12-16 |
| Maximum seating: |  |  |  |
| 2 men to each double <br> seat $\qquad$ | 60-79 | 52-64 | 53-64 |
| 3 men to each 2 double seats $\qquad$ | 45-52 | 39-48 | 40-48 |


| Sleeping capacity : | Day <br> coach 1 | Tourist <br> sleeper | Standard <br> sleeper |
| :---: | :---: | :---: | :---: |
| men per berth |  |  |  |
| (maximum) |  |  |  |
| 3 men per section | None | $52-64$ | $53-64$ |
| 1 man per berth $\ldots \ldots$ | None | $39-48$ | $36-48$ |
| None | $26-32$ | $27-32$ |  |

${ }^{1}$ Limited number of steel coaches, 70 feet long or over, available.
${ }^{2}$ Standard sleeper- 12 sections and 1 drawing room or 16 sectlons and no drawing room.

## Section III. OPERATIONS

## 4-9. Planning Requirements

In planning for the most effective use of a railway system, detailed information about items $a$ through $z$ below is essential. FM 55-8 provides additional information on evaluating existing facilities.
a. Length of line.
b. Condition of roadbed and track.
c. Gage of track.
d. Single, double, or multiple track.
e. Weight of rail.
$f$. Type of ballast and depth.
$g$. Type of ties (if wood, treated or untreated).
h. Tie spacing.
i. Axle-load limitations (track and bridge).
$j$. Profile of line showing location and length of ruling grade.
k. Alinement of lines showing location and length of minimum-radius curves.
l. Location and description of bridges and tunnels.
$m$. Location and length of passing tracks.
$n$. Location, type, and quantity of fuel supply.
o. Location, quantity, and quality of water supply.
p. Location and capacity of yards.
q. Location and capacity of car repair shops and enginehouses.
$r$. Type and availability of motive power (weight in working order, expected working tractive effort, drawbar pull, and age).
s. Type and availability of rolling stock (capacity, dimensions, and age).
$t$. Climatic and prevailing weather conditions.
u. Diagrams showing minimum structure, maximum unrestricted loading, and equipment gages.
v. Signal system (wire or radio requirements and coordinating responsibilities).
$w$. Dispatching facilities.
$x$. Route junctions.
$y$. Availability of new equipment and repair parts.
z. Local labor resources.

## 4-10. Outline of Standing Operating Procedure for Rail Movements

a. General. Policies and factors involved in selecting and accomplishing movements via rail.
b. Supply Movements.
(1) Releases. When required, methods of obtaining, formats, dissemination, action required.
(2) Routing. Responsibilities and procedures for determination, coordination, and accomplishment.
(3) Diversions and reconsignments. Authority and initiating procedures for; method of execution.
(4) Records and reports. Responsibilities and methods for the maintenance of specific records; appropriate references to reports to be submitted.
c. Personnel Movements-Troops.
(1) Military authorization identification numbers (MAIN). Purposes, composition, methods, and procedures for assignment and use; marking on and eradicating from trains.
(2) Halts. Types; policies, procedures, and responsibilities for establishment and conduct.
(3) Travel warrants. Types, forms, authority, and responsibilities for issue, distribution, and usage.
(4) Troop-train commanders. Appointment, responsibilities, and functions; relationship with transportation personnel; instructions to be furnished.
(5) Rations and water. Responsibilities and procedures for securing, furnishing en route, and disposition at destination.
(6) Discipline of troops. Responsibilities and command policies, police of rail equipment, sanitation.
(7) Diversions. Authority for ordering, responsibilities and procedures for effecting, reference to reporting.
(8) Records and reports. Responsibilities and methods for the maintenance of specific records and appropriate references to reports to be submitted.

## 4-11. Outline of Standing Operating Procedure for Transportation Railway Service

a. General. Policies and procedures for-
(1) Integration of rail transportation in the theater transportation net.
(2) Operational control.
(3) Coordination with adjacent commands for use of rail capacity and support of operating units.
(4) Coordination of the theater rail plan for selection, rehabilitation, and operation or rail lines in support of theater strategic plans.
b. Mission. Rail net and facilities operated; terminals, installations, and commands supported.
c. Organization. Operating units available, location, and operating limits.
d. Functions. Responsibilities for operation and maintenance of military railways, equipment, and freight, passenger, and special trains.
e. Planning.
(1) Long-range planning responsibility and procedures; selection of rail primary and alternate routes; determination of line capacity, troop equipment, and supply requirements; rehabilitation and project requirements; communications and security requirements; demolition plans.
(2) Current operational plans; current rail line capacity and requirements; phases of operation; selection and rehabilitation of new or additional railheads, yards, and installation facilities.
f. Operations. Procedures for dissemination and implementation of movement programs; coordination with transportation movements officer; priorities for and utilization of rail equipment; responsibilities for preparation and compilation of operational and situation reports; procedures for ordering and documentation of cars; responsibilities for scheduling special trains; construction and use of rail car spanners, responsibility and methods of loading, blocking, bracing, and inspecting loaded cars.
g. Maintenance. Responsibility, procedures, inspections, reports, and standards for maintenance of military and utility railway facilities and equipment, including organizational, field, and depot maintenance.
h. Supply. Responsibility and procedures for requisitioning, stocking, distributing, maintaining levels of, disposing of excess, and accounting for railway operating and maintenance supplies; requirements and priorities for major items, including locomotives and rolling stock.
i. Intelligence and Reconnaissance. Responsibility and procedures for collecting, processing, disseminating, and using intelligence.
j. Security. Procedures, responsibility, coordination, and requirements for security of supplies en route by rail and security of trains and rail line-of-communication facilities; defense and demolition plans.
k. Records and Reports. Responsibility and procedures for reports; railway operation, situation, personnel status, equipment maintenance and inspection, equipment status, and project.
l. Training. Responsibility for conducting unit and technical training.

## 4-12. Maximum Bulk Loading of Typical U.S. Freight Cars

The rated weight capacity of a car does not mean that the car can carry the rated tonnage of all items. For many types of cargo, the cubic capacity of the car is reached ahead of the rated capacity. When this occurs, the tonnage that the car can carry represents its actual capacity.
a. High Density Items. Freight cars loaded with high density items can nearly always be loaded to their rated capacity. Examples of high density items are ammunition, barbed wire, cement, flour, gravel, corrugated iron, rails, rifles in chests, sand, stone, sugar, telephone wire, and engineer tools.
b. Lighter Bulk Items. Some items for which the cubic capacity of the car is reached at the time of or before the rated tonnage has been loaded are listed below.

|  | Car capacity in short tons |  |  |
| :--- | :---: | :---: | :---: |
| Rated | 30 | 40 | 50 |
| Actual, by items: <br> Blankets, baled |  |  |  |
|  | 27 | 32 | 40 |


|  | Car capacity in ahort |  |  |
| :---: | :---: | :---: | :---: |
| Bread | 19 | 24 | 30 |
| Canned goods in boxes | 30 | 36 | 45 |
| Clothing, baled | 27 | 32 | 40 |
| Meat _-.---- | 15 | 24 | 35 |
| Motor vehicle parts | 24 | 28 | 40 |
| Sandbags | 21 | 24 | 30 |
| Tentage | 15 | 20 | 30 |
| Ties, railroad ...-. | 19 | 26 | 32 |

## 4-13. Clearances-General

Overhead clearances and platform heights are measured from top of rail; side clearances from centerline of track. Clearances below those specified are dangerous, and protection must be provided by appropriate warning signs or devices. For example, telltales must be used for overhead clearances ranging between 18 to 22 feet. Unless local conditions require greater clearances, the standard minimum clearances are as follows:

|  | Meters | Feet and inches |
| :---: | :---: | :---: |
| a. Overhead. |  |  |
| Wires: |  |  |
| High voltage | 8.53 | $28^{\prime \prime} 0^{\prime \prime}$ |
| Other | 8.23 | 27'0" |
| Structures | 6.71 | $22^{\prime} 0^{\prime \prime}$ |
| b. Side. |  |  |
| Buildings | 2.59 | $8^{\prime \prime} 6^{\prime \prime}$ |
| Canopies: |  |  |
| Up to $15^{\prime} 6^{\prime \prime}$ | 2.59 | $8^{\prime} 6^{\prime \prime}$ |
| Higher than 15' $6^{\prime \prime}$. | 1.68 | $5^{\prime} 6^{\prime \prime}$ |
| Platforms: |  |  |
| $3^{\prime \prime} 9^{\prime \prime}$ | 1.88 | $6^{\prime \prime} 2^{\prime \prime}$ |
| $4^{\prime}$ | 1.52 | $5^{\prime} 0^{\prime \prime}$ |
| Refrigerator platforms: |  |  |
| $3^{\prime} 2^{\prime \prime}$ | 1.88 | $6^{\prime \prime} 2^{\prime \prime}$ |
| $4^{\prime} 7^{\prime \prime}$ | 2.59 | $8^{\prime \prime} 6^{\prime \prime}$ |
| c. Engine-house Entrance. |  |  |
| Overhead | 5.18 | $17^{\prime \prime} 0^{\prime \prime}$ |
|  | 1.98 | $6^{\prime \prime} 6^{\prime \prime}$ |

d. Bridge and Tunnel. Standard single-track bridge and tunnel clearances are shown in figure 4-2.


Figure 4-2. Standard single-track bridge and tunnel clearances.

4-14. Railway Gages (in inches) by Area

| Gages | 235/8 | 24 | 291/2 | so | 35 | 36 | $s 7$ | 3758 | 377116 | 39\%8 | 40 | 41/4 | 412/2 | $419 / 10$ | 42 | 501/2 | 567/8 | 51/8 | ${ }^{6} 0$ | ${ }^{\text {as }}$ | ${ }^{\boldsymbol{\theta}}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| a. Africa. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Algeria _---------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | X | -- | $\mathbf{X}$ | -- | X | -- | -- | -- |
| Cameroun -------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |
| Central African Republic - | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |
| Congo, Republic of (Brazzaville) | -- | X | -- | - | -- | -- | - | -- | - | X | -- | -- | - | -- | X |  |  |  |  |  |  |
| Congo, Republic of (Leopoldville) | -- | X | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | X |  |  |  |  |  |  |
| Dahomey ----------------1-20 | -- | -- | $\rightarrow$ | -- | -- | -- | -- | -- | -- | -- | -- | - | -- | -- | X |  |  |  |  |  |  |
|  | -- | -- | X | X | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Ethiopia _---------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |
|  | -- | -- | -- | -- | $\cdots$ | --- | -- | -- | -- | $\bar{X}$ | -- | -- | -- | -- | X |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | $\rightarrow-$ | X |  |  |  |  |  |  |
| Guinea -----------------1 | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |
| Kenya ------------------10-1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |
| Liberia ------------------1 | -- | -- | --- | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | X | -- | X | -- |  |  |  |  |  |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Mauritania ------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Nigeria --------------- | -- | -- | -- | $\mathbf{X}$ | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | $\mathbf{X}$ |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - -- | -- | $\mathbf{X}$ |  |  |  |  |  |  |
| Portuguese East Africa <br> (Mozambique) | - | -- | - | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | $\mathbf{X}$ |  |  |  |  |  |  |
| Portuguese West Africa (Angola) | -- | X | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | X |  |  |  |  |  |  |
| Republic of South Africa | -- | $\mathbf{X}$ | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |
| Réunion -.-.-.-.-.-.-.-. | -- | -- | -- | -- | -- | -- | -- | -- | -- | $\bar{X}$ |  |  |  |  |  |  |  |  |  |  |  |
| Rhodesia --------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |  |  | X |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Sierra Leone ------------ | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- |  | X |  |  |  |  |  |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |


| Gages | 23\% | 24 | 291/3 | so | 35 | 36 | 37 | 37\% | $377 / 16$ | 39\% | 40 | 4114 | 411/2 41 | 419/16 | 48 | 561/2 | 567/8 | 51/8 | 60 | 63 | 66 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Swaziland --------------- | -- | -- | -- | -- | - |  |  |  |  |  |  |  |  | \%16 |  |  |  | 5 | 60 | 65 | 66 |
| Tanzania ----------------1 | -- | -- |  | - | -- | -- | -- | -- |  | -- | -- | - | -- | -- | X |  |  |  |  |  |  |
|  | - | -- | -- | -- | -- | -- | -- | -- |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Tunesia ------------------ | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Uganda ------------------ | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |
| Upper Volta ------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | X |  |  |  |  |  |
| Zambia ----------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |  |  | X |  |  |  |  |  |  |
| b. Asia. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Afghanistan ------------- | -- | -- | -- | -- | -- | -- | -- | -- |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Borneo ----------------- | -- | -- | -- | -- | --- | -- | -- | -- | -- | $\underline{X}$ | -- | -- | -- | -- | -- | X | -- | -- | X | -- | -- |
| Burma ------------1--- | -- | -- | -- | -- | -- | -- | -- | -- | - | X |  |  |  |  |  |  |  |  |  |  |  |
| Cambodia ---------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |
| Ceylon ----------------- | - | -- | -- | -- | -- | -- | -- | -- |  | X |  |  |  |  |  |  |  |  |  |  |  |
| China ------------------- | -- | -- | -- | -- |  | -- | -- | -- | -- | -- | -- | -- | --- | -- | -- | -- | -- | -- | -- | -- | X |
|  | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| India --..---------------- | -- | X | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |
| Indonesia -------------- |  |  | -- | X | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |
| Iran ------------------------- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | X |  |  |  |  |  |
| Iraq -------------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | --- | -- | X | -- | -- | X | -- |  |
| Iraq -------------.------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Israel -------------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Japan ---------1--------.. | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | X |  |  |  |  |  |
| Jordan -----------------1 | -- | -- | -- | -- | -- | -- | -- | --- | -- | -- | -- | -- | -- |  |  |  |  |  |  |  |  |
| Korea ------------------- | -- | -- | -- | X | -- | -- | -- | -- | -- |  | -- | $\boldsymbol{N}$ |  |  |  |  |  |  |  |  |  |
| Laos ------------------- | -- | -- | -- | -- | - |  | -- | -- |  | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Malaya ----c----------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | X |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- |  |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Pakistan --------------- | -- | -- | -- | -- | -- | -- | -- | -- |  | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |
| Saudi Arabia ---_------ | -- | -- | - |  | -- | -- | -- | -- | -- | X | X | -- | -- | -- | -- | -- | -- | - | -- | -- | X |
| Syria ----------------1 | -- |  | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | X |  |  |  |  |  |
| Thailand ---------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | X |  |  |  |  |  |
| Tibet | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |
| - ------------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |
| Turkey ------------------ | -- | -- | X | -- | -- | -- | -- | -- | -- | X | -- | -- | X | -- | -- | X |  |  | X |  |  |
| U.S.S.R. ---------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- |  |  |  | X |  |  |
| Vietnam -----------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |
| c. Europe. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Albania ------------------ | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |


| Austria ---------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Belgium _--------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | - | $\overline{\mathbf{X}}$ |  |  |  |  |  |
| Bulgaria ---------------1 | X | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | - | -- | -- | -- | X |  |  | - |  |  |
| Czechoslovakia _---------- | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | - | -- | -- | -- | - | X |  |  |  |  |  |
| Denmark _--------------- | -- | -- | -- | -- | -- | -- | -- | -- | --. | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Estonia -----2-----------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - | - | -- | -- | - | -- | -- | X |  |  |
|  | -- | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | -- | X |  |  |
| France _---------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Germany ---------------1 | -- | -- | -- | X | -- | -- | -- | - | -- | X | -- | -- | -- | - | -- | X |  |  |  |  |  |
| Greece -----------------1 | -- | -- | -- | -- | - | - | -- | - | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Hungary ---------------1 | -- | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | -- | - | -- | -- | X |  |  |  |  |  |
| Ireland ----------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | X |  |
|  | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | X | $\bar{X}$ |  |  |  |  |
| Latvia -----------------1 | X | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | - | X |  |  |
| Lithuania --------------- | X | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | X |  |  |
| Luxembourg ------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 'X | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Netherlands -------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Norway ----------------1 | -- | -- | -- | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | -- | X | X |  |  |  |  |  |
|  | -- | -- | X | -- | -- | -- | -- | -- | -- | - | -- | -- | - | -- | -- | X | -- | -- | X |  |  |
| Portugal --------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | - | -- | -- | -- | -- | - | -- | - | -- | X |
| Rumania ---------------1 | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Spain ------------------1 | -- | -- | -- | -- | - | X | -- | -- | -- | X | -- | - | -- | - | -- | -- | -- | -- | -- | -- | X |
| Sweden ------------------1 | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | $\mathbf{X}$ | X |  |  |  |  |  |
| Switzerland _------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Turkey ----------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - | -- | -- | X |  |  |  |  |  |
| U.S.S.R. ----------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |
| United Kingdom --------- | -- | -- |  | -- | - | -- | -- | -- | - | -- | -- | -- | -- | - | - | X | - | -- | -- | X |  |
| Yugoslavia -------------- | - | -- | -- | X | -- | -- | -- | - | -- | X | -- | - | -- | - | - | X |  |  |  |  |  |
| d. Central America and West Indies. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Costa Rica -------------1 | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |
| Cuba ----------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - | -- | -- | X |  |  |  |  |  |
| Dominican Republic _----- | -- | - | -- | $\mathbf{X}$ | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |
| El Salvador ------------1 | -- | -- | -- | -- | -- | X | -- | -- | -- | -- |  |  |  |  |  |  |  |  |  |  |  |
| Guatemala _------------- | -- | -- | -- | -- | -- | $\mathbf{X}$ | -- | -- | -- | -- |  |  |  |  |  |  |  |  |  |  |  |
|  | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |
| Honduras --------------1 | -- | -- | -- | -- | -- | $\bar{X}$ | -- | -- | -- | -- | - | -- | -- | - | X |  |  |  |  |  |  |
| Jamaica _---------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - | - | X |  |  |  |  |  |
|  | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | $\overline{\mathbf{X}}$ |  |  |  |  |  |  |


| Gages | 23\%/8 | 24 | 291/2 | so | $s 5$ | 38 | 37 | 37\% | 377/16 | 69\%\% | 40 | 413/4 | 411/2 | 419/16 | 48 | 661/2 | 587/6 | 5\% | 60 | ${ }^{68}$ | ${ }^{68}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Panama ------------------ | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |
| Puerto Rico -------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - |  |  |  |  |  |  |  |  |  |  |  |
| Trinidad ----------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -_ | -- | X |  |  |  |  |  |
| e. North America. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Canada ----------------- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | - | X |  |  |  |  |  |
| Newfoundland ---------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |  |  |  |  |  |  |
| Mexico -------.--------- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | $\overline{\mathrm{X}}$ |  |  |  |  |  |
| United States (CONUS) -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |  | -- | X |  |  |  |  |  |
| Alaska ----------------- | -- | -- | -- | -- | -- | X |  |  |  | -- | -- | -- |  |  | -- | $\frac{\mathbf{A}}{\mathbf{X}}$ |  |  |  |  |  |
| Hawaii (see Pacific Ocean) |  |  |  |  |  |  |  |  |  |  | -- |  | -- | -- | -- |  |  |  |  |  |  |
| f. South America. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Argentina --------------- | -- | -- | X | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X | -- | -- |  |  | X |
| Bolivia ---------------.-- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  | -- | -- |  |  |
| Brazil ------------------- | -- | X | -- | X | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- |  | X |  |
| British Guiana ---------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | - |  |  |  |
| Chile ------------------- | -- | X | -- | X | -- | -- | -- | -- | -- | -- | -- | -- |  |  | -- | X |  |  |  |  |  |
| Colombia ---------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- |  | -- | X | X | -- | -- | -- | -- | X |
| Dutch Guiana ----------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |  |  |  |  |  |
| Ecuador --------------1--1 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |  |
| Paraguay ---------------1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |  |  | -- | X |  |  |  |  |  |
| Peru --------------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| Uruguay --------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |  |  |  | X |  |  |  |  |  |
| Venezuela -----------1.--- | -- | X | -- | $\overline{\mathrm{X}}$ | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | X |  |  |  |  |  |
| g. Pacific Ocean. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Australia ---------------1 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- |  |  |  |  | X | X |  |  | -- | X |  |
| Hawaii ----------------- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- |  | X | X |  |  | -- | X |  |
| New Caledonia | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |  | -- | -- | -- | -- |  |  |  |  |  |  |
| New Zealand ----------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |  |  | X |  |  |  |  |  |  |
| Philippines ------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |  | X |  |  |  |  |  |  |
| Tasmania --------------- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | X |  |  |  |  |  |  |

## 4-15. Clearances and Gages

The sample clearance diagrams shown in figures 4-3 and 4-4 refer to the distance that equipment or cargo may project to the side at various heights above track level. They are composites incorporating the smallest dimensions of all similar dimensions of the countries having the gages shown (para 4-4); therefore, not all the limiting clearances shown in the composites will exist simultaneously on any particular rail line. A clearance diagram
for the rail line(s) over which operations are to be conducted must be obtained or made. Horizontal distances shown in the diagrams should not be confused with the track gage. The composite clearances in figure 4-3 show minimum clearances for the standard-gage ( $561 / 2$-inch), and for the broad-gage track indicated. Figure 4-4 shows clearances for three sizes of narrow-gage track. Examples of the use of the diagrams are given below.
a. In figure 4-3, a vertical clearance of 3


Figure 4-S. A composite clearance diagram: $561 / 2-, 60-, 63$-, and 66-inch gages.


Note1: $2^{\prime}-8 \frac{33^{\prime \prime}}{}$ for 36 -inch trock gage
$3^{\prime}$ for $39 \frac{3}{6}$ - and 42 -inch track gage
Note 2: $4^{\prime}$ for 36 -and $39 \frac{3}{8}$-inch track gage $4^{\prime}-5^{\prime \prime}$ for 42-inch track gage

Figure 4-4. A composite clearance diagram: 36-, s93/6, and 42-inch gages.
feet 8 inches can be depended upon for a width clearance which is at least 9 feet 8 inches. In the same figure, a vertical clearance of $93 / 4$ inches can be depended upon if the width clearance is not less than 8 feet $11 / 2$ inches.
b. In figure 4-4, a vertical clearance between
$133 / 4$ inches and 3 feet 4 inches can be depended upon when the width clearance is not less than 8 feet.

