## TRANSPORTATION REFERENCE DATA

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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 when unit or staff libraries are not readily available.
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 general usefulness are included.

### 1.2 Application

The material presented herein is applicable to nuclear and non-nuclear 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.

## AIR

## Section I. ORGANIZATION

### 2.1 Organization

Unit

| Headquarters and headquarters |
| :---: |
| detachment, transportation |

transport aircraft battalion.
Transportation light helicopter company.

Transportation medium helicopter company.

Transportation medium airplane company.

Headquarters and headquarters detachment, transportation aircraft maintenance and supply battalion.

Transportation aircraft direct support company.

Transportation Army aircraft - heavy maintenance and supply company.

Transportation transport aircraft direct support company.

Transportation light transport
helicopter direct support

## Misaion and/or capability

To provide command control, staff planning, and administrative supervision for 2 to 7 transport aircraft companies.
To expedite combat operations by providing direct tactical and logistical air transport support to combat units.
To provide air transport to expedite tactical operations and logistical support in the combat zone. At maximum, it can move 48 tons of cargo or 368 troops within 100 mile radius in 1 lift.
To provide logistical airlift for movement of supplies and personnel in the combat zone and, as directed, to provide tactical airlift of combat units and air resupply of units engaged in combat operations.
To provide command control, staff planning and administrative supervision of assigned or attached transportation aircraft direct support companies, transportation transport aircraft support companies, transportation aircraft general support companies, and transportation aircraft maintenance teams.
To provide backup third-echelon aircraft maintenance and supply and recovery support to divisional aviation units, and to provide direct third echelon maintenance and supply support to nondivisional aircraft units, other than transport aircraft units, in corps and army.
To provide heavy-maintenance and supply support for Army aircraft in a field army.

To provide third-echelon field maintenance and supply and recovery support for light transport airplanes and medium transport helicopters assigned a transport aircraft battalion.
To provide third-echelon field maintenance and supply and recovery

## Assignment

To a field army.

To a field army, normally 3 per transport aircraft battalion.

To a field army, normally 1 per transport aircraft battalion.

To a field army, normally attached to headquarters and headquarters detachment, transportation battalion (TOE 5556).

To a field army or communications zone, normally 1 per 3-7 aircraft maintenance and supply companies.

Normally to a corps or field army, in sufficient number to provide the direct support mission.

Normally to a field army, in sufficient number to provide the general support mission.
To a field army, normally attached to unit under TOE 55-456.

To a field army, normally attached to unit under
support for light transport helicopters assigned to a transport aircraft battalion.

## ROCID:

## ROAD:

Transportation aircraft mainte-
nance company, armored, infantry, or mechanized division maintenance battalion.

| Transportation aircraft mainte- | 55-99 |
| :--- | :---: |
| nance company, airborne |  |
| division maintenance battal- |  |
| ion. |  |
| Transportation helicopter teams | $55-500$ |
| and aircraft field maintenance | and |
| teams.* | $55-510$ |

Transportation aircraft maintenance company, airborne ion.
Transportation helicopter teams teams.*

Transportation aircraft Mainte-
nance detachment (infantry or armored division).

To provide a third-echelon aircraft maintenance capability as an integral part of the infantry or armored division.

To provide third-echelon aircraft capability as an integral part of the support command of the armored, mechanized, or infantry division.

To provide third-echelon aircraft maintenance capability as an integral part of the support command of the airborne division.
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

TOE 55-456. May operate separately providing third-echelon maintenance support to 3 light transport helicopter companies or equivalent.

Organic to the division and attached to the infantry or armored division aviation company (1 per division).

Organic to the infantry division maintenance battalion (TOE 29-15), mechanized division maintenance battalion (TOE 29-25), or armored division maintenance (TOE 29-35).
Organic to airborne division maintenance battalion (TOE 29-55).

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.

- See TOE's 55-500 and 55-510 for additional teams.


## 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 and maintenance personnel, the effects of cargo loading and fuel burn-off on the center of gravity (CG) of the aircraft, mechanical condition of the aircraft, condition of runways, approaches to airfields, and navigation aids available for instrument approaches and landings during bad-weather 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.
b. Variables Affecting Performance. Some of the common variables affecting the performance standards of aircraft are discussed below.
(1) Air density and temperature. The ability of the aircraft to lift weight is directly proportional to the density of the air mass in which it is operating; the density of the air mass is affected by, and is inversely proportional to, the temperature, humidity, and altitude above sea level. For example, the CV-2 (Caribou), weighing 26,000 pounds and operating from a point at sea level where the temperature is $59^{\circ}$ F. ( $15^{\circ} \mathrm{C}$.), requires 1,100 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 2,500
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 payload 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 $59^{\circ} \mathrm{F}$. ( $15^{\circ}$ C.) temperature.
(3) Wind. Surface wind affects both fixedwing and rotary-wing aircraft. In computations in this manual, the surfacewind 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-1 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 further than it can at its maximum speed. The tables and graphs in this chapter are based on normal cruise speed (the speed at which an aircraft is usually operated and which does not cause undue strain on the engine or excessive fuel consumption). For example, the CV-2 at its heaviest weight can fly at 5,000 feet using a horsepower range between 300 and 1,200 from each engine. The tables for this aircraft were computed at 600 horsepower for each engine, as this is the best compromise for good speed with minimum engine wear and fuel consumption. 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. Since there are no pressurized Army aircraft, oxygen supplies are needed for flights at altitudes over 10,000 feet. 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 cannot normally be flown in IFR weather. Of the Army IFR aircraft, only three (U-8, CV-2, and OV-1) have all-weather capability. These are equipped with anti-icing and deicing equipment in addition to other equipment for IFR conditions. However, the availability of allweather 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 below will be added to the inventory.

## (1) Engine types.

(a) Turbo-jet. 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) Turbo-shaft. This engine is a doubleturbine 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) Turbo-prop. This engine is identical in principle to the turbo-shaft 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 singlebank 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 useable pressure prior to induction in to 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 are usually 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 horsepower 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.

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 constantspeed 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 (CG). 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 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 imiginary location in front of the aircraft is set by the designers 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 30 minutes for VFR flights. For IFR flights, the fuel reserve upon arrival at intended destination permits flying to an alternate airport, plus 45 minutes' flight at crusing power.
5. Fuel allowances is 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 run-up, taxi, takeoff, and climb-out.

## e. Considerations Peculiar to Helicopters.

(1) "In-ground effect" 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 lift-off (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 lowlevel 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 autorotational 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


Figure 2.1. $O H-13 H$ (Sioux).


Figure 2.2. UH-19D (Chickasaw).
weight (or a combination 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 55-450series, and FM 101-10.


Figure 2.3. CH-21C (Shawnee).


Figure 2.4. OH-23D (Raven).


Figure 2.5. $\mathrm{CH}-34 \mathrm{C}$ (Choctaw).


Figure 2.6. $\quad \mathrm{CH}-37 \mathrm{~B}$ (Mojave).


Figure 2.7. UH-1B (Iroquois).


Figure 2.8. CH-47A (Chinook).


Figure 2.9. U-6A (Beaver).


Figure 2.10. $\quad U-8 D$ (Seminole).



Figure 2.12. CV-2A (Caribou).


Figure 2.13. $\quad 0-1 E$ (Bird Dog).

Figure 2.14. OV-1A (Mohawk).