## 4-16. Bridge Capacity

a. Cooper's E Rating. This figure indicates, in thousands of pounds, the weight a bridge
can support for each driving axle of a locomotive. Military railroad bridges are normally designed for Cooper's E-45 but may be built for lighter or heavier loadings as required. For example, the following method is used to determine the rating a bridge must have if it is to be crossed safely by a $2-8-0$ locomotive weighing 140,000 pounds on drivers:

A 2-8-0 locomotive has four driving axles. 140,000 pounds (weight of locomotive) divided by 4 (number of driving axles) equals 35,000 pounds (weight per driving axle). Therefore, any bridge which has a rating of E-35 or above can be crossed safely by this locomotive.
b. Steel 1-Beam Bridge (fig. 4-5). The table below refers to bridges already constructed with two, four, six or more steel stringers or girders of equal dimensions. To estimate the capacity of a railway bridge with this type of construction, the width and thickness of the lower flange of one stringer are measured at
the center of the span length; the depth and length of the stringer are also measured. Using the table below, the steel stringer that is nearest to these dimensions is selected, and the corresponding E-rating of the bridge is read. The rating is reduced according to the age and condition of the bridge. The quantity of reduction must be determined by qualified personnel, normally from the Corps of Engineers. For additional information concerning bridge capacities, refer to TM 5-312.


Figure 4-5. Measuring a steel stringer.

| Stringer dimensions (in.) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Lower flange |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Thickness | Width | Stringer depth | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 3/8 | 8\%/8 | 18 | E-42 | E-41 | E-41 | E-41 |  |  |  |  |  |  |  |
| 7/8 | 10\% | 24 | ----- | E-59 | E-48 | E-40 | E-35 | E-31 | E-27 |  |  |  |  |
| 1/2 | 10\% | 30 |  |  | ---- - | E-61 | E-59 | E-51 | E-46 | E-41 | E-37 | E-33 | E-30 |
| 1/2 | $121 / 2$ | 30 | ----- | ---- | ----- | ---- | -...- | E-62 | E-56 | E-50 | E-45 | E-41 | E-37 |
| 1 | 14 | 36 | ---- | --- | ---- | ---- | ---- | -.-- | ---- | E-60 | E-58 | E-55 | E-54 |
| 1/2 | 12\% ${ }^{\text {\% }}$ | 42 | ----- | --.-- | --- | ----- | ---- |  | -- - |  |  | E-60 | E-54 |
| 1/88 | 14 | 42 | -.-. | -..--. | .-... | ----. | ----- | --- | -- | --- | ---- | ---- - | E-63 |
| 11/8 | 16 | 42 |  |  |  |  |  |  |  |  |  |  |  |
| 11/2 | 16 | 48 | ---- |  |  |  |  |  | ---- | --- |  | ---- | ----- |
| 1 | 16 | 48 |  |  |  |  |  |  |  |  |  | ----- | -. --. |
| 1\%/8 | 14 | 54 |  |  |  |  |  |  | ---- | --- | ---- | ---- | ----- |
| 13/4 | 14 | 60 |  |  |  |  |  |  |  |  | ---- | ---- | ----- |
| $11 / 2$ | 14 | 60 - | ---- |  | ---- |  |  |  | ---- | --- | ----- | ---- | ----- |
| 21/8 | 15 | 66 |  |  |  |  |  |  |  | ---- | ----- | --- | ----- |
| 2 | 14 | 66 |  |  | ----- |  | ---- |  | ----- | ---- | ----- | ---- | ----- |
| 2 | 14 | 72 |  |  | ---- | ----- | ---- | ---- | --- - | --- - | ----- | ---- | -.-. |
| 21/2 | 151/2 | 72 |  |  | -.-. |  | ---- | --- | ---. | --- | .-- | --- | ---- |
| 21/8 | 14 | 78 | ---- | ---- | ----- | ---- | --- | .-. - | ----- | --. - | ----- | ---- | ----- |
| $21 / 2$ | 16 | 84 |  |  | ----- | ----- | ---- | ---- | ---- | ----- | ---- | ----- | ---- |
| $211 / 16$ | 20 | 96 | ----- | ---- | ----- | ----- | -- | ----- | ---- | - | ---- | --- | ----- |

Note. This chart presents type data for determination of order of magnitude. One per rail is assumed. Qualified personnel from the
c. Wooden Bridge (fig. 4-6). For a bridge with wooden stringers, the width of each stringer is measured under one track at the center of the length span and added to obtain total stringer width. In figure 4.6, the total
stringer width is 2 x W . The depth and length of one stringer are also measured. The following table is used with the same procedures as the table in $b$ above.

Span length (ft)

| Wiath | Depth | 10 | 12 | 16 | 16 | 18 | \%o | e2 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 18 | 12 | E-16 | E-12 |  |  |  |  |  |
| 18 | 14 | E-22 | E-18 | E-10 |  |  |  |  |
| 18 | 16 | E-28 | E-20 | E-15 | E-10 |  |  |  |
| 18 | 18 | E-38 | E-26 | E-18 | E-14 | E-12 |  |  |
| 20 | 12 | E-18 | E-12 |  |  |  |  |  |
| 20 | 14 | E-25 | E-17 | E-12 |  |  |  |  |
| 20 | 16 | E-33 | E-23 | E-16 | E-12 | E-10 |  |  |
| 20 | 18 | E-43 | E-29 | E-21 | E-16 | E-13 | E-10 |  |
| 24 | 12 | E-22 | E-15 | E-11 |  |  |  |  |
| 24 | 14 | E-30 | E-21 | E-14 | E-11 |  |  |  |
| 24 | 16 | E-40 | E-28 | E-20 | E-15 | E-12 |  |  |
| 24 | 18 | E-52 | E-36 | E-25 | E-19 | E-15 | E-12 | E-10 |
| 36 | 12 | E-34 | E-23 | E-17 | E-12 | E-10 |  |  |
| 36 | 14 | E-47 | E-32 | E-23 | E-17 | E-14 | E-11 |  |
| 36 | 16 | E-62 | E-43 | E-30 | E-23 | E-19 | E-15 |  |
| 36 | 18 | E-78 | E-53 | E-30 | E-30 | E-24 | E-20 | E-16 |
| 40 | 12 | E-38 | E-26 | E-19 | E-14 | E-11 |  |  |
| 40 | 14 | E-52 | E-36 | E-26 | E-20 | E-16 | E-12 |  |
| 40 | 16 | E-69 | E-47 | E-35 | E-26 | E-21 | E-17 |  |
| 40 | 18 | E-87 | E-60 | E-44 | E-34 | E-27 | E-22 | E-18 |
| 48 | 12 | E-46 | E-31 | E-23 | E-17 | E-13 |  |  |


| E-27 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E-31 | E-26 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| E-51 | E-48 | E-43 | E-39 | E-34 | E-26 |  |  |  |  |  |  |  |  |  |  |  |
| E-45 | E-39 | E-34 | E-30 | E-26 |  |  |  |  |  |  |  |  |  |  |  |  |
| E-60 | E-57 | E-54 | E-51 | E-45 |  |  |  |  |  |  |  |  |  |  |  |  |
| -...- |  | ---.- | E-60 | E-54 | E-42 | E-32 |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | E-59 | E-52 | E-47 | E-43 | E-33 |  |  |  |  |  |  |  |  |
| ---- | ----- | ----- | E-66 | E-57 | E-45 | E-35 | E-30 |  |  |  |  |  |  |  |  |  |
|  |  | ---- | ----- | -.-.- | E-54 | E-43 | E-36 | E-28 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | E-60 | E-54 | E-43 | E-37 | E-30 | E-27 |  |  |  |  |  |
|  | ----- | ---- | ---- | --- | --.-. | E-57 | E-48 | E-38 | E-33 | E-27 |  |  |  |  |  |  |
|  |  | -.-. | --.. |  | --.-. . | .-.-. . | .---- | E-57 | E-54 | E-46 | E-41 | E-34 | E-31 | E-26 |  |  |
|  |  | ---- |  | --- | --- | -- |  | E-56 | E-48 | E-40 | E-35 | E-30 | E-26 |  |  |  |
|  |  | ---- |  |  | ---- - | ---- | -- | E-62 | E-54 | E-44 | E-39 | E-32 | E-29 | E-25 |  |  |
|  |  |  |  |  |  |  |  |  | --- | E-55 | E-51 | E-43 | E-38 | E-33 | E-29 |  |
|  |  |  |  |  |  |  |  |  | E-64 | E-52 | E-46 | E-39 | E-35 | E-30 |  |  |
|  |  | -.-. | - |  |  |  |  |  |  |  | E-64 | E-54 | E-49 | E-41 | E-38 | E-30 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | E-59 | E-51 |

Corps of Engineers should be consulted forbridge capacity.

| Stringer dimensions (in.) |  |  |  | Span length ( $f t$ ) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Width | Depth | 10 | 18 | 14 | 16 | 18 | 20 | 22 |
| 48 | 14 | E-63 | E-43 | E-31 | E-24 | E-19 | E-15 |  |
| 48 | 16 | E-83 | E-57 | E-41 | E-32 | E-26 | E-21 |  |
| 48 | 18 | E-105 | E-73 | E-53 | E-41 | E-33 | E-27 | E-22 |
| 54 | 12 | E-52 | E-35 | E-27 | E-19 | E-15 |  |  |
| 54 | 14 | E-72 | E-49 | E-35 | E-22 | E-18 |  |  |
| 54 | 16 | E-94 | E-65 | E-46 | E-36 | E-29 | E-24 |  |
| 54 | 18 | E-119 | E-82 | E-60 | E-46 | E-38 | E-30 | E-25 |
| 60 | 12 | E-58 | E-40 | E-30 | E-22 | E-17 |  |  |
| 60 | 14 | E-79 | E-55 | E-39 | E-30 | E-35 | E-20 |  |
| 60 | 16 | E-104 | E-72 | E-52 | E-40 | E-33 | E-27 |  |
| 60 | 18 | E-132 | E-92 | E-67 | E-52 | E-42 | E-34 | E-28 |



Figure 4-6. Measuring a wooden stringer.

## 4-17. Loading Open-Top Cars

Military equipment loaded on U.S. Army cars traveling over the lines of common carriers and on cars belonging to common carriers within the continental United States must meet the loading standards of the individual railroad and those of the Association of American Railroads (AAR). Cars loaded on foreign lines should meet the blocking and lashing standards of the area involved. The standards for and methods of blocking, nailing, and bracing for some typical military loadings are
given in this paragraph. Association of American Railroads (AAR) regulations, Rules Governing the Loading of Department of Defense Material on Open-Top Cars, should be followed. The following examples apply only to the loading of flatcars and composite gondolas with wooden floors with the equipment listed in $a$ through $d$ below and illustrated in figures 4-7 through 4-11. The letters in the item column refer to the letters shown in the illustrations. In all examples, brake wheels have the clearances shown in figure 4-12. The various wooden blocks, cut to specific patterns and numbered, are illustrated in figure 4-13. Additional details are contained in TM 55601.
a. Six-Wheel Truck (fig. 4-7). ${ }^{1}$

| Item | No. of pieces | Deacription |
| :---: | :---: | :---: |
| A |  | Brake-wheel clearance (fig. 4-12). |
| B | 8 ------ | Blocks, pattern 16 (fig. 4-13). Locate $45^{\circ}$ portion of block against front and rear of front wheels, in front of outside intermediate wheels, and back of outside rear wheels. Secure heel of block to floor with three $40-\mathrm{d}$ nails and toenail that portion under tire to floor with two 40-d nails before items D and E are applied. Substitute, if desired, at each location, blocks, pattern 17 (fig. 4-13), or blocks, pattern 18 (fig. 4-13). |
| C | 8 | 2 by 4 inches. Locate against block pattern 18 (fig. 4-13) lengthwise of car, and secure to floor with four 30-d nails. Not required when blocks, pattern 16 (fig. 4-13) and 17 (fig. 4-13), are used. |
| D | 1 each outside wheel. | Suitable material, such as waterproof paper, burlap, etc. Locate bottom portion under items $E$, top portion to extend 2 inches above items E . |
| E | 6 .....- | Each consisting of 2 pieces of wood 2 by 4 by 36 inches. Secure lower piece to floor with four $30-\mathrm{d}$ nails and top piece to one below in like manner. |
| F | 2 each axle_- | At each location use four strands of No. 8 gage, black annealed wire. Pass over axle, |

Item No. of pieces

| Item | No. of piecea |
| :---: | :---: |
| G | 1 each item |
|  | F |
|  |  |
| H | 4 each unit _ |

4 each unit

## Description

springs, spring shackles, underneath and around item G and twist taut after item $G$ has been nailed in place. 1inch bolts ( 2 for each axle), made from 1 -inch steel rods threaded at each end, may be substituted. Each bolt is secured on the axle with a steel plate having two holes, a lockwasher, and a 1 -inch square nut. The steel plate, with the curved portion of the bolt threaded through the holes, rests under the axle. The bolt passes through the floor of the car then through a 2 - by 4by 18 - inch piece of hardwood, and is secured with a flat washer and 1-inch square nut.

## Description

2 by 4 by 18 inches. Secure to floor, lengthwise of car, with four 30 -d nails. Not required when steel straps are used, pattern 19 (fig. 4-13).
Four strands of No. 8 gage, black annealed wire. Attach to each corner of machine and to stake pockets. Not required for units loaded in gondola cars.
${ }^{1}$ See notes at end of $d$ below.
b. Lighter, Amphibious, 5-ton (LARC-V) (fig. 4-8).

| Item | No. of pieces |  |
| ---: | ---: | ---: |
| A |  |  |
| B | 16 |  |
|  |  |  |
| C | 4 |  |

Deseription
Brake-wheel clearance (fig. 4-12).
Blocks, pattern 18 (fig. 4-13). Locate two in front and two in rear of each of the four wheels, and secure to floor with two $60-\mathrm{d}$ nails in the heel of block and two 40-d nails in each side of block.
Rub rail assemblies, see sketch A (fig. 4-8). Nail 2- by 8by 36 -inch vertical member to the lower piece of 2 - by 4by 36 -inch lumber with five 12-d nails. Position this assembly with 2 - by 8 -inch lumber against tire and secure to floor of car through 2-by 4 -inch piece with five 20 -d


Figure 4-7. Loading a six-wheol truck on an open-top car

$$
\bullet
$$


nails. Secure second 2- by 4by 36 -inch piece of lumber to the lower 2- by 4 -inch piece with five $20-$ d nails.
D 2 .....- Each to consist of two pieces of 2- by 4 -inch lumber, length equal to distance between items C. Secure lower piece to floor with $20-$ d nails spaced 8 inches apart. Nail top piece to lower piece in like manner.
E 4 -_--- Two pieces of 2 - by 4- $\times 24$ inch lumber. Nail to items $C$ and $D$, using eight $20-\mathrm{d}$ nails to each piece.
F 4 _-_-- Suitable protective material between tires and rub rail assemblies.
G $6 \ldots$ 5/8-inch diameter cable, 6 by 19, improved plow steel with IWRC. Form complete loop with 14-inch overlap.
H 4 _..... Same as item G, except with 26-inch overlap. See sketch B (fig. 4-8) for fittings.
J $3 \ldots \quad \begin{array}{r}\text { Shackles. For vehicles having } \\ \text { a } 11 / 16-\text { inch diameter hole }\end{array}$ in the towing bracket, use a 1-inch diameter pin with a 7/8-inch steel galvanized coated anchor shackle. For vehicles having a larger hole in the towing bracket, use an appropriate size pin and shackle. Attach the shackle to the towing bracket and secure the pin with a cotter key.
K 4 _...-- 2 - by 4 - by $141 / 2$-inch wood protective spacer between cable and side of vehicle. Secure to cable with staples.
L 4 …-.- Rubber hose protective spacer, 15 inches long.
M $64 \ldots \quad 5$-inch cable clamp, U-type only.
N 6 _-..-- $5 / 8$-inch closed thimble at load end of bow and stern cables.
$0 \quad 10$ _.... $5 / 8$-inch open thimble. See figure 4-8 for side view of blocking and tiedowns.
c. Mounted Gun or Howitzer (fig. 4-9). ${ }^{1,2}$
Item No. of pieces

## Description

A -----------.--
Brake-wheel clearance (fig. 4-12).
B 4
Blocks, pattern 16 (fig. 4-13). Locate $45^{\circ}$ portion of block

Item No. of pieces

C 2 _-..-- Each consisting of 2 pieces of lumber 2 by 4 by 36 inches. Secure lower piece to floor with three 40-d nails and top piece to one below in like manner.
D 2 _-_--- Support, pattern 62 (fig. 4-13), length $1 / 4$-inch longer than the distance between point of support on gun carriage and floor. Place between floor and gun carriage to partially relieve weight on tires. Secure each to floor with six 40-d nails.
E 2 _---- Four strands of No. 8 gage, black annealed wire. Pass through holes in wheels and secure to stake pockets.
F 2 for single spade, 4 for double spade.

G 2 each item F

H 2
6 by 8 by 24 inches, cut to fit contour of spade. Locate in front and rear of spade. Toenail to floor with five $40-\mathrm{d}$ nails.
Each consisting of 2 pieces of lumber 2 by 4 by 12 inches. Secure lower piece to floor, against item $F$, with three $40-\mathrm{d}$ nails and top piece to one below in like manner.
2 by 4 by 12 inches. Locate against each side of spade and secure to floor with three 40-d nails.
J 1 pair -..---
Stakes or green saplings. Locate one-third of distance from end of gun trail to center of wheels.
K $\quad 1$....... Six strands, No. 8 gage, black annealed wire. Loop around and over top of rear end of gun trail and secure to opposite stake pockets. Substitute, if desired, 2 - by .05 -inch hightension bands or $1 / 2$-inch steel cables.

[^63]d. Tanks and Similar Units, From 60,000 to 100,000 Pounds (fig. 4-10).1,2


## SKETCH "A"



Sketch details.
Figure 4-8. Blocking and tiedowns.

| Item | No. of pieces | Description |
| :---: | :---: | :---: |
| A |  | Brake-wheel clearance (fig. 412). |
| B |  | Blocks, pattern 31 (fig. 4-13). Locate one against each rear crawler tread. |
| C | 2 | Blocks, pattern 30 (fig. 4-13). Locate one against each front crawler tread. |
| D | 1 each items $B$ and $C$. | 2 by 4 by 20 inches. Locate one on inside of items $B$ and $C$ and secure to floor with six 20-d nails. |
| E | 2 each items $B$ and C. | Each consisting of 2 pieces of lumber 2 by 4 by 12 inches. Locate against ends of items $B$ and C. Secure lower piece to floor with four $20-\mathrm{d}$ nails and top piece to one below in like manner. |
| F | 2 each. unit ${ }_{\text {- }}$ | Each consisting of 2 pieces of lumber 2 by 4 by 14 inches. |

Item No. of pieces

G 3 each unit__

H 6 _-_-.-

## Description

Locate on floor against inside of each crawler tread, and secure lower piece to floor with twelve $30-\mathrm{d}$ nails and top piece to one below in like manner.
Each consisting of 2 pieces of lumber 2 by 4 inches long enough to fill space between items $F$. Locate one near center and one near each end of items F. Secure lower piece to floor with four 30-d nails and top piece to one below in like manner.
Each consisting on 2 pieces of lumber 6 by 6 inches, length to suit, cut to fit contour of bogie wheels. Locate one piece between inside and outside wheels of each bogie assembly.

K
$\qquad$

4 ------

Description
Each consisting of 2 pieces of lumber 4 by 4 inches, length to suit. Locate against bogie wheels on top of item $H$.
6 _-_--- Each consisting of 2 pieces of lumber 4 by 4 inches, long enough to fill space between items $H$. Toenail each to items $H$ with two $20-\mathrm{d}$ nails.
Each consisting of two strands No. 8 gage, black annealed wire. Pass under crawler tread and around items H and J. Substitute, if desired, at each location, one $3 / 4$ - by .035inch high-tension band. Use staples or nails bent over to retain bands or wires in position.
114-inch-diameter rods. Attach to lifting lugs and pass through stake pockets and $1 / 2$ by 4 - by 10 -inch plates underneath stake pockets on opposite sides of car. Substitute, if desired, $5 / 8$-inch steel cable, doubled.
${ }^{1}$ Set handbrake and wire, or block, lever. When tiedown rods are found slightly loose in transit, they need not be tightened.
${ }^{2}$ Place turret gun in straight forward position, and wire turretlockhandwheel and elevating-mechanism handwheel to prevent rotating. When unit is not equipped with built-in gun brace, apply two $3 / 4$-inch high-tension bands, securing gun barrel to unit at each side. Rock a tracked vehicle forward and backward under its own power to take the slack out of the tracks and thus secure the vehicle to the blockis.
e. Tanks and Similar Units, 100,000 Pounds and Over (fig. 4-11).
Item
A No. of pieces $\quad$ Brake-wheel clearance (see fig.

4-12).

F 2 _-_-_ Blocks, pattern 31. Locate one

B 2 _......

C As required -

D 4 ------

E 2 -.----

10 inches by 18 inches by 24 feet. Locate, as shown along each side of car. Secure each to car with at least five bolts 1 inch in diameter passed through items B and C, wood filler in stake pocket, and $1 / 2-$ by 4 - by 10 -inch plate underneath stake pocket. Not required for units loaded on floor of car.
Metal filler, length, width, and thickness to suit. Locate between items $B$ and top of stake pockets. Not required when units are loaded on floor of car.
Each to consist of two pieces of lumber 2 by 6 by 18 inches. Locate against item B, as shown. Secure lower piece to floor with four 3-d nails, and top piece to one below in like manner. Not required for units loaded on floor of car.
Blocks, pattern 30. Locate one against each front crawler tread. against each rear crawler tread.


Side view.
Figure 4-8-Continued.


Figure 4-9. Loading a 37 mm to 105 mm mounted gun or howitzer on an open-top car.

| Item | No. of pieces | Description |
| :---: | :---: | :---: |
| G | 2 each items $E$ and $\mathbf{F}$. | 2 by 3 by 30 inches. Locate as shown against each side of items $E$ and $F$ and secure to floor or item B with four 20$d$ nails in each. |
| H | 4 ----- | Each to consist of two pieces of lumber 2 by 12 by 18 inches. Locate one against each item $E$ and $F$. Secure lower piece to floor or item B with five 3-d nails and top piece to one below in like manner. Substitute, if desired, pattern 81 (fig. 4-13). |
| J | 6 | 2 by 8 by 13 inches. Locate as shown against items $B$ and crawler, one near each end of unit and one $a \ddagger$ center. Secure each to item B with four $30-\mathrm{d}$ nails, and to item K with three $30-$ d nails. Not required for units loaded on floor of car or when pattern 80 (fig. $4-13$ ) is used. |

$$
\begin{array}{rc}
\text { Item } & \text { No. of pieces } \\
\mathrm{K} & 3
\end{array}
$$

$$
\text { L } \quad 2
$$

Each to consist of two pieces of lumber 2 inches by 4 inches by 14 feet. Locate against inside of crawler treads. Secure lower piece to floor with 30-d nails spaced about 12 inches apart, and top piece to one below in like manner. Required only when units are loaded on floor of car.
Each to consist of two pieces of lumber 2 by 4 inches, length to suit, suitably spaced between items L. Secure lower piece to floor with $30-$ d nails and spaced about 12 inches apart and top piece to one be-

N As required_ Each to consist of two pieces of lumber 6 by 6 inches, length to suit, cut to fit contour of bogie wheels. Locate one piece between inside and outside wheels of each bogie assembly.
01 each item 2 by 4 inches, length to suit. N.