Use operational data shown below as a planning guide only. Variations in weather, altitude, humidity, and other conditions will cause the values to vary.
a. Crew, Passengers, and Critical Dimensions.


| tions (in.) Cargo space (max) (cuft) | $\left\lvert\, \begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}\right.$ | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\left\lvert\, \begin{aligned} & 51^{\prime \prime} \\ & 125 \end{aligned}\right.$ | $\left\lvert\, \begin{aligned} & 59^{\prime \prime} \\ & 286 \end{aligned}\right.$ | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\left\lvert\, \begin{aligned} & 74^{\prime \prime} \\ & 1,090 \end{aligned}\right.$ | $\left\lvert\, \begin{aligned} & \mathrm{NA} \\ & \mathrm{NA} \end{aligned}\right.$ | $\left\lvert\, \begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}\right.$ | $\left\lvert\, \begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}\right.$ | $\left\lvert\, \begin{aligned} & \mathrm{NA} \\ & \mathrm{NA} \end{aligned}\right.$ | $\left\lvert\, \begin{aligned} & 72^{\prime \prime} \\ & 300 \end{aligned}\right.$ | $\left\lvert\, \begin{aligned} & 48 \\ & 109\end{aligned}\right.$ | 48" 107 | $\left\lvert\, \begin{aligned} & 62^{\prime \prime} \\ & 422\end{aligned}\right.$ | 70" | $\left\lvert\, \begin{aligned} & 67 * \\ & 1.142\end{aligned}\right.$ | \| $78{ }^{\prime \prime}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

a Figures are from design data and are subject to change.
b Unit SOP may include crew chief in addition to crew shown.
c Seats shown are those in the passenger compartment of the aircraft.
ditter spaces shown may be used for ambulatory patients. When both litter and ambulatory spacas are shown, any combination of the total number may be used

- Cargo may be carried on litter racks in lieu of patients.
${ }^{\prime} 28^{\prime} 9^{\prime \prime}$ to forward edge of loading ramp; $32^{\prime \prime} 6^{\prime \prime}$ to aft edge of loading ramp
b. Range, Loading, Lashing, and Balance Factors.

|  | O-1E | OV-1A | U-6A | U-1A | U-8D | CV-2 | $\underset{13 \mathrm{G}}{\mathrm{OH}}$ | $\begin{aligned} & \mathrm{OH}- \\ & 13 \mathrm{H} \end{aligned}$ | $\begin{aligned} & \mathrm{OH}- \\ & 23 \mathrm{C} \end{aligned}$ | $\begin{aligned} & \mathrm{OH}- \\ & 23 \mathrm{D} \end{aligned}$ | $\begin{aligned} & \text { UH- } \\ & \text { 19D } \end{aligned}$ | UH-1A | UH-1B | CH-21C | CH-34C | CH-37B | CH-47A |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\text { Max range (ferry) }{ }^{\mathrm{a}} \text { : }$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 350 | 1,500 | 590 | 900 | 1,260 | 1,017 | 150 | 170 | 88 | 158 | 230 | 188 | 141 | 295 | 240 | 200 | 1.037 |
| Kilometers-.--...----.......-- | 648 | 2.780 | 1.095 | 1.670 | 2,330 | 1.880 | 278 | 315 | 163 | 293 | 426 | 348 | 261 | 547 | 445 | 370 | 1,920 |
| Max range with payload (full fuel) ${ }^{\text {a }}$ : <br> Nautical miles. | 350 | 400 | 575 | 720 | 980 | 850 | 145 | 170 | 77 | 135 | 185 |  | 126 | 255 | 195 | 180 | 200 |
| Kilometers -------------------------- | 648 | 742 | 1,065 | 1,335 | 1,815 | 1,575 | 1269 | 315 | 143 | 1250 | 1343 | 152 | 1234 | 473 | 1361 | 1834 | 370 |
| A verage cargo payload (lb) vs range ${ }^{\text {b }}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Nautical miles Kilometers |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 250463 | (c) | (c) | 1,135 | 1.960 | (c) | 5,100 |  |  |  |  |  |  |  |  |  |  |  |
| 300556 |  |  | 1.120 | 1,885 |  | 4.900 |  |  |  |  |  |  |  |  |  |  |  |
| $350 \quad 649$ |  |  | 1.105 | 1,810 |  | 4,675 |  |  |  |  |  |  |  |  |  |  |  |
| 400741 |  |  | 1.090 | 1.735 |  | 4.475 |  |  |  |  |  |  |  |  |  |  |  |
| $450 \quad 833$ |  |  | 1,075 | 1,660 |  | 4.275 |  |  |  |  |  |  |  |  |  |  |  |
| $500 \quad 926$ |  |  | 1.060 | 1,585 |  | 4,050 |  |  |  |  |  |  |  |  |  |  |  |
| 550 1,020 |  |  | 1.045 | 1,510 |  | 3.875 |  |  |  |  |  |  |  |  |  |  |  |
| 600 1,110 |  |  |  | 1.435 |  | 3,650 |  |  |  |  |  |  |  |  |  |  |  |
| 650 1,205 |  |  |  | 1,360 |  | 3.450 |  |  |  |  |  |  |  |  |  |  |  |
| 700 1,297 |  |  |  | 1,285 |  | 3,250 |  |  |  |  |  |  |  |  |  |  |  |
| 750 1,390 |  |  |  |  |  | 3, 025 |  |  |  |  |  |  |  |  |  |  |  |
| 800 1,482 |  |  |  |  |  | 2.800 |  |  |  |  |  |  |  |  |  |  |  |
| $850 \quad 1.575$ |  |  |  |  |  | 2,625 |  |  |  |  |  |  |  |  |  |  |  |
| $900 \quad 1.666$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 950 1,760 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| External cargo: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Maximum recommended exter- |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| nal load (lb)d. |  | 1,950 |  | NA | NA | NA | NA | NA | NA | NA | 1.000 | 2,500 | 2,200 | 3.000 | 4.000 | 10,000 | 16,000 |
|  | per |  | per |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | wing |  | wing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Rescue hoist capacity (lb).---- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 400 | NA | NA | 400 | 600 | 600 | 600 |
| Floor load capacity (psi): |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Distributed ${ }^{\text {I }}$ | NA | NA | 0.7 | $\begin{aligned} & 0.35- \\ & 1.05 \end{aligned}$ | NA | 13 | NA | NA | NA | NA | 0.327 |  | 1.04 | 0.9 | 1.4 | 2.08 | 1.4 |
| Concentrated--------------- | NA | NA | 1.4 | 1.4 | NA | 40 | NA | NA | NA | NA |  |  | 2.08 | 2.36 |  | $\begin{aligned} & 4.8- \\ & 11.1 \end{aligned}$ | 10-25 |
| Capacity (lb) per running foot of cargo compartment ${ }^{\prime}$ | NA | NA | 400 | 655 | NA | 1,200 | NA | NA | NA | NA | 235 | 1,000 | 1,000 | 500 | 990 | 2,020 | 1.510 |
| Special cargo handing equipment capacitiesf: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| External hook and sling-..-..-- | NA | NA | NA. | NA | NA | NA | NA | NA | NA | NA | 20 | 25 | 25 | 50 | 40-50 | 100 | 160 |
| Tiedown fittings in floor-...-- | NA | NA | 9 | 22 | NA | 54 | NA | NA | NA | NA | ------- | 12 | 12 | 25 | 34 | $18 \quad 94$ | $87 \quad 8$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |


|  | 0-1E | OV-1A | U-6A | U-1A | U-8D | CV-2 | $\underset{13 \mathrm{G}}{\mathrm{OH}}$ | $\begin{aligned} & \mathrm{OH}- \\ & 13 \mathrm{H} \end{aligned}$ | $\begin{aligned} & \mathrm{OH}- \\ & 23 \mathrm{C} \end{aligned}$ | $\underset{23 \mathrm{D}}{\mathrm{OH}}$ | $\begin{aligned} & \text { UH- } \\ & \text { 19D } \end{aligned}$ | U H-1A | UH-1B | CH-21C | CH-34C | CH-37B | CH-47A |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Tiedown fittings on each side.- | NA | NA | -.----- | 20 | NA | 50 | NA | NA | NA | NA |  |  | 12.5 | 20 | 12 | $50 \quad 22$ | $50 \quad 100$ |
|  | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\left\lvert\, \begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}\right.$ |  | 23 | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\left\|\begin{array}{rr} 2 & 18 \\ 100 & 20 \end{array}\right\|$ | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\left\lvert\, \begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}\right.$ |  | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\left\|\begin{array}{rr} 1 & 10 \\ 50 & 20 \end{array}\right\|$ | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ | $\begin{aligned} & \text { NA } \\ & \text { NA } \end{aligned}$ |  |
| Hoist winch . | NA | NA | -------- | ------- | NA | 20 | NA | NA | NA | NA | 6 | NA |  | 4 | 6 | 20 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Rearward. | NA | NA | - | 2 | NA | 2 | NA | NA | NA | NA | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Vertical. | NA | NA |  | 2 | NA | 2 | NA | NA | NA | NA | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Sideward. | NA | NA |  | 1.5 | NA | 1.5 | NA | NA | NA | NA | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Center of gravity (in.)'...-.-.-...-. $\begin{aligned} & 137- \\ & 140\end{aligned}$ |  | 143- | 93.4- | 134.2- | 114- | 347.4- | (1) | (1) | 79.5 | 79.5 | 125- | 128.0- | 128.0- | 36. | 130.7- | 228- | 35.3 k- |
|  |  | 153 | 107.7 | 147.8 | 124.6 | 357.1 | 5-2 | 5-2 | 84.8 | 84.8 | 136 | 137.5 | 137.5 | 6.5 | 146.7 | 245.1 | 11.8 |

a Includes 30-minute fuel reserve.
b Use figure 2.15 when planning for shorter distances.
c Primarily passenger-type aircraft.
d Limited by payload.
e With total fuel and no passenger. Maximum allowable overload of 250 pounds per wing should
be used only with minimum fuel required for the mission.
${ }^{1}$ Applies only up to the weight-carrying capacity of the aircraft.
a All capacities are shown in hundreds of pounds. For tiedown fittings, top line shows number of fittings; bottom line sbows capacities.
${ }^{b}$ Use tbe following formula to determine tbe number of lashings required to secure a piece of cargo with a prescribed angle of tie against one thrust direction. Number of lashinga required $=$

$$
\frac{\text { Weight of cargo (lb) } \times \text { restraint safety factor } \times 100}{\text { Tensile strength of lasbing (lb) } \times \text { percent effectiveness of system }}
$$

Forward and aft center of gravity limitations from reference-datum line (RDL), unless otherwise noted.
Forward and aft of center line of rotor mast.
k Forward and aft of midpoint between rotor maats.

## c. Miscellaneous Operational and Other Data.




- 0-1 has maximum recommended gross weight of $\mathbf{2 , 4 0 0}$ pounds on long runway and 2,165 pounds for takeoff over harrier

Maximum alternate grass weight mission at sea level, standard atmosphere, and payload and fuel of $\mathbf{1 6 , 0 0 0}$ pounds.

- Primary mission to meet the Army "hot day" requirement of $95^{\circ} \mathrm{F}$., 6,000 feet, hovering "out-ol-ground" effect with a 2 -ton payload. All missions hased on a 100 -NM radius.
d Alternate mission to meet the alternate requirement of $100^{\circ} \mathrm{F}$., at 3,000 feet, hovering "out-of-ground" effect with a 3 -ton payload. All misaions hased on a $100-\mathrm{NM}$ radius.
Includes aircraft, oil, and crew. Does not include useable fuel.
May he internal, external, or combination and includes useahle fuel and cargo or passengers. When planning for each additional 20 miles of operating radius above 50 NM , reduce UH-19 payload hy 10 percent, $\mathrm{CH}-21$ hy 9 percent, $\mathrm{CH}-34$ hy 5 percent, and $\mathrm{CH}-37$ hy 5 percent.