P $8 \ldots$ Rods $11 / 4$ inches in diameter. Attach to lifting lugs and pass through stake pockets and $1 / 2$ - by 4 - by 10 -inch plates underneath stake pockets, as shown. Substitute, if desired, 5/8-inch steel cable, doubled. Q 2 ..... 5 -inch steel cable, doubled. Locate, as shown, between gun turret and crawler structure.
When necessary to extend floor to provide
bearing for wheels or for the application of items $G$ on units loaded on floor of car, apply one piece of blocking on top of stake pockets, long enough to extend beyond wheel chock blocks and high enough to be level with top of floor. Use 1 - by 4 - by 18 -inch lumber at each end of blocking, nail each to floor with three 20-d nails, and to blocking with two 20-d nails.
Turret guns should be in straightforward position and turret lock handwheel and elevating mechanism handwheel must be wired to prevent rotation.
When unit is not equipped with built-in gun brace, apply two $3 / 4$-inch high-tension bands, securing gun barrel to unit at each side.
When tiedown rods are found slightly loose in transit, they need not be tightened.
Handbrake must be set and levers wired or blocked.
See General AAR rules for further details.


Figure 4-10. Loading a tank or similar unit, 60,000 to 100,000 pounds, on an open-top car.


Figure 4-11. Loading tanks and similar units over 100,000 pounds on flatcars.


Figure 4-12. Brake-wheel clearance.

## 4-18. High and/or Wide Loads

a. Cars with high and/or wide loads create an operating hazard: both the cargo and the
personnel working on the line are endangered. Every possible effort must be made to reduce such hazards.


Figure 4-13. Chocks with dimensions and pattern numbers of the Association of American Railroads.
b. The transportation officer initiating a high and/or wide load is responsible for coordinating the shipment with the shipping agency to effect the maximum reductions possible; for example, the removal of spotlights and toolkits, the lowering of booms, and the depressing of gun barrels. Shipping configurations of major items of Army equipment are contained in TB 55-46.
c. When the movement of a high and/or wide load is unavoidable, a scale drawing should be given the serving carrier to determine rail transportability and, if transportable, to make necessary routing instructions.
d. It is essential that the dimensions provided the carrier be accurate and that they reflect the absolute minimum that can be achieved by the shipping agency. (The consignee's ability to reassemble dismantled equipment must be considered.)
$e$. Whenever possible, an item of equipment should actually be measured to determine its shipping cube. Dimensions from supply manuals, TMs, FMs, etc., should not be used without verification. Incorrect dimensions can be very dangerous and costly.
$f$. Trains containing high and/or wide loads must be operated at reduced speeds; everyone concerned must be informed of the situation.

## 4-19. Loading Explosives and Other Hazardous Cargo

For detailed information about handling explosives, see regulations of the Interstate Commerce Commission and pamphlets issued by the Bureau of Explosives, Association of American Railroads and TM 55-602. Basic precautions are-
a. Lost space in loading packages in a car should be avoided by pressing each package firmly toward the end of the car as it is loaded.
b. High pressures on small areas must be avoided. The largest possible area of a package must be used to resist pressures. Bevel-edged boards must be nailed to the car floor to cover defects in the floor or projecting pieces of metal or nails. Cars with corrugated or pressed metal ends, not lined, and cars with bowed ends must be boarded up at the inside of the ends to the height of the load.


Figure 4-13-Continued.
c. Placing a large shipment in one end of a car must be avoided. A shipment in excess of 12,000 pounds must not be loaded in one end of a car unless other freight is to be loaded in the other end to balance it. Failure to this may cause the car to leave the track.
d. Bracing and blocking must be made with sound lumber, free from cross grain, knots, knotholes, checks, or splits which impair the strength of the material or interfere with proper nailing.
$e$. Nails should be used plentifully and in the proper places.
(1) Balanced nailing is important. All nails should be of such length as to have the necessary holding power and ample penetration into car walls, floors, or other bracing and
blocking. To obtain the greatest holding power, nails must be long enough to nearly penetrate but not protrude through the timber holding the point of the nail. Nails must not be large enough to cause splitting; they should not be placed along one grain of the wood. Whenever possible, nails should be driven straight-not toenailed. Brass or copper hammers should be used to nail braces around packages of explosives.
(2) The lining of cars is only three-quarters or seven-eights of an inch thick and has little holding power for large nails. Therefore, nails holding sidewall blocking should be driven into the heavy uprights supporting the lining.
$f$. The following must not be used:


Figure 4-18-Continued.

$A=$ NOT MORE THAN $15 \%$ LOAD LIMIT BETWEEN TRUCK CENTERS AND ENDS OF CAR
Figure 4-14. Load limits for explosives.
(1) Cars with end doors.
(2) Cars with automobile loading devices unless the loading device is attached to the roof of the car so that it cannot fall.
(3) Refrigerator cars, except when-
(a) Authorized by the carrier or owner,
(b) Ice bunkers are protected by solid bracing, and
(c) Unfixed floor racks are removed.
$g$. When heavy loads are handled in and out of cars on lift trucks, a temporary steel plate or other floor protection of suitable size must be used to prevent the truck from breaking through the floor.
$h$. When loading in closed cars, the following safety rules must be followed:
(1) Lading must be so secured that it will not come in contact with side doors, or roll or shift in transit.


Figure 4-15. Loading and blocking ammunition in cloverleaf packages.
(2) Adequate stripping must be placed across each door opening to prevent lading from falling, rolling out of a doorway, or coming in contact with a door while in transit.
(3) Load must be so placed in the car that there is not more weight on one side than on the other. One truck must not carry more than one-half the load limit stenciled on the car. Cars should be loaded as heavily as possible up to, but not exceeding, the load limit stenciled on the car. Loads should be placed in cars as shown in figure 4-4. The distances shown in the figure represent lengths of different loads. Relative position on the car of each load is also shown.
(4) Material loaded between truck centers and ends of car must not exceed 30 per-
cent of the stenciled load limit ( 15 percent each end) when both ends are loaded and 10 percent when only one end is loaded. The percentage of stenciled load limits shown in figure 4-14 must not be exceeded for loads located between truck centers, measured lengthwise of car, except when car owner designates otherwise.
i. The following instructions apply in loading and blocking ammunition in cloverleaf packages. Less-than-carload shipments may be loaded and braced in the same manner as the partial shipment shown in figure 4-15. All space between sides of car and rows of bundles must be tightly wedged in place at time of loading. Bulkhead braces for partial layers must be long enough to permit nailing to up-
The
 HANDLE CAREFULLY KEEP FIRE AWAY
STATION $\qquad$ 18
CONDENSED RULES FOR HANDLING THIS CAR

1. In switching this car in yards or on sidings have a nom-plecarded car between this car and engine.
2. This car must not be cut off while in motion.
3. Avoid all shocke to this car. Other cars must not bo allowed to strike this car. Couple carefully.
4. When the exploaives are unloaded this placard muat be nemoved from car.

Figure 4-16. Explosives placard, rail cars.

Labels must be of diamond shape, white in color, and with each side 4 inches long. Printing must be in red letters inside a red line border measuring $3 \frac{1}{2}$ inches on each side.


Figure 4-17. Rndioactive material labels.
right braces behind car lining. Length will vary, depending on weight of lading supported. The filler strips nailed to the sides of the car must be extended across the doorway. No other doorway protection is required.

## 4-20. Marking Dangerous-Cargo Cars

a. Loaded Cars. Closed cars and tank cars containing dangerous ladings are marked with placards giving the contents. These cards, usually 10 to 14 inches square and printed with large red and black lettering, indicate the contents of the car and give special handling instructions. The placards usually are tacked to placard boards bolted to the outside of the car-one at each end and one on each door on each side of the car. Cars of all-steel construction often have a framed card pocket, one
each in the four locations enumerated, into which the printed placards are slipped.
b. Empty Cars. Empty tank cars and boxcars are often placarded with notices that warn of lingering gases and fumes. These warning cards on cars stress that care must be used in switching the cars as well as in unloading their contents.
c. Examples. Typical car placards used on commercial and military railroads in the United States are shown in figures 4-16, 4-17, and 4-18, and four-language placards for use by the Army in Europe are shown in figure 4-18.

## 4-21. Cargo Security

a. At Origin.
(1) The shipper is responsible for the
security of carload freight until the car is coupled to a locomotive or train for movement. The shipper must be fully aware of this responsibility.
(2) Before loading, the shipper should inspect the car thoroughly to insure that it meets security requirements. Cars with holes or damaged places in floors, roofs, or sides, or insecure doors must be repaired before they are used.
(3) The shipper is responsible for properly loading and bracing the load and forclosing and sealing the car. Improperly stowed or braced loads may be damaged in movement and invite pilfering.
(4) Loading should conform to the standards necessary for safe movement under existing operating conditions. In sealing closed cars, the best protection is provided by tightly twisting a 10 -inch length of heavy-gage wire
through the locking eyes and snubbing off the wire ends closely. Usually No. 8- or 10-gage wire is used. Zero-gage may be necessary when the pilferage or sabotage threat is acute. The door hasps of closed doors are always sealed with a thin, metallic seal on which a serial number is stamped. This seal is broken easily and provides little protection against pilferage; however, the absence or breakage of a seal indicates tampering. Shipments in open cars should be covered with securely fastened tarpaulins if required by nature of shipment. Small items shipped on flatcars should be fastened securely to the car floor.
(5) The shipper prepares an accurate list of contents, prepares the waybills, and affixes placards to the cars. After a car is loaded, sealed, and documented, it should be moved as quickly as possible.
(6) At military installations the originat-


EXPLOSIVE STOFFE

SUBSTANCE EXPLOSIVE

SOSTANZA ESPLOSIVA

EXPLOSIVES

Figure 4-18. Railuay car placards, U.S. Army Europc.
ing transportation officer and railway personnel must inspect all open-top cars before movement to insure that they are loaded properly and meet clearance requirements.
b. In Transit.
(1) In CONUS the appropriate commercial railroad and in oversea theaters the transportation railway service is responsible for the security of all carload freight in transit from the time the car is moved from its loading point until it is placed at the designated unloading point. In CONUS the originating railcarrier and in oversea theaters the transportation railway service prepares all car records, train documents, and other records required to insure prompt movement and to prevent loss of cars en route. When operating conditions permit, cars containing freight subject to pilferage are grouped to permit economy in the use of guards. Special handling is given to mail or high-priority traffic of a classified nature.
(2) Train guards are provided by appropriate Army headquarters in CONUS. In oversea theaters, trainguards are provided by military police or other units assigned or attached to the transportation railway service for security duties. These units also guard cars and trains during movement in railroad yards. Sensitive supplies may be guarded by personnel assigned to the car by the loading agency. The yardmaster advises the dispatcher on receipt of cars with special guards. He also notes the receipt on the train consist that is transmitted to yards and terminals. This insures that all railway personnel avoid delays in transit and expedites placement at the destination.
(3) Guard crews check car seals and inspect trains for cars that are not secure. They prepare a record, by car number, of all guarded cars in trains, noting any deficiencies or incidents en route. Whe relief guard takes over, the crews make a joint inspection and sign this record.
(4) When a bad-order car containing supplies subject to pilferage is set out, a member of the guard crew should remain with the car until he is properly relieved. Guard crews must be alert at all times, particularly when
the train has stopped, and when it is passing through tunnels, cuts, and villages at slow speed.
c. At Destination.
(1) The consignee becomes responsible for carload freight when it is placed at the depot, siding, or track he designates. Cars should be unloaded as quickly as possible to lessen chances for pilferage.
(2) In removing wire seals from closed cars, care must be taken to avoid breaking latches on the car door. Wire cutters are recommended for this purpose.

## 4-22. Troop Movements

a. Space Requirements. For planning purposes, the following capacity data may be used when loading troops on U.S. equipment (other details contained in TM 55-601).
(1) Sleeping cars (average). Thirty-two troops with individual equipment.
(a) Officers and warrant officers are moved in standard pullmans, 2 per section, and are listed by number of sections; for example, 14 officers are shown as 7 sections. Officers and warrant officers of all units in one train will be grouped in one or more pullman cars as required.
(b) Enlisted men move in tourist pullmans, usually two per section. NCOs of the first five grades are entitled to separate berths. Space must be provided for personnel attached from medical units and men detached as guards on freight cars.
(2) Coaches (average). Fifty-five troops with individual equipment.
(3) Passenger . trains (long-distance moves, average). Eleven sleeping cars, 2 kitchen cars, 1 or 2 baggage cars; 350 troops per train is typical.
(4) Freight trains. For troop-unit moves, including such heavy equipment as tanks, artillery, and engineer equipment, trains seldom exceed 65 cars ( 650 short tons) for infantry divisions; 55 cars ( 1,200 short tons) for armored divisions.
(5) Mixed trains. Desirable from a tacti-
cal and organizational standpoint, since they carry all personnel with their vehicles, artillery, and equipment. Not economical when pasenger equipment is in short supply because they move at freight train speed. In mixed trains, boxcars should be substituted for baggage cars.
(6) Kitchen-baggage cars. Furnished on the basis of 1 per 250 men or fraction thereof. Requirements per train depend upon how transportation is grouped. For tentative estimates, allow one per unit.
(7) Flatcars. Number required is computed on the basis of maximum utilization of each car, regardless of length. Computation is not restricted to cars of one length. Twelve inches is left clear at one end of each car for brake-wheel clearance.
b. Organizational Equipment.
(1) Amount of headquarters, kitchen, and maintenance equipment varies somewhat in all units. For planning, allow 20 short tons per company or equivalent unit.
(2) Organizational equipment is usually loaded in unit transportation; loading it separely requires more boxcars. Checkable baggage up to 150 pounds is carried free; generally, this is loaded in a baggage car or boxcar. When transportation groupings permit, checkable baggage for two companies or similar units may be loaded in one boxcar.

## c. Foreign Railways.

(1) Few foreign railways are capable of moving complete troop units by rail at the same time the rail net is supplying a major force. Accordingly, tracked vehicles and foot troops may move by rail while wheeled vehicles with their normal towed loads move on highways.
(2) For planning, the following capacities may be assumed:
(a) Freight cars.


## 4-23. Troop-Train Commanders

## a. Assignment.

(1) An officer in charge of troops (train) is appointed or detailed for all troop trains. He is usually senior officer commanding troops.
(a) If only one unit is involved, he may be detailed by headquarters of unit ordered to move.
(b) If more than one unit is moving, he may be appointed by transportation movements officer at entrainment station unless an officer has been appointed by higher headquarters.
(2) If the troops are of mixed nationalities, the senior officer commanding troops, regardless of nationality, is troop-train commander; in cases of equal senior rank, the commander of largest number of troops served will be the troop-train commander.
(3) He serves until journey is completed, regardless of officers boarding train en route.

## b. Duties.

(1) Administration. the troop train com-mander-
(a) May appoint one or more officers as assistants. When troops of other nationalities are traveling on same train, officers of the nationalites concerned are appointed as assistants.
(b) Complies with instructions received en route from the responsible transportation movements officer.
(c) Ascertains details of loading baggage, vehicles (if any), and personnel from transportation movements officer, stationmaster, or port commander if moving from a port.
(d) Submits troop-movement order to transportation movements officer.
(e) Makes location of troop-train commander's headquarters on train known to all troops.
( $f$ ) Gives order of entrainment; directs entrainment, noting location of various units and their baggage.
(2) Discipline. The troop-train com-mander-
(a) Is responsible for the protection, discipline, and conduct of all troops aboard the train.
(b) Directs that separate accommodations be provided for all females traveling; details an officer to any car in which separate compartments are occupied by male and female personnel to insure observance of proprieties.
(c) Issues orders that prohibit-

1. Discussing the move with unauthorized persons.
2. Detraining without orders.
3. Throwing rubbish out of windows.
4. Leaning out of windows.
5. Damaging railway property.
6. Marking or writing on side of cars.
7. Violating blackout.
8. Wasting water in lavatories.
9. Riding on trains except where authorized.
10. Using intoxicants.
11. Using train latrines while in stations.
(3) Sanitation. The troop-train commander is advised by train crew of-
(a) Approximate time and duration of rest stops to be made during a long journey.
(b) Whistle signal to be used for notification of such stops.
(4) Air defense. The troop-train commander will-
(a) Interrupt movement program only if assault is specifically directed against the destination station.
(b) Be prepared to assist local antiaircraft after consultation with transportation movements officer.
(c) Enforce blackout.
(5) Defense against ground attack. This will depend upon the area involved, type and degree of attack, and the forces available to the troop-train commander. He should follow instructions and/or SOP provided by the local commander.

## 4-24. Estimating Railway Capacity

Since the direction of military supply move-
ments is primarily forward, military rail line capacity estimates generally are based on net tonnage moved in one direction. However, total capacity is based on train density and must take into consideration movements of trains in both directions. When the railway net under consideration is composed of several divisions and branch lines, separate estimates should be made for each dividion and branch line. In estimating railway line capacity in terms of payload hauled, the limiting factors are the power of the locomotive and resistance offered by the grade, the curve, the locomotive, the cars, the lading. and the weather. The formulas and factors presented in the following paragraphs are listed in the order in which they must be considered.

## 4-25. Weight on Drivers

a. General. The weight on drivers of a locomotive is expressed in short tons. It is that weight which is supported by the coupled driving wheels when they rest on a straight and level track. It does not include any of the remaining portion of the locomotive's weight. Different types and classes of locomotives have different weight. All locomotives are constructed to specifications issued by the purchaser, the using railroad, or the manufacturer.
b. Army Locomotives. The weights on drivers of some common types of locomotives used by the Department of the Army are included herein for ready reference. A complete table of Army locomotive characteristics is contained in table I, FM 55-21.
(1) Diesel-electric locomotive.

| Type | $\begin{aligned} & \text { Weight on } \\ & \text { drivers (STON) } \end{aligned}$ | Horsepatucr |
| :---: | :---: | :---: |
| 0-6-6-0, standard-gage | 131 | 1600 |
| 0-6-6-0, multi-gage | 127 | 1600 |
| 0-4-4-0, standard-gage | 120 | 1200 |
| 0-4-4-0, standard-gage | 120 | 1500 |
| 0-4-4-0, standard-gage | 80 | 1000 |
| (2) Steam locomotives. |  |  |
| 0-6-0, standard-gage | 80 | ---- |
| 2-8-0, standard-gage | 82 | ---- |

## 4-26. Tractive Effort (TE)

a. General. Tractive effort is a measure of
the potential power of a locomotive expressed in pounds; it is the horizontal force which a locomotive can exert, providing that the wheels do not slip. A locomotive's tractive effort is included in the data supplied by the manufacturer. The tractive effort of some locomotives used by the Department of the Army will be found in table I, FM 55-21. When such data are not available, tractive effort can be computed using the formulas. Due consideration must be given to the locomotive's age and condition.
b. Starting and Continuous Tractive Effort. Starting tractive effort is the power that a locomotive has available to move itself and the load it is hauling from a stopped position. Continuous tractive effort is the effort required to keep a train rolling after it has been started. As the train increases in momentum, the tractive effort necessary diminishes rapidly. In steam locomotives no differentiation is made between starting and continuous tractive effort. A steam locomotive can generally continue to pull what it can start. However, a diesel-electric locomotive cannot continue to exert the same force achieved in starting without damaging its power unit. The continuous tractive effort of a diesel-electric locomotive is approximately fifty percent of its starting tractive effort.

## c. Rule-of-Thumb Method of Determining Tractive Effort.

(1) Starting tractive effort is closely correlated to the adhesion which the driving wheels maintain at the rails. If the tractive effort expended exceeds this adhesion element, the drivers will slip. Normally, the adhesion element when the rails are dry is 30 percent of the weight on drivers; when the rails are wet, 20 percent. Therefore, 25 percent is taken as the average.
(2) Thus, for a locomotive weighing 80 tons or 160,000 pounds on drivers, the approximate starting tractive effort would be $\frac{160000}{4}$ or 40,000 pounds.
(3) If it were a steam locomotive, the con-
tinuous tractive effort of the above locomotive would also be 40,000 pounds. If it were a dieselelectric locomotive the continuous tractive ef-
fort would be approximately $\frac{40000}{2}$ or 20,000 pounds.

## 4-27. Drawbar Pull

a. General. Drawbar pull is the actual pulling ability of a locomotive, less the effort necessary to move the locomotive. Actual tests have indicated that 16 to 20 pounds of pull per ton are required to start the average locomotive or freight car on straight, level track under favorable weather and temperature conditions. A locomotive or car equipped with roller bearings will start with somewhat less effort. For railway planning, 20 pounds per ton will be used. This resistance drops after equipment starts rolling; but to establish pulling ability (drawbar pull) available for starting and pulling a train, 20 pounds per ton of locomotive weight will be subtracted from the continuous tractive effort of the locomotive. Thus, a diesel-electric locomotive weighing 80 tons on drivers and having a continuous tractive effort of $\mathbf{2 0 , 0 0 0}$ pounds has a drawbar pull of 18,400 pounds ( 20,000 pounds minus 1,600 pounds).
b. Speed Factors. Maximum drawbar pull can be exerted only at lowest speeds-up to approximately 10 miles per hour-after which it drops off sharply. Drawbar pull at given speeds can be obtained by applying a speed factor to the maximum drawbar pull. However, speeds are different for different types of locomotives. In one type of steam locomotive, drawbar pull was found to diminish in inverse ratio to speed. For example, drawbar pull is 80 percent at 20 miles per hour, 50 percent at 50 miles per hour, and 20 percent at 80 miles per hour. This may be used as a rule-of-thumb for estimating drawbar pull of steam locomotives at various speeds. The drawbar pull of diesel-electric locomotives diminishes more rapidly at the higher speeds.

## 4-28. Rolling Resistance

The force components acting upon a train in a direction parallel with the track which tend to hold or retard the train's movement constitute rolling resistance. The components of rolling resistance are friction between the railheads and the treads and flanges of the wheels, resistance due to undulation of track under a moving train, internal friction of rolling stock, and resistance in still air. An absolute figure to be used as rolling resistance is unknown. Experience indicates that a safe average value to use in the theater of operations for rolling resistance is as shown below:

Pounds per ton of train
Track condition
5
6
7
8
$9-1$

Excellent
Good to fair Fair to poor
Poor
Very poor

## 4-29. Grade Resistance

As determined by the following formula, grade resistance is equal to 20 pounds per ton of train times the rate percent of grade.

$$
R g=\frac{W R}{B}
$$

$$
\text { Where } \begin{aligned}
\mathrm{Rg} & =\text { grade resistance } \\
W & =1 \text { ton }(2000 \text { pounds) } \\
R & =\text { rate percent of grade } \\
B & =\text { one station ( } 100 \text { feet) }
\end{aligned}
$$

Thus, $R g$ in pounds per ton may be expressed

$$
R g=\frac{2000 \times \text { percent of grade }}{100}
$$

## 4-30. Curve Resistance

No entirely satisfactory theoretical discussion of curve resistance has been published; however, engineers in the United States usually allow from 0.8 to 1 pound per degree of curve. In military railway planning, the factor 0.8 pound per ton of train per degree of curve is used. The continual passing of trains around a curve eventually moves the track, which disturbs alinement and distorts the curve. The track should be restored to its correct curvature after determining whether any distortion
exists. This should be done by TRS mainte-nance-of-way personnel. A field expedient for determining the curvature of a track is the string method (para 4-44).

## 4-31. Weather Factor

a. General. The weather factor is another expression of train resistance. It reflects, by percentage, the effects of adverse cold and wet weather upon actual hauling power of a locomotive. Experience and tests have proved that whenever the temperature drops below $32^{\circ} \mathrm{F}$, the hauling power of the locomotive is decreased. Table III, FM 55-21, shows the weather factor (percent) for different degrees of temperature.
b. Ordinarily, wet weather is regarded as local and temporary and is disregarded in normal planning. However, in countries of extended wet seasons the loss of tractive effort due to slippery rail may prove serious if sanding facilities are inadequate. The applicable reduction is a matter of judgment but, in general, tractive effort will not be less than 20 percent of weight on drivers.

## 4-32. Gross Trailing Load (GTL)

Gross trailing load is the maximum weight or load in short tons that a locomotive may safely pull under given conditions of curvature, grade, or on level track. It is determined by combining all of the factors discussed in the preceding paragraphs. When double-heading with steam locomotives or using pushers, the GTL is equal to the sum or the GTL of the two locomotives (or 100 percent of the total GTL for diesel-electric locomotives). The formula for gross trailing load is as follows:

$$
G T L=\frac{D B P \times W}{R R+G R+C R}
$$

Where $G T L=$ gross trailing load
$D B P=$ drawbar pull
$W=$ weather resistance
$R R=$ rolling resistance
$G R=$ grade resistance
$C R=$ curve resistance

## 4-33. Net Trainload (NTL)

Net trainload is the payload carried by the train. The total weight of cars under load is gross weight. The light weight, or weight of cars empty, is tare. The difference between these two is the net load or payload of the train. In military railway planning, the net trainload is taken as 50 percent of the gross trailing load.

## 4-34. Train Density (TD)

a. General.
(1) The term train density is used to denote the number of trains that may be operated safely over a division in each direction during a 24 -hour period. Work trains are not included in computing train density. However, their presence on divisions, and the amount of time they block the main track, can reduce the density of a rail division. Train density may vary greatly over various divisions due to the condition and length of the main line, number and location of passing tracks, yard and terminal facilities, train movement control facilities and procedures, availability of train crews, motive power, and rolling stock.
(2) On a single-track line, passing tracks are normally 6 to 8 miles apart. When multiple tracks (three or more) are encountered, they generally will be considered as double track since it is frequently necessary to remove a portion of the third and fourth tracks in order to maintain the double track line.
(3) The capacity or operating turnover of cars and trains in and out of terminal yards must be considered, either from definite experience and intelligence factors or by inference from other related information.
(4) The following rule-of-thumb and formula are primarily designed to determine freight train density; however, they will be reasonable accurate on lines having 20 percent passenger trains included.
b. Rule-of-Thumb for Determining Train Density. In the absence of sufficient intelligence upon which to evaluate the potential train density of a rail line, a train density of

10 for single track and 30 for double track will be used as planning factors.
c. Formula for Determining Single-Track Train Density. When sufficient operational intelligence is available, the following formula and factors may be used in determining train density for a specified railway division. In determining the number of passing tracks, those less than 5 miles apart should not be included. Passing tracks selected should be uniformly spaced throughout the division.

$$
T D=\frac{N T+1}{2} \times \frac{24 \times S}{L D}
$$

Where $T D=$ train density
$N T=$ number of passing tracks
$1=$ constant (number of trains that could be run if there were no passing tracks)
$2=$ constant to convert to one direction
$24=$ constant (number of hours per day)
$S=$ average speed (table IV, FM 55-21)
$L D=$ length of division
d. Formula for Determining Double-Track Train Density. In determining the train density for double-track operations, fluidity and flexibility must be maintained. Thus, the number of trains operated should not exceed that number which can be cleared off either main track in case of emergency at any given time. Using the factors in $c$, above, train density for double track may be computed as follows:

$$
T D_{2}=(N T+1) \times \frac{24 \times S}{L D}
$$

## 4-35. Nef Division Tonnage (NDT)

a. Net dividion tonnage is the tonnage in short tons, or payload which can be moved over a railway division ( $90-150$ miles) each day. It includes railway operating supplies which must be programed for movement the same as the supplies of any other service.
$b$. Net division tonnage is determined by multiplying the net trainload (NTL) by the train density (TD) of the particular division.

Net division tonnage is computed separately for each division.
$c$. When calculating net division tonnage, certain other factors must be taken into consideration. For example, troop, passenger, or hospital trains will replace an equal number of tonnage freight trains. When the operation of such trains is anticipated, allowance in net division tonnage estimates is made by adjusting the train densities of the divisions concerned.

## 4-36. End Delivery Tonnage

In military operations, the end delivery tonnage measured in short tons which is delivered at the end of the railway line (railhead) each day. In all all-rail movement, the end delivery tonnage is the same as the net division tonnage of the more restrictive division.

## 4-37. Miscellaneous Operatinal Values

a. Effect of Temperature on Hauling Power of Locomotives.
Temperature ( ${ }^{\circ} \mathrm{F}$ ) Loss in hauling power (percont)
Above +32 -------------- 0
+31 to +16 ---------------- 5
+15 to 0 ......-.-.-.-. 10
-1 to -10 -.........-.-.-.-. 15
-11 to -20 .-............. 20
-21 to -25 ----------.--.-. 25
-26 to $-30 \ldots-\ldots-\ldots$
-31 to -35 .-.-.-.-.-.-.-. 35
-36 to -40 ......-.-.-.-. 40

-46 to -50 -.-.-.-.-.-.-.-. 50
b. Average Rolling Resistance Values.

Condition of truck
Pound per ton of train
Exceptionally good .-......-...-. 5
Good to fair .-........-............. 6
Fair to poor $-\ldots . .-\ldots-\ldots$

Very poor -.-.-.-.-.....-.-.-. 9 to 10
c. Terminal Times.

| Tupe of locomotivs | Hours |
| :---: | :---: |
| Steam |  |
| Diesel-electric | 8 |

d. Rolling Stock.
(1) Freïght.
(a) Requirements are computed separately for operations between major supply installations or areas on each line of communication as follows:
$\frac{\text { Daily tonnage }}{\text { Average tons }}$ per car turnaround time $=$ number of cars per car
Turnaround time is the total estimated number of days required for a car from the time it is placed for loading at its point of origin, moved to its destination, unloaded, and returned to its point of origin. Such time may be computed as follows: Allow 2 days at origin, 1 day at destination, and 2 days' transit time for each division, or major portion thereof, which the cars must traverse. This method, rather than an actual hour basis, is used to incorporate delays due to terminal and waystation switching as well as intransit rehandling of trains.
Rolling stock
Location or typs of operation
Days' dispatch required
At base of operation
Forward traffic
Return traffic
At railhead
(b) Computations should be increased by 10 percent to meet operational peaks, commitments for certain classes of cars, and bad order cars.
(c) An average planning factor for net load per car may be assumed as follows:

(d) Tank car requirements are computed separately based on the bulk POL requirement and the computed turn-around time.
(2) Passenger.
(a) Passenger car requirements -will vary, depending on troop movement policies, evacuation policies, and rest and recuperation policies.
(b) Theater passenger car requirements are fulfilled by acquisition of local equip-
ment with the exception of hospital cars and trains.
e. Road Locomotives. The number of road locomotives required for operation over a given railway division may be determined by the following formula:

$$
\underset{\text { tives required: }}{\text { Road }} \frac{T D \times(R T \times T T) \times 2 \times 1.20}{24}
$$

where $T D=$ train density $R T=$ running time (length of division divided by average speed)
$T T=$ terminal time (time for servicing and turning locomotive)
$24=$ number of hours per day
$2=$ constant for two-way traffic
$1.20=$ constant allowing 20 percent reserve

Note. The expression RT x TT is the percent of time during a 24 -hour period in which a road locomotive is in use and is called the locomotive factor. The expression provides for the pooled use of motive
power which may make one or more trips per day over a short division.

## f. Switch Engines.

(1) The number of switch engines required at a terminal is based on the number of cars dispatched and received, or passing through the terminal per day. When the number of cars has been computed, that figure is applied to the table in (2) below to determine the number of switch engines required at each terminal.
(2) When the total number of switch engines required for the railway line has been computed, add 20 percent as a reserve to allow for maintenace, operational peaks, etc.

Switch engines

Type of terminal
Port, railhead, loading, un- 1 per 67 cars dispatched loading.
Division and received per day.
1 per 100 cars passing per day.

## g. Fuel Requirements.



Steam (coal-burning) :
2-8-0, 82-ton, standard gage.
2-8-0, $90-$ ton, standard gage.
2-8-2, 60-ton, narrow gage.
Steam (oil-burning) :
2-8-0, 82-ton, standard gage.
2-8-2, 60-ton, narrow gage.

| Type of operation | Estimated average rate <br> of fuel consumption |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Coal |  | $\left.\begin{array}{c} \text { Oil } \\ (\text { onal. } \end{array}\right)$ | Coal (lb) | $\begin{aligned} & \text { Oef } \\ & \text { oil } \\ & \text { (b) } \end{aligned}$ | $\begin{gathered} \text { Oil } \\ \text { (gal.) } \end{gathered}$ |
| Road | 90 |  | --- | 700 | --- |  |
|  | 115 | --- | ---- | 950 | --- |  |
| Road | 100 | --- | --- | 750 | --- | --- |
| Road |  | 55 | --- | --- | 450 |  |
| Road |  | 60 |  | --- | 500 |  |
| Road switcher |  |  | 2.5 |  | --- | 11.5 |
| Road switcher |  | --- | 0.9 |  | --- | 8.0 |
| Road switcher |  | --- | 1.5 |  |  | 10.0 |
| Road switcher |  |  | 0.9 |  | --- | 8.0 |

h. Determining Average Speed Values. For planning purposes, average speed values can be estimated by using the table below. To determine speed, select the most restrictive factor of the eight factors shown. If the restrictive factor(s) is not known, use an average speed value of 8 mph ( 13 kmph ) for a single track and $10 \mathrm{mph}(16 \mathrm{kmph})$ for double track. If the most restrictive factor affects only a
comparatively short distance ( 10 percent or less) of the division, use the next higher average speed. If the average speed falls below 6 mph ( 10 kmph ) because of the gradient, reduce tonnage to increase speed. (A 2-percent reduction in gross tonnage increases speed 1 mile per hour.) If the ruling grade materially affects the tonnage, consider using helper service.

|  | Restrictive factore Condition of tracle | Perccnt ofgrade |  | $A v e$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Exceptionally |  |  | $m p h$ 12 | cmph 19.3 | mph 14 | kmph 22.5 |
| Good to fair |  | 1 to 1.5 | 10 | 16.1 | 12 | 19.3 |
| Fair to poor |  | 1.5 to 2.5 | 8 | 12.9 | 10 | 16.1 |
| Poor --- |  | 2.5 to 3 | 6 | 9.6 | 8 | 12.9 |

## Section IV. CONSTRUCTION, MAINTENANCE, AND SUPPLY

## 4-38. Construction Requirements

## a. New Construction.

(1) For planning purposes, a railroad division includes 100 principal-route miles of main line, single- or double-track, with its terminal operating and maintenance facilities, fueling and watering facilities, and the signaling equipment or interlocking facilities necessary for safe operation. Passing sidings on single-track lines, crossovers on double-track lines, and stations are located at intervals as
required by traffic. Normally, at least one spur or siding is provided at each station. The engineer service in the theater of operations is responsible for new rail construction and large-scale rehabilitation. Transportation railway service maintenance-of-way personnel, however, may be required to assist engineer personnel in the latter work.
(2) The following table shows the materials and net effective man-hours required for new construction of 1 mile of standard-gage (561/2-inch), single-track railroad.

| Short tons | Measurement tons | Manhours |
| :---: | :---: | :---: |
|  |  | ${ }^{1} 4,000$ |
|  | -------- | ${ }^{\text {b } 2,500 ~}$ |
|  |  | 2,570 |
| 101 | 111 | 2,200 |
| 8 | 7 | 1,400 |
| 218 | 300 | ------ |
| 160 | 45 | ------ |
| 33 | 10 | ------ |
| 520 | 473 | 12,670 |

from a port, using average percentage of demolition over the entire division. For further information, see FM 55-21.
be anticipated for a 100 -mile ( $161-\mathrm{km}$ ) stand-ard-gage, single-track division extending inland

| Item | Quantity per 100 milcs | Percent of demolition | Rehabili-tation tquation(quaty) | Material ${ }^{\text {d }}$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $\underset{\text { Short }}{\text { Sont }}$ | Measure- ment tons 2 |  |
| ${ }^{\prime}$ Main line | 100 mi | 13 | 13 mi | 3,820 | 2,514 | 68 |
| Port trackage ${ }^{\text {- }}$ | 3 mi | 100 | 3 mi | 1,440 | 1,098 | 22 |
| Passing sidings ${ }^{\text {a }}$ | 4.5 mi | 80 | 3.6 mi | 1,730 | 1,320 | 17 |
| Station sidings ${ }^{\text {a }}$ | 3 mi | 80 | 2.4 mi | 1,150 | 880 | 12 |
| Railway terminal ${ }^{2,8}$ | 1 ea | 75 | 0.75 ea | 7,100 | 5,800 | 160 |
| Water stations | 3 ea | 100 | 3 ea | 135 | 210 | 9 |
| Fuel stations | 1 ea | 100 | 1 ea | 21 | 18 | 1 |
| Bridging | 7,000 | 70 | 4,900 | 8,950 | 7,770 | 154 |
|  | linear ft |  | linear ft |  |  |  |
| Culverts | 28,000 | 15 | 4,200 | 120 | 105 | 21 |
|  | linear ft |  | linear ft |  |  |  |
| Grading |  |  | ----- | ------ | ----- | 35 |
| Ballast | - | ------ | - | ------ | ------ | 44 |
| Totals | -------- | --. | -------- | 20,715 | 24,466 | 543 |

[^64]
## Q-39. Mainfenamee Responsibilifies

a. After railways are constructed and turned over to the transportation railway service for operation, minor railway maintenance in the communications zone and in the combat zone to the forward limit of traffic is the responsibility of the transportation railway service.
$b$. The transportation railway service is responsible for the maintenance of the railway communications circuits that are used exclusively for the operation and administration of the railways. This responsibility becomes effective when all the circuits on the line have been turned over to the transportation railway service for administration and operation. The transportation railway service is responsible for the operation and for the organizational and direct support of railway block signals, of interlocking plants, and of centralized traffic control devices. It is also responsible for the installation, maintenance, and operation of internal communications.
c. The transportation railway system is normally divided into a number of divisions for maintenance and operation. Each division is assigned a railway battalion; each battalion includes personnel from the railway engineering company to perform necessary maintenance of tracks and structures.
d. The battalion commander has overall responsibility for railway maintenance, including maintenance work, instructions, and procedures. The company commander of the railway engineering company is maintenance-ofway superintendent and is directly responsible for the maintenance of tracks and structures, for the proper supervision of all maintenance work and procedures, and for the necessary inspection of track and structures on the division. Platoon and section leaders are charged with the proper supervision of assigned maintenance operations.

## Q-AO. Alainienamce Caiegories

a. General. Army maintenance is divided into four categories: organizational, direct support, general support, and depot.

## b. Locomotives.

(1) Organizational maintenance consists of during-operation maintenance, inspection of visible moving parts, lubrication, and repair or replacement of parts whose condition might interfere with the efficient operation of the equipment. During-operation maintenance is performed by the railway operating company, the balance is performed by the railway equipment maintenance company.
(2) Direct support maintenance is performed by the mobile railway workshop in the forward area and by the railway equipment maintenance company in the rear areas. When the repairs are not too extensive, the locomotive is repaired and put back into service. If the repairs are beyond the capabilities of the railway workshop, only those repairs will be made that are necessary to move the locomotive to a fixed installation for repair.
(3) General support maintenance and limited depot maintenance are performed by the diesel-electric locomotive repair company.
(4) There are no units provided in the transportation railway service for the performance of full depot maintenance. This category of maintenance beyond the capabilities of the railway car repair company and diesel-electric locomotive repair company is normally provided by a civilian facility.
c. Rolling Stock.
(1) Normally the railway battalion's train maintenance sections and crews perform organizational and direct support maintenance; this includes running repairs and inspection of rolling stock. The supply and railway repair car companies are responsible for general support and limited depot maintenance.
(2) Organizational maintenance is performed at the originating point of the train and at inspection points en route by military car inspectors or civilian railroad personnel. It consists of making running repairs required for the safe operation of the train.
(3) Direct support maintenance is performed by maintenance personnel, either military or civilian, at the home terminals of the
cars or at a prescribed location. It consists of running and emergency repairs that necessitate taking the car out of service for a short time. (See TM 55-203.)
(4) Repair track installations (rip tracks) normally are set up at main terminals. Usually they are also necessary at other points on the division, such as function points or heavy loading centers, to take care of repairs that cannot be made at the loading installation and to avoid moving the cars into the main terminal. The master mechanic (railway equipment company commander) is responsible for the operation of the repair-track installation.

## 4-41. Inspection and Maintenance of Locomotives

a. Basic Principles.
(1) Suitable inspection pits and facilities must be provided for inspection, repair, and adjustment of parts.
(2) The engineman is responsible for the equipment he operates.
(3) The fireman is responsible for maintaining the proper water level and steam pressure on steam locomotives. He receives instructions from the engineman, his immediate superior.
(4) Each locomotive must be inspected daily, or at the end of each trip, and DA Form 55-226 must be completed for steam locomotives ; DD Form 862 for diesel-electric locomotives.
(5) Each locomotive must be inspected monthly and DA Form 55-227 completed for steam locomotives; DD Form 1336 for dieselelectric locomotives.
(6) In addition to the daily and monthly inspections, each locomotive must be inspected quarterly, semiannually, and annually. Maintenance documentation will be in accordance with TM 38-750.
b. Enginehouses. The two general types of enginehouses are turnaround and maintenance. The turnaround enginehouse is small and is only equipped with facilities for performing
minor repairs and services. Work done in this enginehouse usually requires only $11 / 2$ to 3 hours. The maintenance enginehouse has facilities for making major as well as minor repairs; here the division locomotives are maintained in good operating condition and kept at maximum availability. TM 55-201 (steam locomotives) and TM 55-202 (dieselelectric locomotives) are general references covering maintenance procedures at enginehouses.

## 4-42. Maintenance-of-Way

a. Roadway. Roadway maintenance is the care taken and work performed to keep that part of the right-of-way on which the track is constructed in good condition. Right-of-way includes excavations, embankments, slopes, shoulders, ditches, and diversions of roads and streams.
b. Track. In a theater of operations, the track must be maintained in operable condition at all times. The four primary considerations in track maintenance are gage, surface, alinement, and dress. The roadbed and track must be inspected frequently to avoid delays in operation resulting from damage caused by sabotage, direct enemy action, or weather.
c. Structures. In a theater of operations, the structures essential to the railway operation must be maintained in accordance with the standard maintenance prescribed. Structures include bridges, culverts, tunnels, and fueling and watering facilities. When repairing structures, minimum clearances must be observed at all times.
d. Distortion. The continual passing of trains around a curve eventually moves the track, which disturbs alinement and distorts the curve. The track should be restored to its correct curvature after determining if any distortion exists. This should be done by TRS maintenance-of-way personnel. A field expedient for determining the curvature of a track is the string method (para 4-44).


Figure 4-19. Determination of degree of curvature, using the string method.

## 4-43. Degree of Curvature and Curve Radius

The table below shows relationships between degree of curvature and radius of curvature for simple curves. Degree of curvature means the degrees of central angle subtended by a 100 -foot ( 30.48 -meter) chord. Radius of curvature is the distance from the apex of the central angle out to the curve. The degree of curvature and radius of curvature form the sector of a circle; the area of this sector may be expressed in either of the following ways-

$$
\begin{aligned}
\text { Area } & =\frac{R \times \operatorname{arc}}{2} \\
& =\frac{3.1416 \times R^{2} \times D}{360}
\end{aligned}
$$

Equating the two expressions above, $R=$

$$
\begin{aligned}
& \frac{\operatorname{arc} \times 360}{2 \times 3.1416 \times D} \\
& =\frac{\operatorname{arc} \times 57.3}{D}
\end{aligned}
$$

where
$R=$ radius of curvature in feet
$D=$ degree of curvature in degrees
For a $1^{\circ}$ curve, the arc and chord are almost the same. Therefore, for practical purposes the arc in the formula for $R$ above can be called a 100 -foot chord for a $C$ value of $1^{\circ}$. $R$ then equals 5730 for a $1^{\circ}$ curve, and $\frac{5730}{D}$ for a $D$ degree curve.

| $D$ | $R$ | $D$ | $R$ | $D$ | $R$ |
| ---: | :---: | :---: | :---: | :---: | ---: |
| 1 | 5730 | 8 | 716 | 15 | 382 |
| 2 | 2865 | 9 | 637 | 16 | 358 |
| 3 | 1910 | 10 | 573 | 17 | 337 |
| 4 | 1433 | 11 | 521 | 18 | 318 |
| 5 | 1146 | 12 | 478 |  |  |
| 6 | 955 | 13 | 441 |  |  |
| 7 | 819 | 14 | 409 |  |  |

## 4-44. Determining Curvature by String Method

(fig. 4-19)
If a surveying instrument is not available, the degree of simple curvature (arc of a circle) of a track may be computed by the string method. Although this method is not exact because of the uncertainty of how much the string has stretched, the degree of error is insignificant. To determine the degree of curvature of a track by the string method-
a. Select a portion of track well within the main body of the curve.
b. Measure a chord distance of 62 feet (18. 897 meters) along the inside (five-eighths of an inch down from the top) of the high rail (A to B, fig. 4-19).
c. Stretch a string or strong cord very tightly between points A and B, and measure the distance $M$ at the midpoint of the cord. The distance in inches is approximately equal to the degree of curvature. In the example shown in figure $4-19$, if $M$ is 5 inches, the degree of curvature is $5^{\circ}$. (As a curve gets sharper, the distance $M$ increases.)