$$
\text { Fuel required }(\mathrm{lb})=\frac{\text { Distance }(\mathrm{NM}) \times \text { Fuel Consumed Per Hour }(\mathrm{lh})}{\text { Cruise speed }(\mathrm{K})}
$$

Assuming $59^{\circ} \mathrm{F}$, 29.92 inches Hg , and $2,000-\mathrm{foot}$ altitude. Figures shown represent fuel consumption with payload.
$t$ Varies according to load, temperature, humidity, and headwind. These figures give general planning information for emergency airfields.

### 2.4 Army Aircraft Payload Versus Range

a. General. Payload is the number of passengers and/or the amount of crago 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 ap-
proximated for Army aircraft by using figure 2.15, 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 possible payload is used. Pounds of fuel not required to fly the mission have been replaced with payload. Figure 2.15 is a rapid reference that should be used for general planning only. When planning cargo operations over distances greater than 220 nautical miles, see paragraph 2.3.


Figure 2.15. Payload versus range of Army Aircraft.
c. Nautical Miles Computation.

|  | 0-1E | OV-1A | U-6A | U-1A | U-8D | CV-2 | $\underset{\text { OH- }}{\text { 13G }}$ | ${ }_{13 \mathrm{H}}^{\mathrm{OH}}$ | $\mathrm{OHC}_{23 \mathrm{C}}$ | $\mathrm{CaH}_{\text {23D }}$ | ${ }_{19 \mathrm{D}} \mathrm{OH}$ | UH-18 | CH-21C | CH-34C | CH-37B | CH-47A |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Maximum gross weight (take-off) | 2,400 | 14,018 | 5,100 | 7,600 | 7,000 | 26,000 | 2,350 | 2,350 | 2,500 | 2,700 | 7,300 | 6,400 | 13,500 | 13,300 | 31,000 | 23,300 |
| Basic opnl weight subtracted. | 1,865 | 10,694 | 3,547 | 5,201 | 5,260 | 17,400 | 1,752 | 1,887 | 1,944 | 1,998 | 6,100 | 4,220 | 9,700 | 8,428 | 22,355 | 16,000 |
| Fuel and payload | 535 | 3,324 | 1,553 | 2,399 | 1,740 | 8,600 | 598 | 463 | 556 | 702 | 1,200 | 2,180 | 3,800 | 4,872 | 8,645 | 7,300 |
| Maximum useable fuel subtracted | 246 | 1,683 | 828 | 1,296 | 1,380 | 4,332 | 249 | 256 | 159 | 276 | 918 | 860 | 1,800 | 1,572 | 4,200 | 3,126 |
| Maximum take-off payload | 289 | 1,641 | 725 | 1,103 | 360 | 4,268 | 349 | 217 | 397 | 426 | 282 | 1,320 | 2,000 | 3,300 | 4,445 | 4,174 |
| Nautical miles per hr (cruise speed) | 87 | 200 | 105 | 100 | 160 | 156 | 60 | 70 | 60 | 60 | 65 | 80 | 70 | 75 | 80 | 130 |
| Lb fuel per hr (cruise speed) (max). | 60 | 750 | 144 | 198 | 216 | 1,680 | 84 | 84 | 92 | 100 | 270 | 377 | 515 | 510 | 1,320 | 1,600 |
| Lb fuel for 50 nautical miles. - | 35 | 188 | 69 | 99 | 68 | 358 | 70 | 60 | 77 | 84 | 208 | 235 | 368 | 340 | 825 | 615 |
| Lb fuel for 100 nautical miles. | 70 | 376 | 138 | 198 | 136 | 1,076 | 140 | 120 | 154 | 168 | 416 | 470 | 736 | 680 | 1,650 | 1,230 |