## 4-45. Railway Supply

a. Railway supplies, as distinguished from organizational supplies, are expendable supplies required for the operation and maintenance of railway divisions.
$b$. Whenever possible, local sources of supply should be used to ease transportation requirements. In a theater of operations, supplies may be procured from military stocks, manufacturers that are in or near the theater, foreign railways, captured enemy material and equipment, parts and assemblies manufactured
or repaired by the railway battalion, and transfers from other railway operation units.
c. All operating units must submit reports of supplies on hand at the beginning of operations to facilitate supply control.
d. The battalion supply officer serves as fuel agent for the railway transportation battalion; he is responsible for the operating agencies of the transportation railway service receiving sufficient locomotive fuel-regardless of source. Requisitions for fuel and lubricants are made through normal supply channels.
$e$. Tables of allowances and supplies are prepared by the supply officer of the highest transportation railway echelon for all units within the command. A workable stock level allowance must be determined for each unit to insure uninterrupted operation at all times. Normally, stock levels for the railway division are determined from past requirements.
$f$. An estimate of spare parts requirements may be made by using the factor of 1.5 short tons per month for each train per day moving in either direction. Beginning with the first railway division, select the train density established for the division, and multiply by 2 (for two-way travel) ; then multiply this result by 1.5, which equals the total amount in short tons of spare parts required per month for this specific division. Continue this process for each successive division to determine the grand total of short tons required per month for the entire railway. This is an estimate only. Revisions are necessary based on operating conditions.

## 4-46. Supply Requesi Procedure

a. The normal procedure for requesting a Transportation Corps item of supply is as follows. The company commander submits a request to the battalion supply officer. The battalion supply officer consolidates requests, makes lateral transfers of transportation supplies when necessary, prepares a formal request, and forwards it to the railway group supply officer. The supply officer of the railway
group determines if the item or items requested are available in one of the other units assigned to the railway group. The item or items are transferred if they are available; if they are not available, the request is processed and forwarded to the assistant general manager, supply (G4). The assistant general manager, supply, may then direct the transfer of the requested item or items from one railway group to another. If the items cannot be obtained from another railway group, he passes the request to the transportation depot company for issue.
b. When the railway group is the highest echelon of the transportation railway service in the theater, the group supply officer discharges the responsibilities of the assistant. general manager, supply. When the railway battalion is not operating as a part of a railway group, the battalion supply officer is authorized to handle supply matters directly with supply agencies. The highest transportation railway service headquarters in the theater may authorize the battalion supply officer to request certain transportation items of routine supply directly from the appropriate supply depot without the approval of the next higher echelon. Items in short supply may be controlled as necessary, depending on the stock level in the depot. The battalion supply officer may be permitted, by the same headquarters, to request routine items from the depots of the other technical services.
c. To obtain supplies from outside sourcesindustry, railway stocks, and railway supply channels-the battalion supply officer prepares purchase orders or requests in accordance with the policy established in the particular theater. Normally, purchase orders or requisitions are forwarded to the railway group supply officer for further action; however, the railway battalion commander may be delegated the authority to approve purchase order and requisitions for specified quantities of particular supplies. In such cases, the battalion procures the supplies locally and sends information copies of the transaction to the railway group supply officer. When the company commander is au-
thorized to make local purchases, information copies of each transaction must be sent to the battalion supply officer. It is essential that accurate records be maintained of all transac-
tions in order to protect the U.S. Government from fraudulent claims.
d. All captured enemy material and equipment must be recorded and accounted for.


## CHAPTER 1

## GENERAL

## 1-1. Purpose and Scope

$a$. This manual is both a planning guide for staff and unit officers and a digest of operational data for use às a reference by operators and users of transportation when unit or staff libraries are not readily available.
b. This manual does not include policies and procedures governing the mode selections for commercial CONUS transportation or the use of Government Bills of Lading. For the assignment of routing authority, see paragraphs 202012 and 202013, (AR 55-355) ; for the preparation and/or use of the Government Bills of Lading, see paragraphs 214009 and 214016, (AR 55-355).
c. This manual includes characteristics of typical transportation equipment and facilities and methods for estimating the capabilities of, or requirements for, transportation equipment, facilities, and troop units. Personnel and equipment data for the modes of transportation and for transportation terminals are presented as well as data for computing requirements for staff, supervisory, and control activities. Factors concerning administrative support requirements are included. It also contains report formats and examples of orders and standing
operating procedures. Loading data for water, rail, motor, and air movements; tables on weights, measures, and conversion factors; and miscellaneous data of general usefulness are included.
d. Planning data contained herein should be modified as necessary to reflect known conditions and requirements. Current data should be used when available rather than that contained in this reference. Information contained in various chapters does not necessarily reflect current tables of organization and equipment.

## 1-2. Application

The material presented herein is applicable to nuclear and nonnuclear warfare.

## 1-3. Changes and Revision

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to the Commandant, U.S. Army Transportation School, Fort Eustis, Virginia 23604.


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## CHAPTER 2

## AIR

## Section I. ORGANIZATION

## 2-1. Organization

Unit TOE
Light airmobile company, aviation battalion, airborne division.

Airmobile company
(light), aviation battalion, infantry division, or aviation company (airmobile).

Headquarters and headquarters company, aviation battalion.

Aviation medium helicopter company.

To provide tactical air movement of combat troops in airmobile operations. To
provide tactical air movement of combat troops in airmobile operations. To
provide tactical air movement of combat supplies and equipment within the combat zone.

1-256 To provide command control, staff planning, and administrative supervision for 3 to 7 transport aircraft companies.
-

To provide tactical air movement of combat troops in airmobile operations. To provide tactical air movement of combat supplies and equipment in airmobile operations.

To the field army or corps aviation group when the primary mission is tactical support. To the field army support command aviation group when the primary mission is logistical support.

To the field army, theater army support command, or other commands as required. Normally attached to headquarters and headquarters company, aviation battalion, TOE 1-256.

To an aviation group, TOE 1-252. Normally attached to headquarters and headquarters company, aviation battalion, TOE 1-256.

To a field army support command. Normally attached to a headquarters and headquarters company, transportation brigade, TOE 55-62.

A viation battalion, infantry division, TOE 1-75. As required when organized as separate company.

## Assignment

Organic to aviation battalion, airborne division, TOE 1-55.

Headquarters and headquarters detachment, transportation movement control center.

To plan and program nontactical movements of personnel, materiel, and supplies (except bulk POL) within the field army area, other than those between general support/direct support

[^65]To command and control air transport, motor transport, terminal transfer, and transportation movements units. groups and their supported units. To maintain liaison, as required, with transportation elements of other component U.S. Forces and with allied and host nation transportation agencies.

To a field army support command.

Unit
Headquarters and headquarters detachment, transportation airlift maintenance and supply battalion.
toe
55-66

Mission axd/or capabiluty
To provide the command and staff, and administration, supply, and communications for the transportation aircraft maintenance and supply general support battalion. To provide repair parts general support for aircraft and aircraft armament peculiar items for the field army.

Transportation maintenance company, maintenance battalion, infantry division.

Transportation aircraft maintenance company, maintenance battalion, airborne division.

Transportation aircraft maintenance and supply battalion, airmobile division.

Transportation maintenance and supply company, transportation aircraft maintenance and supply battalion, airmobile division.

Transportation aircraft maintenance company, armored and infantry (mechanized) division.

Transportation aircraft direct support company.

Transportation aircraft maintenance general support company.

55-89 To provide direct support aircraft maintenance capability as an integral part of the support command of the infantry division.

55-99 To provide direct support aircraft maintenance capability as an integral part of the support command of the airborne division.

55-405 To provide aircraft direct support maintenance, including avionics and armament maintenance, and repair parts support for aircraft organic to an airmobile division.

55-407 To provide aircraft direct support maintenance, including avionics and aircraft armament maintenance, and repair parts support for aircraft organic to an airmobile division.

55-424 To provide direct support aircraft maintenance capability as an integral part of the support command of the armored division or infantry division (mechanized).

55-457 To perform direct support maintenance on Army aircraft, aircraft armament, limited maintenance on avionics, equipment, and related supply and recovery support to nondivisional aviation units.

55-458 To perform general support and back up direct support maintenance on Army aircraft and aircraft armament and

Transportation helicopter teams and aircraft field maintenence teams.* back up direct support maintenance on avionics equipment.

55-500 To provide personnel and equipment to supplement TOE units where additional trained personnel are required in numbers less than TOE strength, to perform transportation functions as part of a larger unit where the need for the activity is less than a similar TOE unit and to operate as a separate organization where no TOE unit is provided.

Assignment
To a field army support command or a logistical command.

Organic to maintenance battalion, infantry division, TOE 29-15.

Organic to maintenance battalion, airborne division.

Organic to support command, airmobile division, TOE 29-41.

Organic to transportation aircraft maintenance and supply battalion, airmobile division, TOE 55-405.

Organic to maintenance battalion, infantry division (mechanized), TOE 29-25, or maintenance battalion, armored division, TOE 29-35.

To a field army or corps or a logistical command.

To a field army support command, corps support brigade, or a logistical command. Normally attached to an aircraft maintenance and supply battalion (general support).

Teams may be attached or assigned to higher echelon units or may be organized into service units to perform functions as required by existing conditions.

[^66]
## Section II. AIRCRAFT

## 2-2. Army Aircraft

a. Mission Planning. All planning beyond the preliminary stage should be coordinated with, or accomplished by, the aviation officer, the local operations officer, and the aviator designated to fly the mission. Some variables which are not discussed below but which must be considered in planning each mission are the proficiency of aviators and other operating personnel, the effects of cargo loading and fuel burn-off on the center of gravity (CG) of the aircraft, condition of runways, approaches to airfields, and navigation aids available for instrument approaches and landings during badweather operations. The conditions and criteria set forth in this manual are useful only for preliminary or general planning; they cannot and must not be used for specific mission planning. Detailed aircraft performance data and limitations under varying air density and temperature conditions, power settings, and cargo loading are set forth in the TM 10 -series pertaining to the specific aircraft.
b. Variables Affecting Performance. Some of the common variables affecting the performance standards of the aircraft are discussed in (1) through (6) below.
(1) Air density and temperature. The ability of the aircraft to lift weight is directly proportional to the density of the airmass in which it is operating; the density of the airmass is affected by, and is inversely proportional to, the temperature, humidity, and altitude above sea level. For example, the U-8F (Seminole), weighing 7,700 pounds and operating from a point at sea level where the temperature is $59^{\circ} \mathrm{F}$. ( $15^{\circ} \mathrm{C}$.), requires 2,200 feet from the start of its takeoff run to clear a 50 -foot obstacle. The same aircraft, operating at the same weight from an airport 5,000 feet above sea level where the temperature is $95^{\circ} \mathrm{F}$. ( $35^{\circ} \mathrm{C}$.), requires over 2,985 feet to clear a 50 -foot obstacle. The capability of a helicopter with an externally slung load can be reduced as much as 80 percent between sea level at $0^{\circ} \mathrm{F}$. and 6,000 feet at $95^{\circ} \mathrm{F}$.
(2) Range and payload. Range and pay-
load capabilities outlined in this chapter are based on a sea-level takeoff in a standard atmosphere as defined by the International Civil Aeronautics Organization. The ICAO defines standard atmosphere as a dry air condition of 29.92 inches of mercury ( Hg ) pressure and $59^{\circ} \mathrm{F}$. ( $15^{\circ} \mathrm{C}$.) temperature.
(3) Wind. Surface wind affects both fixed-wing and rotary-wing aircraft. In computations in this manual, the surface-wind velocity is assumed to be zero or negligible. If utilized in conjunction with available runways, a surface wind has a pronounced beneficial effect on the takeoff and landing characteristics of an aircraft, since lift capability is directly proportional to the speed of the air past the lifting surfaces.
(4) Speed. Within the range of speeds in which a particular aircraft can fly, it can be said generally (except for turbine-powered aircraft) that the slower the speed, the longer the range for available fuel. A fixed-wing aircraft flying about 20 percent faster than its minimum speed can fly farther than it can at its maximum speed. This same principle applies in a general sense to helicopters. However, since helicopters have no minimum forward speed, the best range is usually determined as some percentage of the maximum forward speed.
(5) Altitude. The amount of oxygen available in the air decreases as altitude increases. Flight above 10,000 feet for an extended period is extremely dangerous unless personnel are supplied with oxygen or unless the aircraft is pressurized so that the atmosphere within corresponds to a lower level. A minimum of 1,000 feet should be allowed for clearing obstacles; therefore, when the terrain altitude is over 9,000 feet, only aircraft supplied with oxygen should be programed for flight. While oxygen supplies for the crew permit cargo flights above 10,000 feet, troop transport for extended periods is impractical without other provisions for oxygen.
(6) Weather. For weather to permit VFR (visual flight rules) flight, the underside of
the cloud ceiling should be at least 1,000 feet above the terrain for the entire route, and the visibility should be at least 3 miles in control zones around airfields and 1 mile outside control zones. All other weather is referred to as IFR (instrument flight rules). VFR aircraft normally cannot be flown in IFR weather. The availability of all-weather aircraft and qualified aviators does not always guarantee the start of a mission; an aviator may very well have to refuse to attempt a mission if extreme weather is anticipated. If air turbulence or other conditions are such that an aircraft cannot remain airborne, it is foolhardy to attempt a mission. The high speed and long range of modern aircraft require adequate weather intelligence for the entire route before the start of any mission. The weather to be encountered en route may not, and very frequently is not, apparent at the originating point.
c. Powerplants and Accessories. Powerplants used in Army aircraft are of several different types. As technological advances are made, it can be expected that powerplants and accessories other than those discussed in (1) through (4) below, will be added to the inventory.
(1) Engine types.
(a) Turbojet. This is a turbine type engine which utilizes the thrust of its exhaust gases for propulsive power. This engine is not currently used in any Army aircraft.
(b) Torboshaft. This engine is a double turbine type which utilizes the thrust of its exhaust gases to drive a second or power turbine. The energy imparted to the power turbine is, in turn, transferred to a rotating shaft. This type of engine is used in Army helicopters to drive the rotors through gear reductions.
(c) Turboprop. This engine is identical in principle to the turboshaft engine, but the power is imparted to a propeller through a gear reduction.
(d) Reciprocating. This is a conventional engine having aircraft, automobile, and marine applications. Aircraft reciprocating engines are divided into several types and classes. The type is determined by the engine's
shape and cylinder arrangement. The two classes are air cooled and liquid cooled. At present, Army aircraft do not use liquid-cooled engines. The types of reciprocating air-cooled engines used in Army aircraft are-

1. Opposed. The cylinders are arranged in two rows opposite each other. In fixed-wing aircraft, the engine is usually mounted so that the length of the cylinder is parallel to the ground. All opposed engines used in Army aircraft have six cylinders.
2. Radial. The cylinders are arranged radially around a central crankshaft. These engines are classified as single-bank or multibank. Single-bank engines always have an odd number of cylinders. Multibank engines are essentially two single-bank engines mounted back to back on a common crankshaft. Army aircraft employ both types of radial engines.
3. Supercharged. Reciprocating engines may be modified by superchargers which serve two purposes. They enable engines to develop more horsepower per unit of weight by increasing the quantity of combustible mixture that can be induced into each cylinder. They also permit engine operation at higher altitudes by compressing the rarefied air to a usable pressure prior to induction into the cylinders. Except for the smallest reconnaissance types, all Army aircraft that use reciprocating engines have superchargers.
(2) Weight and power. Because weight is such a critical factor, aircraft engines are engineered to give the most possible power per pound of weight. To permit rapid acceleration during takeoff (the most dangerous stage of flight), engines are designed to operate for short periods of time at power outputs that would be self-destructive if continued for long periods. For most aircraft engines, this period of excessive power is limited to 5 minutes during any one application. The power ratings of engines used in Army aircraft usually are referred to as one of the following:
(a) Takeoff horsepower. This is the maximum horsepower an engine can develop for a period of 5 minutes or less without immediate damage. Some engines, when operated at the lower altitudes, can exceed this horse-
power output. This power, misused, can destroy an expensive engine; it is one of the many reasons for extensive training of aircraft operating personnel.
(b) METO horsepower. This is the maximum horsepower that an engine can develop continuously. (The term METO is derived from the words 'maximum, except takeoff.")
(c) Cruise horsepower. This is the horsepower which gives the best speed with minimum engine wear and delivers' the best flight characteristics with respect to flight attitude, control response, and minimum vibration.
(3) Propellers. The propellers used on Army fixed-wing aircraft fall into three categories.
(a) Fixed pitch. This is a one-piece, metal propeller used on $0-1$ aircraft. The pitch or angle of bite of the propeller blades is fixed and cannot be changed.
(b) Constant speed. This propeller consists of two or three blades and a hub. The hub is designed to permit the blades to change their pitch angle as necessary to maintain a constant engine speed. The desired engine speed is set by the aviator; it is maintained by a governor which transmits its commands to the propeller hub by means of hydraulic pressure, using the engine lubricating oil as a medium.
(c) Full feathering. This is a constant speed propeller which can be set for a maximum degree of pitch. This enables the aviator to reduce propeller drag to a minimum when one engine of a multiengine aircraft is inoperative. (The Army uses full feathering propellers on multiengine aircraft only.)
(4) Rotors. The rotor blades used on Army rotary-wing aircraft vary in design and construction, depending on the manufacturer and the desired speed and gross weight of the aircraft. The pitch angle or bite of the blades on all rotary-wing aircraft can be controlled by the aviator. The control mechanism, which is part of the flight control system of the aircraft, is peculiar to the aircraft and is not a property of the rotor blade itself.

## d. Aircraft Balance and Range.

(1) Center of gravity ( $C G$ ). The center of gravity of an aircraft is an important factor in flight characteristics and safety. It must be computed by trained personnel for each aircraft for each flight. (Center of gravity locations given in this manual are from design data and should be used as guides only.) The computation includes more than the takeoff configuration of the aircraft; it must also consider the progressive change of the center of gravity as fuel is consumed in flight. An aircraft could be loaded so that it would be completely safe at takeoff, but be enough out of balance at the end of the mission that the aviator could lose control, especially during letdown or landing. Each aircraft varies in weight and balance from other aircraft, even of the same type, model, and series. The actual basic weight and center of gravity of each must be known before center of gravity changes due to load and fuel can be computed.
(2) Linear measurements. Linear measurements of cargo compartments are usually expressed in inches. For fore and aft measurements, the locations are referred to as stations. The station points are used in computing the fore and aft CG of the aircraft; all stations are computed as having a plus factor. Station zero (reference datum line) on most aircraft is usually at the nose of the aircraft or at an imaginary point in front of the aircraft. To eliminate the possibility of having to use negative station factors in the future, the imaginary location of the aircraft is set by the de: signers as the most forward position to which future modifications can reasonably be expected to extend.
(3) Operating distances and fuel load.
(a) Range. For the purposes of this manual, unless otherwise noted, range is the one-way distance that an aircraft can fly with the stipulated load, without refueling, based on the following assumptions:

1. Takeoff altitude is sea level.
2. Flight altitude for the mission is 5,000 feet.
3. Wind condition at altitude is zero.
4. Fuel reserve on arrival at destination is 20 minutes for VFR and IFR flights.
5. Fuel allowances are made for taxi, runup, takeoff, and climb-out to altitude.
(b) Radius of action. Radius of action, or radius, is the maximum distance that an aircraft can fly with payload to a destination and return empty without refueling, unless otherwise specified (return fully or partially loaded). Reserve conditions for this type of mission are the same as in (a) 4 above. A further fuel allowance must be made for one additional runup, taxi, takeoff, and climb-out.
e. Considerations Peculiar to Helicopters.
(1) "In-ground eff ect" takeoff. The flight characteristics of the helicopter are affected by the high pressure region or "ground cushion" between the helicopter and the ground. This cushion, created by the downward displacement of air through the rotor blades, is effective to a height of approximately one-half the rotor diameter and increases the lift capability of the helicopter. The use of this takeoff technique increases safety and decreases wear on the engine, power train, and associated equipment. It requires horizontal flight near the ground until sufficient speed is attained for safe flight.
(2) "Out-of-ground effect" takeoff. When this vertical takeoff method is used, the ground cushion is lost almost immediately after liftoff (height of one-half the rotor diameter). Usually this takeoff method is employed when a sling load is to be lifted or when the takeoff area is too restricted to permit a ground run or low-level flight. When possible, other methods should be used since payload is reduced and certain risks are involved in this technique. The lift capability, or power, which the engine can develop at maximum continuous power in a vertical takeoff is never equal to the lift capability of the helicopter under forward flight using normal cruise power. If the engine fails above the ground cushion before
altitude or forward speed permits autorota tional landing, the helicopter may be destroyed or seriously damaged.
(3) "Ground run" takeoff. This type of takeoff employs the same technique used for fixed-wing aircraft and involves a run over the ground until sufficient speed is attained for safe flight. It is employed when the altitude, temperature, or aircraft weight (or a combinatoin of these factors) is such that the aircraft cannot hover close to the ground.
f. Transportability. For disassembly, crating, and crated and uncrated shipment of Army aircraft, see appropriate technical manuals for the aircraft, including manuals of the TM 55-450-series and FM 101-10.

## 2-3. Army Aircraff Payload Versus Ramge

a. General. Payload is the number of passengers and/or the amount of cargo that an aircraft can carry, usually expressed in pounds. As the distance to be flown is increased, the fuel required is increased and the payload is decreased. The payload varies with changes in altitude, temperature, air pressure, humidity, and wind.
b. Computations for Range Versus Payload. Payload for various ranges may be closely approximated for Army aircraft by using figure 2-1, which has been constructed from computations for 50, 100, and 200 nautical miles shown in the table in $c$ below. In computing total payload for the mileages shown, the maximum payload possible is used. Pounds of fuel not required to fly the mission have been replaced with payload. Figure 2-1 is a rapid reference that should be used for general planning only. When planning cargo operations over distances greater than 200 nautical miles, see the appropriate -10 technical manual for detailed planning information.


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Figure 2-2. Cargo compartment envelope and access limitations.


Figure 2-3. O-1E (Bird Dog).


Figure 2-4. OV-1A (Mohawk).


Figure 2-5. U-1A (Otter).


Figure 2-6. U-1A (Otter). Cabin dimensions.


RIGHT-HAND SIDE VIEW-CABIN


LEFT-HAND SIDE VIEW-CABIN

Figure 2-7. U-1A (Otter). Troop seating.

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Figure 2-8. U-6A (Beaver).


Figure 2-9. U-8D (Seminole).


Figure 2-10. OH-13H (Sioux).


Figure 2-11. OH-23D (Raven).


Figure 2-12. UH-1A (Iroquois).


Figure 2-13. UH-1A (Iroquois). Cargo features.


Figure 2-14. UH-1B (Iroquois).


CODE


1. Tio down fittings.

2. Corgo orea, maximum loading dimensions.
3. Optional loading oreo, eqpilots seat removed.
4. Interior orea obove moximum packoge.
,
5. Floor obstruction. ( Heater outlofs)

NOTES:

1. Cargo floor looding ve. G lood factor Lbs. Sq. Ft. 300 $150 \quad 2.0$ $100 \quad 3.0$
2. Tie down fittings, strength $\mathbf{1 2 5 0} \mathrm{Ibs}$. vertical, 500 lbs. horizontal lood per fitting.


Figure 2-15. UH-1B (Iroquois). Cargo features.


Figure 2-16. UH-1D. (Iroquois).


Figure 2-17. UH-1D. (Iroquois). Cargo features.

FM 55-15


Figure 2-18. UH-19D (Chickasaw).


Figure 2-19. UH-19D (Chickasaw). Cabin.


Figure 2-20. CH-21C (Shawnee).


Figure 2-21. CH-21C (Shawnee). Cargo-passenger compartment dimensions.


Figure 2-22. CH-34C (Choctaw).


Figure 2-23. CH-34C (Choctaw). Cargo compartment dimensions.


Figure 2-24. CH-37B (Mojave).


Figure 2-25. CH-37B (Mojave). Cargo compartment dimensions.


Figure 2-26. C $\dot{H}-37 B$ (Mojave). Equipment load planner.


Figure 2-27. CH-47A (Chinook).


Figure 2-2r CH-47A (Chinook). Cargo compartment.


Figure 2-29. CH-54 (Sky Crane).

## Section III. OPERATIONS

## 2-5. Outline Standing Operating Procedure for Air Movements

a. General. Amplification of command policies on use of air transportation (intratheater and intertheater), including responsibilities, utilization, and procedures in the employment of organic aviation units; responsibilities for coordination with Air Force aerial ports.
(1) Submission of space requirements. Responsibilities for, timing, format, procedures, and policies affecting submission of advance and firm space requirements for air movement of supplies and personnel.
(2) Airspace assignments. Controlling agency; procedures for application, space assignment, and use of space assignments; formats.
(3) Air priorities system. Controlling agency; procedures and responsibilities for application, determination, dissemination, and use of priorities; implementation of command policies and directives.
(4) Aerial port calls. Responsibilities and procedures for the issue of port calls for supply and personnel movements, implementation and execution of such calls.
(5) Special movement control actions. Special actions required to integrate movement control of air transportation with other applicable modes of transportation.
(6) Loading and unloading of aircraft. Policies, responsibilities, and procedures for loading and unloading troops, accompanied supplies, and equipment at air terminals.
(7) Diversions and reconsignments. Authority, procedures, and channels prescribed for effecting and executing diversions or reconsignments.

## b. Supply Movements.

(1) Designation for air movement. Authority for, responsibilities, how accomplished and disseminated, actions to be taken.
(2) Special packing requirements. Special instructions for packing or preparing supplies for air movement. Responsibility for packing and inspecting before air movement.
(3) Special marking. Types, responsibilities for applying marking on containers and for obliterating old markings.
(4) Documentation. Responsibilities and procedures for preparing and distributing established documents.
(5) Airdrops and extractions. Amplification of command policies and directives on packaging and delivery responsibilities, methods and procedures for obtaining and accomplishing airdrops, methods and responsibilities for marking landing or drop zones.
(6) Records and reports. Responsibilities and methods of maintenance of specific records and reference to reports to be submitted.

## c. Personnel Movements.

(1) Preparation for air movement. Command policies and directives on procedures and requirements for preparing units and individuals for air movement.
(2) Movement to air terminals. Procedures and responsibilities for the movement of units and individuals to air terminals for air movement.
(3) Documentation. Preparation, distribution, and uses of established flight forms and documentation.
(4) Records and reports. Responsibilities and methods for maintenance of specific records and reference to reports to be submitted.

## 2-6. Outline Standing Operating Procedure for Air Transport Service (Air Force and Army Aviation)

a. General. Policies involved in control, operation, and maintenance of facilities, equipment, and installations; command responsibility; technical supervision required and agencies involved; responsibility for operational control.
b. Mission. Service to be provided by organic aviation units when made available for administrative movements, Air Force troop carrier units, and other aircraft in direct support; extent of operation.

## c. Functions.

(1) Scheduled and nonscheduled operations.
(2) Maintenance of equipment: responsibilities, procedures, facilities, inspections.
d. Operational Planning. Personnel, equipment, and supply requirements; capabilities and capacities; communication procedures.
e. Operations. Operational procedures and control; utilization of personnel, equipment, and facilities; priorities; coordination; documentation; records and reports; service to be given personnel and cargo; liaison established between aviation and user units.
f. Maintenance. Responsibilities and procedures for maintenance, regulations, reports, and records.
g. Supply. Responsibilities, authorized levels, procedures, and accounting methods for the Air Force.
h. Intelligence. Responsibility for collection, collation, evaluation, and dissemination of air transportation intelligence.
i. Security. Responsibilities, disaster and defense plans, and equipment and supply security.
j. Records and Reports. Responsibilities: technical, operational, personnel, and stock records and reports.
k. Training. Responsibilities: unit and technical training.

## 2-7. Weight and Balance Terms

a. Aircraft Balance Limits. The maximum forward and maximum aft permissible locations of the aircraft center of gravity expressed as station numbers or as percentages of the mean aerodynamic chord (MAC). If these limits are exceeded, the aircraft will have unsatisfactory flight characteristics.
b. Center of Gravity (CG). The point about which an object would balance if supported at that point or the point at which the weight of an object or group of objects can be considered concentrated.
c. Reference Datum Line ( $R D L$ ). An imagi-
nary vertical line at or near the nose of the aircraft from which all horizontal distances are measured. Aircraft diagrams show this line as structural station zero.
d. Station Number. A number, generally marked on the interior of an aircraft, indicating a plane extending across the fuselage of the aircraft parallel to the reference datum line and representing the distance from it in inches.
e. Arm. The horizontal distance in inches from the reference datum line to the center of gravity of an object.
$f$. Moment. The product of the weight of an item multiplied by its arm. Moment may be expressed in pound-inches; for example, 2 pounds (weight) $\times 10$ inches (arm) $=20$ pound-inches (moment).
g. Allowable Cabin Load-Allowable Cargo Load. The load, of either passengers or cargo, which an aircraft is considered capable of airlifting safely over a given route under prescribed conditions. Expressed in terms of weight.
h. Basic Weight. The empty weight of an aircraft in its basic configuration, including all appointments, integral equipment, instrumentation, and trapped fuel and oil, but excluding passengers, cargo, crew, and fuel and oil.
i. Operating Weight. Basic weight of the aircraft plus minimum crew but excluding fuel and cargo.
j. Ready-for-Loading Weight. Total aircraft, crew, oil, and fuel weight; or the gross weight less cargo; or the basic weight plus crew, oil, and fuel.
k. Maximum Allowable Gross Weight.•The maximum allowed total weight of the aircraft prior to takeoff; the "basic weight" of the aircraft plus the crew, personnel equipment, special devices, passengers/cargo, and usable fuel and oil. This is limited by structure, power available, or landing load.
l. Maximum (Alternate) Gross Weight. A gross weight in excess of the design gross weight. The maximum alternate gross weight
is normally used in combat operations, but does not afford any margin of safety.

## 2-8. Calculating Safe Placement of Aircraft Loads

$a$. The general rules for determining the placement of a given load so as to cause the center of gravity of the aircraft to fall within safe limits are as follows:
(1) From the aircraft diagram in the TM 10 -series, determine the reference datum line.
(2) Determine the center of gravity of each item involved in the loading. This will be required for computations in (7) below. Calculate the moment for each item.
(3) Select from design data the desirable center of gravity at which the loaded aircraft should balance.
(4) Compute the desired load moment (the ready-for-loading weight of the aircraft and its load multiplied by the distance between the desirable center of gravity and the reference datum line).
(5) Subtract the moment of the ready-forloading aircraft from the moment of the loaded aircraft.
(6) Obtain the arm (station number) at which to place the load in the aircraft, by dividing the weight of the load into the difference between the gross moment and the ready-for-loading moment.
(7) The arm thus obtained will apply to the point at which the load is concentrated. It must be borne in mind that for multiple-piece loads the moment which applies to the point of load concentration is equal to the sum of the moments for each piece.
Example: The entire load consists of three trucks. Determine center of gravity of each vehicle. Calculate the moment of entire load by accomplishing the following:

Multiply the fuselage station number where
the center of gravity of each vehicle is positioned by the weight of the vehicle. Add these three figures to obtain the total moment in pound-inches.

$$
\begin{aligned}
& \text { Weight } \times \text { distance }=\text { moment (pound-inches) } \\
& \text { Vehicle No. } 1=17,660 \times 627=11,072,820 \\
& \text { Vehicle No. } 2=18,000 \times 992.1=17,857,800 \\
& \text { Vehicle No. } 3=16,000 \times 1157=18,512,000 \\
& \text { Total load moment }=47,442,620
\end{aligned}
$$

Add the weights of the three vehicles to obtain the total load weight.

$$
\begin{aligned}
\text { Vehicle No. } 1 & =17,660 \text { pounds } \\
\text { Vehicle No. } 2 & =18,000 \text { pounds } \\
\text { Vehicle No. } 3 & =16,000 \text { pounds } \\
\text { Total load weight } & =51,660 \text { pounds }
\end{aligned}
$$

Divide the total load moment by the total load weight to obtain the fuselage station number at which the center of gravity of the total load is located.

$$
\frac{47,442,620}{51,660}=\text { Fuselage station No. } 918.4
$$

The total load center of gravity should be as close as possible to the desirable center of gravity of the aircraft. To determine vehicle center of gravity, see paragraph 3-53.
(8) Verify that the load will fit into the aircraft at the desired station.
b. For accurate weight and balance determination, see the -10 manual of the TM 55series for the appropriate Army aircraft and the -5 and -9 technical orders for the appropriate Air Force aircraft.

## 2-9. Air Movement Designator

This combination of code letters and numbers is assigned by the issuing agency to identify and indicate precedence of traffic movement within each service's allocation (AR 59-8 and para 7-20). Each air movement designator consists of code symbols in sequence as shown in the following example and as explained below.


## Type of Traffic

a. SUU-Indicates the MAC airport of origin of the traffic; in this example, "Travis AFB."
b. TAW-Indicates the MAC airport of destination of the traffic; in this example, "Tachikawa."
c. 3-Indicates the priority assigned to the traffic movement; in this example, "Priority 3 " (para 2-10).
d. $E L$-Indicates the type of traffic (i.e., whether passenger or cargo moved; in this example, "Passenger-Emergency leave").
e. 5671-Indicates the traffic movement serial number assigned by the issuing agency; in this example, "Movement No. 5671." (These numbers are issued consecutively, from 0001 through 9999, after which the issuing agency begins again with 0001.)
$f$. GF-Indicates the sponsoring department in whose interest the traffic is being moved; in this example, "The Department of the Army."
g. 6-Indicates the month in which the traffic is to be moved; in this example, "June."

## 2-10. Cargo Priorities

MILSTAMP Transportation
MILSTRIP Laste Priority Designator
1 through 3
4 through 8
9 through 15
16 through 20

## 2-11. Restraint

a. Restraint Safety Factor (RSF). A numerical factor developed by the designer of a particular aircraft. The restraint safety factor multiplied by the weight of the cargo gives the total thrust or force that must be compensated for or restrained against in an aircraft.
b. Cargo Tiedown Fitting Pattern. The location and spacing of the cargo tiedown fittings in the floor, ceiling, or walls of an aircraft.
c. Rated Strength. The safe load capacity of a cargo tiedown device with an applied safety factor.
d. Effective Angle. Angle of tiedowns used
to secure cargo to prevent movement in multiple directions.
e. Restraint Device. Straps, cable, or chains used to apply the required restraint to cargo and generally referred to as tiedown devices. (Rope may be used only when special devices are not available.)
f. General Cargo. Any cargo other than ammunition, vehicles, or personnel.
g. Tensile Strength. The greatest longitudinal stress a substance can bear without wearing apart.

## 2-12. Computing Required Restraint

a. Restraint Safety Factors. The restraint safety factor (RSF) is a numerical factor established by the designer of an aircraft. The RSF is sometimes expressed in G's acting on a given load. One $G$ is equal to the force of gravity. This factor multiplied by the weight of the cargo gives the amount of thrust which must be offset with tiedowns. For example, when a C-97 stops abruptly, tiedowns must withstand a forward thrust equal to four times the weight of the cargo. Accordingly, a 1,000pound load requires 4,000 pounds restraint to withstand forward thrust. Restraint safety factors are determined by certain characteristics of the aircraft-acceleration during takeoff, stability during flight, deceleration during landing, and the type of landing field for which it is designed. Aircraft with a greater forward thrust factor require a greater forward RSF. For instance, the C-123 has more of a forward thrust factor than the C- 97 because it can stop in a very short distance on relatively unimproved fields.
b. Rated Strength of Tiedown Devices. The rated strength (RS) and characteristics of the common type of tiedown devices must be known to determine the kind of device needed. The rated strength includes an applied safety factor. Figure 2-30 illustrates these devices. Appropriate types of tiedown fittings with the highest rated strength should be selected, thereby providing the needed restraint with the least number of fittings.
c. Types of Tiedown Devices.
(1) A-1A-An 18 -foot length of cotton


Figure 2-30. Types of tiedown devices.
webbing with two metal hooks, one stationary and one movable, and a quick-release adapter. It has a 1.250 -pound rated strength and is used for lashing general cargo. Although still in use, this device is gradually being phased out.
(2) $B-1$ - A length of cable with a snap fastener on one end and a quick-release and tightening assembly on the other. It has a 5,000 -pound rated strength and is used for general cargo and light vehicles and equipment.
(3) C-2-A length of chain with an Lshaped hook at one end and a detachable quickrelease jaw and tightening machanism at the other end. It has a 10,000 -pound rated strength and is used for all vehicles.
(4) $D-1-A$ steel chain with a hook at one end and a detachable jaw and turnbuckle fitting at the other. It has a 25,000 -pound rated strength and is used primarily on heavy vehicles.
(5) MB-1-Similar to the C-2 but with a hook which is engaged with the tiedown fitting in place of the jaws on the C-2. It is used with the same chain as the $\mathrm{C}-2$. It has a 10,000 -pound rated strength.
(6) MB-2-Similar to the D-1. It has a heavy hook that is engaged with the tiedown fitting and is used with the same hooked chain as the D-1 except that is has a quick-release device. It has a 25,000 -pound rated strength.
(7) $M C-1-A$ nylon web strap with two metal hooks, one stationary and one movable. It is similar in appearance to the A-1A and has a 5,000 -pound rated strength.
(8) Manila rope-Usually an 18 -foot length of $1 / 2$-inch manila hemp rope with a rated strength of 2,000 pounds.

## 2-13. Angle of Tie

The effectiveness of a tiedown device is determined not only by its rated strength, but also by the angle at which it is used. This element is the angle of tie. The four basic angles of tie are $45^{\circ}, 45^{\circ} \times 45^{\circ}, 30^{\circ}$, and $30^{\circ} \times 30^{\circ}$. Since the $30^{\circ}$ angles are most effective against forward thrust, they are used whenever possible. Arrangement of tiedown fittings may make it necessary to use $45^{\circ}$ angles. Figure 2-31 illustrates these four angles of tie and summarizes their effectiveness.
a. Straight $45^{\circ}$ Angle. Tiedowns secured at angles of $45^{\circ}$ with the cargo floor and in the direction of expected thrust have a holding strength of approximately 70 percent against forward, rearward, and vertical thrusts, but give no protection against sideward thrust. This angle is used for general cargo. When computing straight $45^{\circ}$ angles of tie, it is nec-
essary to compute only for forward and sideward thrusts since each tiedown passes over the top of the cargo and attaches to a floor fitting. Since straight $45^{\circ}$ ties need not be used in pairs, decimals are rounded off to the next higher number.
b. $45^{\circ} \times 45^{\circ}$ Angle. By using tiedowns secured at a $45^{\circ}$ angle with the cargo floor and $45^{\circ}$ with the longitudinal axis of the cargo compartment, sideward protection is also obtained. Tiedowns at this angle are used for vehicles. The $45^{\circ} \times 45^{\circ}$ combination, however, reduces forward thrust protection to 50 percent but adds 50 percent sideward protection. The restraint against vertical thrusts remains at 70 percent. In this type of arrangement, only the tiedowns for forward and rearward thrusts need be computed, as tiedowns strong enough to protect against forward movement are strong enough for sideward and vertical thrusts. These tiedowns attach on one end to the cargo rather than passing over the top to attach to a floor fitting. In computing the $45^{\circ} \mathrm{x}$ $45^{\circ}$ combination, pairs must always be used, so decimals are rounded off to the next higher even number.
c. Straight $30^{\circ}$ Angle. Tiedowns at $30^{\circ}$ angles with the cargo floor and in the direction of expected thrust exert a strength of 87 percent against forward and rearward thrusts, 0 percent against sideward thrust, and 50 percent against vertical thrust. Each tiedown at this angle, like the straight $45^{\circ}$, passes over the top and is used for restraining general cargo. To figure straight $30^{\circ}$ angles of tie, compute for forward and sideward restraint and round off the decimals to the next higher number.
d. $30^{\circ} \times 30^{\circ}$ Angle. Tiedowns secured at a $30^{\circ}$ angle with the cargo floor and $30^{\circ}$ with the longitudinal axis of the cargo compartment hold approximately 75 percent of their rated strength against forward and rearward thrust, 50 percent against vertical thrust, and 43 percent against sideward thrust. This angle of tie is used for vehicles. Tiedowns computed at $30^{\circ}$ $\times 30^{\circ}$ angles need only be computed for forward and rearward thrust, as tiedowns strong enough for this protection are strong enough to secure against sideward and vertical thrusts.


Figure 2-31. Tiedowns at $45^{\circ}$ and $30^{\circ}$ angles.

These tiedowns attach to the cargo the same as the $45^{\circ} \times 45^{\circ}$ angle. Because $30^{\circ} \times 30^{\circ}$ combinations are always used in pairs, decimals must be rounded off to the next higher even number.

## 2-14. Strength and Location of Tiedown Fittings

a. As a chain is only as strong as its weakest link, so is a tiedown device only as strong as the fitting to which it is attached. For example,
a 10,000 -pound tiedown device tied to a $40,000-$ pound fitting has a-holding strength of only 5,000 pounds.
b. To determine the number of fittings needed, divide the required number of devices by the number of devices one fitting can sustain.

Example:
$-\frac{48 \text { devices required }}{2 \text { devices per fitting }}=24$ fittings required.
c. For both forward and rearward restraint, devices should be attached in a regular pattern by using corresponding points of attachment on opposite sides of the equipment and corresponding tiedown fittings on each side of the cargo 'floor centerline.

## 2-1.5. Computing Number of Tiedowns Required

a. Two elements used for computing the exact number of tiedowns required in a given situation are-(1) force to be secured, and (2) effectiveness holding strength of one device. The first is the product of the cargo weight and restraint safety factors. The second is the product of the rated strength of the tiedown device and the angle of tie. The first element divided by the second makes up the formula for computing the number of tiedowns required in any situation.

b. Specific working formulas for each angle of tie are as follows:
(1) Straight $45^{\circ}$ angle of tie (forward and sideward)

Cargo weight
$\frac{x \text { restraint safety factor }}{\text { Tiedown rated strength } \times 70 \%}=$ Number of tiedowns
(2) $45^{\circ} \times 45^{\circ}$ angle of tie (forward and rearward)

$\frac{$|  Cargo weight  |
| :---: |
|  restraint safety factor  |}{Tiedown rated strength$\times 50 \%$}$=$ Number of tiedowns

(3) Straight $30^{\circ}$ angle of tie (forward and sideward)
$\frac{\begin{array}{c}\text { Cargo weight } \\ \text { x restraint safety factor }\end{array}}{\text { Tiedown rated strength } \times 87 \%}=$ Number of tiedowns
(4) $30^{\circ} \times 30^{\circ}$ angle of tie
(forward and rearword) $=$ number of tiedowns
Example: C-130 aircraft
$3 / 4$-ton truck (5,687 pounds) plus cargo (2,000 pounds)
10,000 pound devices
$30^{\circ} \times 30^{\circ}$ angle of tie


## 2-16. Typical Loads

See TM 57-210 or TM 1-series ( -9 Loading Instruction) for the applicable aircraft for typical loads.

## 2-17. Standard Parachutes and Carrying Capacities

| Parachute | Diameter (ft) | Maximum load capability (lb) |
| :---: | :---: | :---: |
| G-12D | 64 | 2,200 |
| G-13 | 24.25 | 500 |
| G-11A | 100 | 3,500 |
| T-7A | 28 | 300 |

## 2-18. Aerial Delivery Containers and Typical Loads

| Container | $\begin{gathered} .4 \text { verage saje } \\ \text { load }(l b) \end{gathered}$ | Typical load |
| :---: | :---: | :---: |
| A-7A | 500 | Packaged nonfragile supplies |
| A-21 | 500 | Fragile and nonfragile supplies |
| A-22 | 2,200 | Fragile and nonfragile supplies |
| A-22 (G-12D) | 750 | Fragile and nonfragile supplies |

## 2-19. Loading or Unloading Time for Army Aircraft

a. Rotary-Wing Aircraft.
(1) Troops- 3 minutes.
(2) Casualties- 10 minutes.
(3) Cargo, in fuselage- 5 to 25 minutes, depending on the type cargo and aircraft.
(4) Cargo, external load- 30 seconds.
(5) Refueling-
(a) Observation ( $\mathrm{OH}-13$ and $\mathrm{OH}-23$ ) -7 minutes.
(b) Utility (UH-19 and UH-1)-10 minutes.
(c) Light transport (CH-21 and CH34) - 15 minutes.
(d) Medium transport (CH-37 and CH-47)-20 minutes.
b. Fixed-Wing Aircraft.
(1) Troops-approximately 2 to $3 \mathrm{~min}-$ utes, depending on aircraft.
(2) Casualties- 10 minutes.
(3) Cargo, in fuselage-
(a) Load- 10 to 30 minutes, depending on cargo.
(b) Unload-5 to 15 minutes.
(4) Cargo, external load-
(a) Load- 10 minutes.
(b) Air-landed- 10 minutes.
(c) Parachute- 30 seconds.
(d) Free fall.
(5) Refueling-
(a) Observation, light (0-1)-5 minutes.
(b) Utility (U-6)-8 minutes.
(c) Transport (U-1A) - 15 minutes.
(d) Staff transport (U-8)-10 minutes.

## 2-20. Maximum Ground Times for Air Force Aircraft

The following information may be used for general planning purposes:
a. Cargo Flights. Ground time at point of origin is 3 hours; 2 hours is time at en route bases. At destination bases where only off-loading is done, 2.5 hours is ground time.
b. Passenger Flights. Aircraft have maximum ground times of 2.5 hours at on-load bases and 3 hours at destination bases for off-loading and reloading.

## 2-21. Aircraft Landing Sites

See FM 57-35, FM $1-100$, TM 5-330 and TM 5-366.

## 2-22. Estimating Army Aircraft Movement Capability

a. General. To assess capability to move personnel and supplies by Army aircraft, the analyst must consider the various factors involved. Some or all of the factors will apply to a particular problem. Factors involved and methods of making capability estimates are given in $b$ and $c$ below.
b. Factors Involved. Depending upon the nature of a particular mission, the analyst must consider the following:
(1) Type and number of aircraft involved. (2) Loading.
(a) Weight of cargo and lift capability (payload) of aircraft.
(b) Configuration of cargo in relation to size of cargo compartment and cargo compartment doors.
(c) Sling loads for helicopters.
(d) Wing loads for fixed-wing aircraft.
(3) Hours of daily operation (flying hours).
(a) Helicopters-4.
(b) Fixed-wing aircraft-6.
(4) Daily round trips per aircraft. This is obtained by dividing daily flying hours by the product of the round-trip distance divided by flying speed plus pattern time.
(5) Availability. Availability is affected by the adequacy and efficiency of maintenance and supply and by the relative location of operating and service units. The average availability of aircraft on hand for sustained and short-term operations is shown below.

|  | Sustained (percent) | Short-term (percent) |
| :---: | :---: | :---: |
| Fixed-wing aircraft | 75 | 90 |
| Helicopters | 67 | 90 |

(6) Aircraft requirement. The number of aircraft sorties required to accomplish a mission is determined by two factors-the basic requirement and the type of operation.
(a) Basic requirement. The number of aircraft needed to meet the basic requirement is obtained by dividing the total tonnage to be moved by the payload of one aircraft of the type to be used in the operation.
(b) Type of operation. The basic aircraft requirement figure has to be adjusted according to the variable factors involved. The most common variable factors are-

1. Distance. Distance causes the fuel and payload relationship to vary inversely. When the operation exceeds 50 miles ( 80 kilometers), the basic aircraft requirement should be increased approximately 7 percent for each 20 -mile ( 32 -kilometer) increment.
2. Sustanied operation. In a sustained operation, the basic number of aircraft required should be increased by 50 percent.
3. Combat loading. A 10-percent increase of the basic requirement is necessary for combat loading.
4. Miscellaneous variables. As altitude and/or temperature increase, the aircraft
requirements will also increase because of a decrease in weight lifting capability. Humidity and other weather conditions also affect the aircraft requirement. The analyst must determine the adjustments to be made because of these variables.
c. Making the Estimate. When estimating the aircraft requirement or the tons that can be moved daily by aircraft, use the formula below.
(1) Formula.

$$
A=B \times C \times D
$$

Where
$A=$ daily tonnage capability
$B=$ daily round trips flown per aircraft
$C=$ payload of one aircraft
$D=$ number of aircraft employed
(2) Movement by helicopter.
(a) Problem. What is the daily lift capacity of 25 helicopters in the communications zone where

## $4=$ operational hours

$90=$ average speed in miles in the hour (includes loading and unloading time)
$=144.8$ kilometers in the hour
$75=$ round trip distance in miles
$=120.7$ kilometers
$90=$ percent of aircraft available
$1.4=$ short tons of payload of reach aircraft
$0.9=$ availability of 90 percent
(b) Solution.
$B=\frac{4 \times 90 \mathrm{mih}}{75 \mathrm{miles}}$ or $\frac{4 \times 144.8 \mathrm{kmih}}{120.7 \text { killometers }}=\quad \begin{gathered}5 \text { round } \\ \text { trips } \\ \text { per } \\ \text { air- } \\ \text { craft }\end{gathered}$
$A=5 \times 1.4 \times 25 \times 0.9=157$ short tons per day
(3) Movement by fixed-wing aircraft.
(a) Problem. What is the sustained fixed-wing aircraft requirement to move 500 short tons of cargo per day a distance of 35 miles ( 56.3 kilometers) under combat conditions where
$1.1=$ multiplier for combat loading
$1.5=$ multiplier for sustained operations
$1.4=$ short tons of payload for each aircraft
$80=$ average speed in miles in the hour (includes loading and unloading time)
$=128.7$ kilometers in the hour
$6=$ operational hours per day

## 2-23. Strategic Airlift

This paragraph contains a monograph (fig. 2-32) which provides staff planners a rapid and accurate method for determining strategic airlift capability, requirements, and deployment times under sustained operations.
a. General. Although aircraft planning factors and related data are available in various Army and Air Force manuals, these factors are neither correlated nor assembled in such manner as to permit their ready application to strategic air transport problems that daily confront staff planners. This graph is designed to overcome this deficiency and, in addition, eleminates the many tedious computations required for determining airlift capability and deployment times as shown in the example of standard methodology below. To make full use of this graph, particular note should be made of the "Uses and Application" at the end of this section and the "Explanatory Notes" on the graph.
b. Standard Methodology. Determine the time required to deploy a unit with 3,330 personnel and 625 short tons (STON) of equipment/supplies from Okinawa to Saigon (distance of 1,816 nautical miles) with $50 \mathrm{C}-124$ aircraft.
(1) Compute monthly ton-mile outbound capability.

Step 1. Distance $\div$ speed $=$ flying time (FT) $x$ ton-mile (TM/hour capability $x$ No. of aircraft $=$ one-way lift capability

Example: $1,816 \div 190=9.6 \times 2,242 \times 50$ $=1,076,160 \mathrm{TM}$ one-way left capability

Step 2. Monthly utilization rate (FT/ day $\times 30$ ) $\div$ round $\operatorname{trip}$ FT (FT x 2 ) $=$ sorties/month x one-way lift capability $=$ monthly outbound capability in ton-miles.

Example: ( $8 \times 30$ ) $240 \div(9.6 \times 2) 19.2$ $=12.5 \times 1,076,160=13,452,000$ ton-miles monthly outbound capability
(2) Determine deployment time.

Step 1. Compute ton-mile requirement. Personnel $\div$ conversion factor $=$ short tons + STON equipment/supplies x distance $=$ tonmile requirement

Example: $3,330 \div 7=476+625=$ $1,101 \times 1,816=1,999416$ ton-mile requirement

Step 2. Ton-mile requirement $\div$ monthly outbound capability $=$ percent month x base month $=$ deployment time in days

Example: 1,999,416 $\div 13,452,000=.149$ x $30=$ approximately $41 / 2$ days deployment time. (See first example on graph)
c. Functions and Factors Employed for Graph.
(1) Aircraft payload. The payload (ACL -allowable cabin load) of a transport aircraft, in short tons, is obtained from the payloadrange curve for the aircraft. Since the payload reduces as the nonstop range increases, the longest nonstop distance (critical leg) of the route determines the maximum cargo payload for an entire route because effective strategic airlift operations assume the movement of a fixed load over all legs of a route. Since unit movement requirements include primarily outsize/vehicle (bulky or low density) cargo, average ACL's are provided for both bulk and outsize cargo.
(2) Aircraft speed. Speed in knots (nautical miles per hour) is used herein.
(3) Aircraft utilization rate. The above elements reflect basic characteristics of the aircraft and are relatively firm, whereas utilization rate, the planned flying hours per day/ month, is variable and affects airlift capability accordingly. For this graph, it was considered that airlift operations are conducted on a sustained basis based on a smooth flow of airlift resources and do not exceed the utilization rate shown below.
(4) Airlift capability. Airlift capability is the product of the above elements, payload times speed times utilization, and is expressed in ton-miles per hour or month as the case may be.
(5) Ton-mile requirement. Short tons passengers, equipment, and supplies to be moved times the distance to be moved.
d. Value of Functions and Factors Employed for Graph.
(1) Aircraft payload. (Average outsize/ vehicle capability used).

| Type | Outaide cargo $(A v g A C L)$ | Bulk cargo (Avg ACL) |
| :---: | :---: | :---: |
| C-124 | 11.8 short tons | 15.0 short tons |
| C-130 | 9.8 | 14.3 |

(2) Speed. (Nautical miles per hour)
C-124 190

C-130 ------------------- 270
(3) Utilization rate. (Flying hours per day)

(4) Ton-mile hour capability. (Outsize cargo payload times speed)
C-124
2,242
C-130
2,646
(5) Ton-mile requirement. (For both C124 and C-130 aircraft)
(a) Passenger conversion factor. troops $=1$ short ton (combined passenger and baggage weight of approximately 286 pounds). Use precomputed personnel short ton conversion chart (fig. 2-33).
(b) Equipment/supplies. Actual weight in short tons.
(c) Distances. Use table of approximate airline distances (fig. 2-34).
$e$. Uses and Application. The three main uses and examples of applicable factors are shown in $f$ through $h$ below.

## f. Use for Other Types of Aircraft.

(1) Conversion factors. (C-124 and C130 AIRCRAFT EQUIVALENTS (This graph can also be used if the airlift force contains other types of aircraft. By application of conversion factors, a given inventery of various types of military transport aircraft can be converted to either $\mathrm{C}-124$ or $\mathrm{C}-130$ "equivalents" and applied to the number of aircraft scale on the graph. These factors are as follows:

# STRATEGIC AIRLIFT - PACOM AREA 

 CAPABILITY - REQUIREMENTS - DEPLOYMENT TIMES| TON MILE REQUIREMENT/ CAPABILITY (OUTBOUND) (000's) | number of alrcraft |
| :---: | :---: |
| - ${ }^{-\infty}$ | ${ }^{10}$ |
| ${ }^{-\infty}$ | $\infty$ * |
| Ein deployment time |  |
| $\mathrm{E}_{-\infty}^{\infty}$ (days) | ${ }^{0}$ |
|  |  |
| $\mathrm{E}_{-10}$ C-124 |  |
| = |  |
| =-100 |  |
|  |  |
| $=^{-100}$ |  |
|  |  |
| $\mathrm{E}^{-500} 5$ |  |
|  |  |
|  |  |
| = $\times \mathrm{m}$ |  |
| = $\times 0$ |  |
|  |  |
|  |  |
| - ${ }^{-5000}$ |  |
| $E_{\text {Imax }}$ | $3-$ |
|  |  |
| Emm | , |




## PRECOMPUTED PASSENGER:SHORT TON CONVERSION CHART

| Number of Passengers | Number of Short Tons | Number of Passengers | Number of Short Tons | Number of Passengers | Number of Short Tons |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 7 | 1 | 252 | 36 | 497 | 71 |
| 14 | 2 | 259 | 37 | 504 | 72 |
| 21 | 3 | 266 | 38 | 511 | 73 |
| 28 | 4 | 273 | 39 | 518 | 74 |
| 35 | 5 | 280 | 40 | 525 | 75 |
| 42 | 6 | 287 | 41 | 532 | 76 |
| 49 | 7 | 294 | 42 | 539 | 77 |
| 56 | 8 | 301 | 43 | 546 | 78 |
| 63 | 9 | 308 | 44 | 553 | 79 |
| 70 | 10 | 315 | 45 | 560 | 80 |
| 77 | 11 | 322 | 46 | 567 | 81 |
| 84 | 12 | 329 | 47 | 574 | 82 |
| 91 | 13 | 336 | 48 | 581 | 83 |
| 98 | 14 | 343 | 49 | 588 | 84 |
| 105 | 15 | 350 | 50 | 595 | 85 |
| 112 | 16 | 357 | 51 | 602 | 86 |
| 119 | 17 | 364 | 52 | . 609 | 87 |
| 126 | 18 | 371 | 53 | 616 | 88 |
| 133 | 19 | 378 | 54 | 623 | 89 |
| 140 | 20 | 385 | 55 | 630 | 90 |
| 147 | 21 | 392 | 56 | 637 | 91 |
| 154 | 22 | 349 | 57 | 644 | 92 |
| 161 | 23 | 406 | 58 | 651 | 93 |
| 168 | 24 | 613 | 59 | 658 | 94 |
| 175 | 25 | 420 | 60 | 665 | 95 |
| 182 | 26 | 427 | 61 | 672 | 96 |
| 189 | 27 | 434 | 62 | 679 | 97 |
| 196 | 28 | 441 | 63 | 686 | 98 |
| 203 | 29 | 448 | 64 | 693 | 99 |
| 210 | 30 | 455 | 65 | 700 | 100 |
| 217 | 31 | 462 | 66 | 798 | 114 |
| 224 | 32 | 469 | 67 | 903 | 129 |
| 231 | 33 | 476 | 68 | 1001 | 143 |
| 238 | 34 | 483 | 69 | 2002 | 286 |
| 245 | 35 | 490 | 70 | 3003 | 429 |

NOTES: 1. Passengers and short tons are shown in multiples of 7 and 1. For ease in computation, fractions of these multiples $s$ hould be rounded off to the next highest multiple of 7 passengers or 1 short ton.
2. Use combinations of the above conversions for number of passengers not shown.
Figure 2-33. Precomputed personnel short ton conversion chart.

## nautical miles

| $\begin{array}{\|l\|} \hline \mathbf{R} \\ \mathbf{O} \\ \mathbf{U} \\ \mathbf{T} \\ \mathbf{E} \\ \mathbf{R} \\ \mathbf{E} \\ \mathbf{E} \\ \mathbf{N} \\ \mathbf{N} \\ \mathbf{O} \\ \hline \end{array}$ | AREN／AIPPIELD | 亝 <br> s <br> ； | $\begin{aligned} & \text { id } \\ & \stackrel{\rightharpoonup}{2} \\ & \underset{x}{2} \end{aligned}$ |  | 0 <br> 0 <br> 0 <br> 0 <br> 0 |  | $\begin{aligned} & \text { 谹 } \\ & \text { 星 } \\ & ? \end{aligned}$ |  |  | 咅 |  | 曷 <br> $\stackrel{3}{4}$ |  | 㽞 <br> 品 |  |  | 菏 <br> $\stackrel{3}{3}$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| （1） | U．s．－travis | 0 | 578 | 8461 （14） | $7469(14)$ | 6536（9） | $5461(18)$ | 2142 | 2852（ 7 ） | $5551(12)$ | 4273（ 8） | 6296（9） | 3289（ 7 ） | 6350（18） | 6891（18） | 7814 （14） | 6716（13） | 8144 （14） | 4151 （ 7 ） |
| （ 2） | Buda－McChoid |  | 0 | 8647 （14） | 7655 （14） | 6722（9） | 5647 （18） | 2328 | 3038（7） | 5737 （12） | 4459（8） | 6482 （ 9） | 3475（ 7） | 6536（18） | 7077（18） | 8000（14） | 6902 （13） | 8330（14） | 4337（ 7 ） |
| （4） |  |  |  | 0 | 2228（15） | 2887 （ 4） | 3000 （14） | 6319（18） | 5803（10） | 3310（14） | 4382（ 6） | 3138（13） | $5341(18)$ | 2463 （14） | 1570（17） | 725 （17） | $2200(14)$ | 317 | 4310（6） |
| （5） | －shanchar |  |  |  | 0 | 659 | 2008（14） | 5327 （18） | $4812(10)$ | $1718(16)$ | 3390（ 6 ） | 1515（13） | 4349（18） | 840（16） | 578 | 1503 | 474 | 1911（15） | 3318（ 6） |
| （6） | Gun |  |  |  |  |  | 1690 （13） | 433419 （12） | $4127(18)$ | 985 | ${ }_{13862}^{338(18)}$ | $\frac{466}{2131(9)}$ | 3247（9） | 440 | 1001（13） | $2162(4)$ | 371 | 2570（15） | 2750（9） |
| （7） | Habail－hicker |  |  |  |  |  |  | 0 | 710 | 3809 （12） | 1382 | 2131（ 9） | 2341（18） | 1250 | 1430 | $2353(14)$ | 1616 （13） | 2683 （14） | 1310 |
| （8） | Johnston island |  |  |  |  |  |  |  | \％ | 3409 （12） | 2131（ 8） | 4154（ 9） | 1147 | 4280（ 9） | 4749（6） | 5672（14） | 4646 （13） | $6002(14)$ | 2009 |
| （9） | JAPAN－TACHIMAKA |  |  |  |  |  |  |  | 0 | 3142 （18） | 1421 | 3887 （18） | 816 | 3576 （18） | 4233 （6） | $5156(14)$ | 4303 （13） | 5486 （14） | 1377 |
| （10） | KLAJALEIN 1SLand |  |  |  |  |  |  |  |  |  | 2401 （18） | 745 | 2262 | 871 | 1740 | 2663（14） | 1244 | 2993（14） | 1765 |
| （11） | KOREA－ximpo |  |  |  |  |  |  |  |  |  | 0 | 3146 （9） | 1667（18） | 2632（6） | 2812（6） | 3735 （14） | 2998 （13） | 4005 （14） | 636 |
| （12） | MIDUAY ISLand |  |  |  |  |  |  |  |  |  |  | 0 | 3007（9） | 675 | 1568 （13） | 2491 （14） | $1041(13)$ | $2821(14)$ | 2510（ 9） |
| （13） | OKINARA－RADEM |  |  |  |  |  |  |  |  |  |  |  | 0 | 3133（9） | $3771(6)$ | 4694 （14） | $3500(y)$ | 5024 （14） | 1031 |
| （14） | Philippine I．－Clask |  |  |  |  |  |  |  |  |  |  |  |  | 0 | 893 | 1816 （14） | 366 | 2146 （14） | 2199 |
| （15） | s．vietma－Saicon |  |  |  |  |  |  |  |  |  |  |  |  |  | 0 | 923 | 630 | 1253 | 2740（6） |
| （16） | TALWAN－TAIPEI |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0 | 1553（14） | 408 | 3663（ 6） |
| （17） | thailand－bangior |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0 | 1883（14） | 3370（6） |
| （18） | makr island |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0 | 3993（ 6） |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0 |


| $\begin{aligned} & \text { DISTANCE } \\ & \text { (NAUTCAL } \\ & \text { nILES) } \end{aligned}$ | AIECRAFT／SPEED IN KNOTS |  |  |  | distance （nautical mILES） | AlRCRAFT／SPRED IN ENOTS |  |  |  | Dlstance （hautical hiles） | A1RCRAPT／SPEED 1N ENOTS |  |  |  | distance （nautical mLeS） | AIRCRAPT／SPEED IN RNOTS |  |  |  | distance （nautical miles） | AIRCRAFT／SPEED IN RNOTS |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | C－124／200 |  | c－130／270 |  |  | C－124／200 |  | C－130／270 |  |  | C－124／200 |  | C－130／270 |  |  |  |  |  |  |  |  |  |  |  |
|  | HR | HiN | HR | kin |  | He |  |  |  | C－124／200 |  |  | C－130／270 | C－124／200 |  | C－130／270 |  |  |  |  |  |  |
| 200 | 1 | 00 | 0 | 45 | 1300 | 6 | 30 | 4 | 49 |  |  |  |  |  | MN | HR | MIN | $4{ }^{1}$ | MiN |  | HR | hin | HR | Min | HR | MIN |
| 300 | 1 | 30 | 1 | 07 | 1400 | 7 | 00 | 5 | 11 | 2600 | 13 | 00 | 8 | 54 |  | 4600 | 23 | 00 | 17 | 03 | 6800 | 34 | 00 | 25 | 11 |
| 400 | 2 | 00 | 1 | 29 | 1500 | 7 | 30 | 5 | 34 | 2800 | 14 | 00 |  |  |  | 480 | 24 | 00 | 17 | 47 | 7000 | 35 | 00 | 25 | 56 |
| 500 | 2 | 30 | 1 | 51 | 1600 | 8 | 00 |  | 56 |  |  |  |  |  | S000 | 25 | 00 | 18 | 32 | 7200 | 36 | 00 | 26 | 40 |
| 600 | 3 | 00 | 2 | 14 | 1700 | 8 | 30 |  |  |  | 15 | 00 | 11 | 07 | 5200 | 26 | 00 | 19 | 16 | 7400 | 37 | 00 | 27 | 25 |
| 700 | 3 | 30 | 2 | 36 | 1800 | 9 | 00 | 6 | 40 | 3400 | 17 |  | 12 |  | 5400 | 27 | 00 | 20 | 00 | 7600 | 38 | 00 | 28 | 09 |
| 800 | 4 | 00 | 2 | 58 | 1900 | 9 | 30 | 7 | 03 | 3600 | 18 |  |  |  |  | 28 | 00 | 20 | 45 | 7800 | 39 | 00 | 28 | 54 |
| 900 | 4 | 30 | 3 | 20 | 2000 | 10 | 00 | 7 | 25 | 3800 |  |  |  |  | 5800 | 29 | 00 | 21 | 29 | 8000 | 40 | 00 | 29 | 38 |
| 1000 | 5 | 00 | 3 | 43 | 2100 | 10 | 30 | 7 | 47 |  |  |  | 14 |  | 6000 | 30 | 00 | 22 | 14 | 8200 | 41 | 00 | 30 | 23 |
| 1100 | 5 | 30 | 4 | 05 | 2200 | 11 | 00 | 8 | 09 | 4200 | 21 |  | 14 |  | 6200 | 31 | 00 | 22 | 58 | 8400 | 42 | 00 | 31 | 07 |
| 1200 | 6 | 00 | 4 | 27 | 2300 | 11 | 30 | 8 | 34. | 4400 | 22 | 00 | 16 | 18 | 6400 | 32 | 00 | 23 | 43 | 8600 | 43 | 00 | 31 | 51 |
|  |  |  |  |  |  |  |  |  | 3. |  | 22 | 0 | 16 |  | 6600 | 33 | 00 | 24 | 27 | 8800 | 44 | 00 | 32 | 36 |

Figure 2－34．Table of approximate airline distances．

|  | Type of aircraft | Conversion C-124 equivalent | $\begin{gathered} \text { factors } \\ C 180 \\ \text { equivalent } \end{gathered}$ |
| :---: | :---: | :---: | :---: |
| C-124 |  | 1. | - |
| C-130 |  | - | 1. |
| C-133 |  | 3.25 | 2.76 |
| C-141 |  | 2.93 | 2.48 |
| C-97 |  | . 72 | . 61 |
| C-135 | (Bulk cargo only) | (1.01) | (.86) |
| C-121 | (Bulk cargo only) | (2.71) | (2.30) |

(2) Application of conversion factors. The number of $\mathrm{C}-124$ or $\mathrm{C}-130$ aircraft equivalents is derived by multiplying the number of given types of aircraft by applicable C124 or C-130 factors shown above. For example, conversion of an inventory to C-124 equivalents is as follows:

| Aircraft in inventory Type | Number | $\times \begin{gathered} \text { Conversion } \\ \text { factor } \end{gathered}$ | $=\frac{c-124}{C-124}$ |
| :---: | :---: | :---: | :---: |
| C-124 | 20 | 1. | 20 |
| C-97 | 10 | . 72 | 7 |
| C-133 | 4 | 3.25 | 13 |
| C-141 | 10 | 2.93 | 29 |
| Totals -- | $\overline{44}$ | -- | $\overline{69}$ |

## g. Use if Requirement is Bulk Cargo.

(1) Conversion factors. Aircraft payloads used in this graph were based on the outsize/ vehicle average ACL of the $\mathrm{C}-124$ and $\mathrm{C}-130$ aircraft. This graph can be used if the movement requirement consists of only bulk cargo by applying the following conversion factors to the answer derived from any of the given uses:

| Use (answer) | Conversion factors |  |
| :--- | :---: | :---: |
| C-124 scale | C-1so scalc |  |
| Deployment time | .79 | .69 |
| Ton-mile capability $-\ldots$ | 1.27 | 1.45 |
| No. of aircraft $-\ldots-\ldots$ | .79 | .69 |

(2) Application of conversion factors. The answer derived from use of the graph "as is" is merely multiplied by the conversion factors shown above to derive a new answer. This will reflect the increased capability if only bulk
cargo is to be moved. An example of the application of $\mathrm{C}-124$ conversion factors is shown below.

| Example | Outside cargo <br> answer | $\times$Conversion <br> factor |
| :--- | :---: | :---: | :---: |$=$| Bulk cargo |
| :---: |
| answer |

h. Use if Scale Values for Other Types of Aircraft Are Desired.
(1) Conversion factors. By application of conversion factors to the answer derived from any of the given uses, this graph can also be used if answers are desired for other type aircraft scale values. These factors are as follows:

| Usc (answer) | Graph acft scale value | C-133 | $\underset{\substack{\text { Conver } \\ C-141}}{ }$ | ${ }_{C-97}^{8 i o n} f a$ | $\begin{gathered} \text { ctors } \\ =-121^{\circ} \end{gathered}$ | C-1.95 ${ }^{\circ}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Deployment time and No. of aircraft |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | C-124 | . 31 | . 34 | 1.39 | . 99 | . 37 |
|  | C-130 | . 36 | . 41 | 1.64 | 1.17 | . 44 |
| Ton-mile |  |  |  |  |  |  |
| capability | C-124 | 3.24 | 2.93 | . 72 | 1.01 | 2.71 |
|  | C-130 | 2.76 | 2.48 | . 61 | . 86 | 2.30 |

${ }^{\text {BBulk cargo only. }}$
(2) Application of conversion factors. The answer derived from use of the graph "as is" is merely multiplied by the conversion factors shown above to derive a new answer. This will reflect the scale values of the type aircraft desired. For example, the C-141 conversion factors above, as applied to each example shown on the graph, is as follows:

| Example | $\begin{gathered} C-194 /-130 \\ \text { answer } \end{gathered}$ |  |  |
| :---: | :---: | :---: | :---: |
| Deployment |  |  |  |
| time | 4.5 days | . 34 | 1.53 days |
| Ton-mile |  |  |  |
| capability | 2,000,000 | 2.93 | 5,860,000 |
| No. of aircraft | 46 | . 41 | 19 |




[^0]:    manual supersedes FM 55-15, 31 December 1963.

[^1]:    Cargo weight
    $\frac{\times \text { restraint safety factor }}{\text { Tiedown rated strength } \times 70 \%}=$ Number of tiedowns
    (2) $45^{\circ} \times 45^{\circ}$ angle of tie (compute for forward and aft).
    $\begin{aligned} & \text { Cargo weight } \\ & \times \text { restraint safety factor } \\ & \text { Tiedown rated strength } \times 50 \%\end{aligned}=$ Number of tiedowns

[^2]:    *4 RSF may be used when passengers are not seated forward of cargo.
    $3 / 4$-ton truck ( 5,687 pounds) plus cargo ( 2,000 ) 10,000 -pound tiedown devices
    $30^{\circ} \times 30^{\circ}$ angle of tie
    $\frac{7,687 \text { pounds } \times 8 \mathrm{RSF}}{10,000 \text { pounds } \times .75}=\frac{61,496}{7,500}=\begin{gathered}8.19 \text { or } 10 \mathrm{de} \text { de- } \\ \text { vices for for- } \\ \text { ward restraint }\end{gathered}$
    $\frac{7,687 \text { pounds } \times 1.5 \mathrm{RSF}}{10,000 \text { pounds } \times .75}=\frac{11,530}{7,500}=1.53$ or 2 devices

[^3]:    a Top of hood is higber tban steering wheel.
    $b$ Use cube indicated under column headed "Top of side racks." Side racks are higher than steering wheel.

[^4]:    o Cubic capacity reduced 27.0 cubic feet for spare tire and carrier in cargo body.
    $p$ Cubic capacity reduced 6.9 cubic feet for curve of bow.
    $q$ Cubic capacity reduced 22.6 cubic feet for spare tire and cartier in cargo body.
    $r$ Cubic capacity reduced 7.0 cubic feet for curve of bow.
    8 Cubic capacity reduced 10.2 cubic feet for curve of bow.
    $t$ Use cube indicated under column beaded "Top of side racks." Side racks are higber tban steering wheel.
    $u$ Cubic capacity reduced 21.9 cubic feet for spare tire and carrier in cargo body.
    $v$ Cubic capacity reduced 7.5 cubic feet for curve of bow. $w$ Increased cube (because of top 4.5 inches of side panels being 46.0 inches wide).
    $x$ Cubic capacity reduced 4.6 cubic feet for wheel wells.
    $y$ Cubic capacity reduced 5.6 cubic feet for wbeel wells.
    $z$ Cubic capacity reduced 0.5 cubic feet for curve of bow.

[^5]:    *Distances shown are in miles (multiply by 1.609 to convert to kilometers). Average rate of march=14.2 mih=22.9 kmih. Ton-miles: Forward-2,861; Return150. Passenger-miles: Forward-0; Return-1,800.

[^6]:    ${ }^{1}$ If cargo includes explosives, include data required by local SOP and/or regulations.

[^7]:    ${ }^{2}$ Remarks should include statement of nature and quantity of all logistical support required.

[^8]:    1 Add 30 feet, or 10 yards, or 9 meters to each total stopping distance shown when determining actual gap to use between vebicles.
    2 Does not include buses. For this type of passenger-carrying vehicle, select figures from an applicable section in the remainder of the chart.

    - Rule-of-thumb method for determining the gap between vehicles in a convoy may be used for speeds marked with an asterisk.

[^9]:    (iritical points arc sclected pointa along the route used for reference in giving inatruction. Theae points include atart point, releaae point, sind othir wilnts ilong the route where interference with the movement may occur or where timing ia critical
    ${ }^{2} A$ minumint sirlil is an element or group of elements within a series and in this table hat a numerical deaignation for convenience in planning - licilulfar, ur cuntrol of movement.
    ${ }^{3}$ Inlunnilion whiflis cummon to two or more serials will be given in the beginning of the tablc, items $1-7$.

[^10]:    a Recommended for emergency use only ; no troop seats provided.
    $b$ Number of trips based on employment of unit in tactical situation (short turnaround times); for general troop movements, planner should plan on four trips per day.

[^11]:    ${ }_{b}^{n}$ Recommended for emergency uae only; no troop seats provided.
    Number of personnel per vehicle based on employment of unit in tactical situation; for general troop movements, planner should recompute using 16 troopa per vehicle.

[^12]:    *This figure may be a one-time lift or a day-to-day lift, depending upon the mission.

[^13]:    *The communications railway signal platoon will be transferred to TOE 55-226 under the H series TOE.

[^14]:    *These units are dependent upon adjacent or colocated units fcr organizational maintenance of assigned motor vehicles, and upon an adjacent or supporting personnel services unit for personnel administrative services.

[^15]:    ${ }^{1}$ To determine vehicle-carrying capacity of flatcars, use these three columns in conjunction with the information contained in chapter 3. Determine first the numher of vehicles hy type that will fit on the flatcar hed.
    

[^16]:    ${ }^{1}$ Specific gravity of a liquid should be checked before it is loaded to avoid exceeding weight capacity of car
    ${ }^{2}$ See paragraph 7-24 for liquid volume in partially filled tank cars.

[^17]:    ${ }^{1}$ When tiedown rods are found slightly loose while in transit, they need not be tightened.
    ${ }^{2}$ Place turret gun in straight forward position, and wire turret-lock handwheel and elevating-meshanism handwheel to prevent rotating.
    ${ }^{8}$ Handbrakes must not be set.
    4For loads superimposed above car floor, use method illustrated in figure 4-11.
    e. Tanks and Similar Units, 100,000 Pounds and Over (Fig 4-11). .1,2,3,4

[^18]:    ${ }^{1}$ Turret sun should be in straisht forward position; turret-lock handwheel and elevating mechantsm-handwheel must be wired to pre vent rotation.

    When tiedown rods are found slightly loose while in transit, they need not be tightened.
    ${ }^{8}$ Hand brakes must not be set.

    - See General AAR rules for further details.

[^19]:    Tunnels require spectal consideration. To repair (by timbering) a 60 -foot demolition at each end of a aingle-track tunnel ( 100 ft total per tunnel), allow 70 short tons or 87 measurement tons, and 3,000 man-hours. Estimate includes tees, raill, rastenings, turnouts, rracksaying tnd surfacing. It is assumed ballast is avallable at worksites.
    I Includes replacement of buildings 100 perrent, tiea 30 percent, rail and turnouts 85 percent.

[^20]:    Headquarters and headquarters company, transportation terminal
    command C.

    55-111 (Tentative)
    command C.

[^21]:    ${ }^{\text {a Range are eatimated as free running. }}$

[^22]:    ${ }^{1}$ Characteristics of U.S. Navy ships vary within each class. Exact data. detailed hold dimensions, and cargo carrying capacities will be found in individual "Ship's Loading Characteristics Pamphlets."
    ${ }^{2}$ The LSD is not a true landing ship in that it does not have beaching capabilities.

[^23]:    a Information not available.
    ${ }^{6}$ May vary because of propulsion design.
    c Combat equipped.
    d Safety factors permitting.

[^24]:    " Wlthout ring mount, reduclble to 7'6".
    b Draft calculated from tire bottoms.
    c Emergency.

    * Reducible to 18'8".
    - Formerly BARC.
    "Reduclble to 15 '4".
    * Armored amphibian assault personnel and cargo carrler.
    "Reduclble to 8'719".
    Armored amphiblan assault engineer vehlcle.
    J Blade wings folded.
    t Armored amphiblan recovery and maintenance vehicle.
    'Reduclble to $10^{\prime} 9^{\prime \prime}$.
    m Armored amphlbian assault vehlcle.
    n Reduclble to 10 '51/2".

[^25]:    a All data for planning purposes only. For exact data, see the individual ship's characteristics pamphlet.
    b Cargo space in square feet is for vehicle planning.
    c Maximum sustained speed and range.
    d Varies with vessel.

[^26]:    See footnotes at end of chart.

[^27]:    -See footnote at end of chart.

[^28]:    ${ }^{*}$ No. 4 hatch is not large enough for vehicle loading.

[^29]:    *All LCUs., Utility Landing Craft, were reclassified from "Service Craft" to "Boats" in Nov. 1958.

[^30]:    1 Great Lakes not included
    ${ }^{1}$ Mississippi River not included.
    ${ }^{3}$ Quantities in parentheses represent kilometers.

[^31]:    Bituminous coal and lignite, POL and POL products, limestone, sand, gravel,

[^32]:    *Safety factor of 4.

[^33]:    "If the type of iron in a chain ie unknown, a safe working load (in short tone) is figured my multiplying 8
    meter (in inches) of the metal etock on one side of any link. This applies only to chaine made of ferroue metals.

[^34]:    See footnote at end of table.

[^35]:    ${ }^{1}$ See FM $\overline{5}-\mathbf{5 0}$ for detailed planning information on overload, off-highway, maximum sustained, and other types of operations

[^36]:    ${ }^{1}$ Daily forward tonnage, assuming sustained operations, adequate road maintenance, and two-way traffic.
    ${ }^{2}$ The capacities of pipeline systems vary, depending on the size of pipe, gradient, location, and size of pumps, and type of construction. Welded commercial pipelines can be operated at much greater pressures than standard military lines which have flexible couplings. a Water terminal discharge rate of 1,440 STON per day required to adequately maintain 1 division slice. See also paragraph 5-22.

[^37]:    ${ }^{3}$ Includes weight of sled.
    ${ }^{2}$ Reduce 50 percent when load is doubled.

[^38]:    ${ }^{1}$ A plastic boat-type sled is also available and used extensively in northern areas. It weighs 38 pounds, is 88 inches long, 25 inches wide, and 8 inches deep, and has a 200 -pound capacity.

[^39]:    ${ }^{\text {a }}$ Based on mode of operation (moble versus stationary).
    ${ }^{0} \mathrm{High}$ and low power figures.

[^40]:    For explanation of footnote see end of chart.

[^41]:    1 Basic field ration of approximately 200 items, including such perishables as fresh and frozen meats, vegetables, and fruit. For use primarily under stable conditions and during static phases of military operations when there are normal cooking and refrigeration facilities. Should be issued in preference to any other type of ration whenever circumstances permit its use. Components, weight, and volume vary.
    ${ }^{2}$ Canned or dry items or staple items; for use whenever mess facilities and personnel are available and no perishable foods are issued. Components, weight, and volume vary. SB $10-495$ has information on its breakdown. Ration supplement, spice pack, consists of assorted spices, condiments, and leavening agents to supplement 1,000 operational rations $B$. The spice pack varies in weight and volume, being tailormade for different situations and scaled to the $B$ ration.
    ${ }^{3}$ Nonperishable precooked food whicb may be eaten hot when organized messing is impossible but feeding in amall groups is possible.

    - Nonperishable precooked food which may be eaten hot or cold, carried and prepared by the individual soldier. For use when tbe tactical situation is so unstable that messing in small groups is not possible and kitchen facilities are not available.
    ${ }^{5}$ For use in extremely cold climates by amall patrols or trail teams when resupply is impossible.
    ${ }^{8}$ Comfort items sucb as toilet articles, tobacco, and candy as a supplement to ration $B$, for issue before the establisbment of adequate sales facilities.

    TSpecial nourishment in the form of hot stimulating beverages for combat zone casualties at aid and clearing stations.
    ${ }^{8}$ For survival kits aboard aircraft operating over arctic regions, in the emergency kit forming a part of the ejection seat in combat aircraft, and in emergency kits for passengers aboard transport aircraft.

    - Palatable food of bigb caloric density carried in survival kits of aircraft operating over the tropics.

[^42]:    ${ }^{1}$ Refers to temporary storage of ammunition along roadways and in urban fields and forests, such as may be found in combat zones.

    2 Data based on the assumption that hardstand area will not be required for the total number of vehicles at any one time.

[^43]:    a If used as a field billet.
    Average for normal conditions.
    c Six equal sides of 105 inches each.
    Tent also ventilated by lifting sidewalls.
    Arched top.
    The two measurements shown are the longest dimensions, including vestibule (trapezoid measuring $120^{\prime \prime} \times 48^{\prime \prime} \times 89.5^{\prime \prime} \times 89.5^{\prime \prime}$ ).
    Liner does not cover vestibule.
    Liner weighs additional 155 pounds.
    Includes tent, liner, pins, and poles.
    Liner weighs additional 90 pounds and occupies a stored cubage of 8 cubic feet.

[^44]:    E Does not include vestibules at each end, which measure $48^{\prime \prime} \times 90^{\prime \prime}$.
    1 Bed patients on cots.
    m Height shown is for stack section. Service section is 108 inches high.
    a Ventilator screens on all gides of the service and stack sections, to be used as required.
    o Plus one large opening (120" $\times 120^{\prime \prime}$ ) in roof.
    p Tubular tunnel entrance, 24 inches long.
    a Either of the ventilator openings may be used as stovedipe openin $g$.
    r Dimensions shown for flys and paulins are length and width.

    - Screen has a 3 -foot overlap on one side for an entrance.
    $t$ Battom edge of screen normally 9 inches off ground.
    une for average company-size unit.

[^45]:    ${ }^{1}$ meter $=10$ decimeters $=100$ centimeters $=1,000$ millimeters.
    ${ }^{4 \rightarrow}$ A nautical mile is the length on the earth's surface of an arc aubtended by one minute of angle at the center of the earth. Therefore, the circumference of the earth is equivalent in nautical miles to the number of minutes in a circle ( $360 \times 60=21,600$ ).

[^46]:    See footnotes at end of table.

[^47]:    *Available at Army installation libraries.

[^48]:    ${ }^{1}$ For time and space definitions, see FM 55-35.

[^49]:    ${ }^{1}$ Critical points are selected points along the route used for reference in giving instruction. These points include start point, release point, and other points along the route where interference with the movement may occur or where timing is critical. ${ }_{\text {d }}^{4}$ A
    ${ }^{3}$ Information which is common to two or more serials will be given in the beginning of the table, items 1-7.

[^50]:    *For explanation of footnote see end of ample report.

[^51]:    ${ }^{2}$ If cargo includes explosives, include data required by local SOP and/or regulations.
    ${ }^{3}$ Remarks should include statement of nature and quantity of all logistical support required.

[^52]:    Based on vehicle availability $\times$ avg load per veh trip $\times$ round trips per veh per day.
    ${ }^{\text {b }}$ Based on vehicle availability $\times$ avg load per veh trip $\times$ avg daily distance capability.
    ${ }^{c}$ Tonnage figures not applicable.
    d Based on liquid POL weighing $6 \mathrm{lb}(2.7216 \mathrm{~kg})$ per gal.

[^53]:    ${ }^{1}$ Requires special authorization. Normally assigned to Ordnance special ammunition companies
    ${ }^{2}$ Equipment shown does not include all ground servicing equlpment.

[^54]:    - Basic capacity is based upon the assumptions that a 24 -foot surface width (two lanes) is used; a 12 -foot shoulder is on each side; there is straight and level alinement; surface and subsoil are in excellent condition; traffic control is provided; movements are sustained; and vehicles travel in both directions.

    D Operational capacity is approximately 80 percent of basie capacity.

    - Intervale increase as quality of surface decreases due primarily to the dust hazard.

[^55]:    a For pavement widths between 12 and 18 feet, consider $1 / 2$ the width over 12 feet as additional ahoulder width

    - For one-way movements on pavements more than 18 feet in width, the factor for half the actual pavement width will be selected, and will then be doubled to reflect the two lines of traffic that can effectively use pavements 18 feet or more in width.
    c Even though a road has three lanes, the capacity estimate should be based on two-lane traffic movement, thereby eliminating the inherent inefficiency and loss of capacity caused by three lanes of movement.

[^56]:    ${ }_{\infty}{ }^{2}$ Under frozen conditions, a maximum movement can be supported for the duration of the freeze.
    ${ }^{2}$ Sce note 2, table 3-5.

[^57]:    ${ }^{1}$ Add 30 feet, 10 gards, or 9 meters to each total stopping distance shown when determining actual gap to use between vehicles.
    ${ }^{1}$ Does not include buses. For this type of passenger-carrying vehicle, select figures from an applicable section in the remainder of the

[^58]:    ${ }^{6}$ To determine vehicle-carrying capacity of flatcars, use these three columns in conjunction with the information contained in paragraph 3.2 . Determine first the number of vehicles by type that will fit on the flatear bed. Then check their combined weights (including any cargo in the vehicles) against the weight capacity of the car. Either the platform tanks, where the total loaded weight is resting on the outer tanks, where the total loaded weight is resting on the outer edge of the car deck

[^59]:    ${ }^{1}$ Specific gravity of a liquid should be checked before it is loaded to avoid exceeding weight capacity of car
    a See paragraph 7-24 for liquid volume in partially filled tank cars.

[^60]:    a Ice capacity, 4 tons.
    Ice capacity, 5 tons.
    c 8,000 gallons.
    d 10,000 gallons

    - Diameter.

[^61]:    ${ }^{\text {a }}$ Height of flatcars is determined by height of stanchion
    b4,356 U. S. gallons.
    c 14,266 U. S. gallons

[^62]:    ${ }^{a}$ Estimated
    b 9.620 U. S. gallons.

[^63]:    12 See notes at end of $a$ below.

[^64]:    ${ }^{1}$ Tunnels require special consideration. To repair (by timbering) a 50 -foot demolition at each end of a single-track tunnel ( 100 ft total per tunnel), allow 70 tons, 87 measurement tons, and 3,000 man-hours.
    ${ }^{2}$ Estimate includes ties, rails, fastenings, turnouts, tracklaying and surfacing. It assumes ballast is available at worksites.
    ${ }^{3}$ Includes replacement of buildings 100 percent, ties 30 percent, rail and turnouts 85 percent.

[^65]:    Headquarters and headquarters company, transportation brigade.

[^66]:    *See TOE 55-500 for additional teams.