| Lb fuel for 200 nautical miles. | 140 | 752 | 276 | 396 | 272 | 2,152 | 280 | 240 | 308 | 336 | 832 | 940 | 1,472 | 1,360 | 3,300 | 2,460 |
| Computation for range vs payload 50 nautical miles |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Maximum fuel load | 246 | 1,683 | 828 | 1,296 | 1,380 | 4,332 | 249 | 246 | 159 | 276 | 918 | 860 | 1,800 | 1,572 | 4,200 | 3,126 |
| Fuel for 50 NM subtracted | 35 | 188 | 69 | 99 | 68 | 538 | 70 | 60 | 77 | 84 | 208 | 235 | 368 | 340 | 825 | 615 |
| Lb avail for added payload ( 50 NM ) | 211 | 1,495 | 759 | 1,197 | 1,312 | 3,794 | 179 | 186 | 82 | 192 | 710 | 625 | 1,432 | 1,232 | 3,375 | 2,511 |
| Lb payload with full tanks added. | 289 | 1,641 | 725 | 1,103 | 360 | 4,268 | 349 | 217 | 397 | 426 | 282 | 1,320 | 2,000 | 3,300 | 4,445 | 4,174 |
| Total payload for 50 NM | 500 | 3,136 | 1,484 | 2,300 | 1,672 | 8,062 | 528 | 403 | 479 | 618 | 992 | 1,945 | 3,432 | 4,532 | 7,820 | 6,685 |
| 100 nautical miles |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Maximum fuel load. . | 246 70 | $\begin{array}{r} 1,683 \\ 376 \end{array}$ | $\begin{aligned} & 828 \\ & 138 \end{aligned}$ | $\begin{array}{r} 1,296 \\ 198 \end{array}$ | $\begin{array}{r} 1,380 \\ 136 \end{array}$ | $\begin{aligned} & 4,332 \\ & 1,076 \end{aligned}$ | $\begin{gathered} 249 \\ 140 \end{gathered}$ | 246 120 | 159 | 276 168 | 918 416 | 860 470 | 1,800 736 | 1,572 | 1,650 | 3,126 |
| Fuel for 100 NM substra |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Lb avail for added payload (100 NM | 176 | 1,307 | 690 | 1,098 | 1,244 | 3,256 | 109 | 126 | 5 | 108 | 502 | 390 | 1,064 | 892 | 2,550 | $1,896$ |
| Lb payload with full tanks added. .-...... | 289 | 1,641 | 725 | 1,103 | 360 | 4,268 | 349 | 217 | 397 | 426 | 282 | 1,320 | 2,000 | 3,300 | 4,445 |  |
| Total payload for 100 NM | 465 | 2,948 | 1,415 | 2,201 | 1,604 | 7,524 | 458 | 343 | 402 | 534 | 784 | 1,710 | 3,064 | 4,192 | 6,995 | 6,070 |
| 200 Nautical miles |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Maximum fuel load.- | 246 | 1,683 | 828 | 1,296 | 1,380 272 | 4,332 2,152 |  |  |  |  |  |  | 1,472 |  |  |  |
| Fuel for 200 NM subtracted. | 140 | 752 | 276 | 396 | 272 | 2,152 |  |  |  |  |  |  | 1,472 |  |  | 2,460 |
| Lb avail for added payload (200 NM) - .-- | 106 | 931 | 552 | 900 | 1,108 | 2,180 |  |  |  |  |  |  | 328 2 |  | - | 666 4,174 |
| Lb payload with full tanks added. .-.-.--- | 389 | 1,641 | 725 | 1,103 | 360 | 4,268 |  |  |  |  |  |  | 2,000 |  |  | 4,174 |
| Total payload for 200 NM -------------- | 395 | 2,572 | 1,277 | 2,003 | 1,468 | 6,448 |  |  |  |  |  |  | 2,328 |  |  | 4,840 |
| Maximum range with payload (with $30-$ minute fuel reserve). | 350 | 400 | 575 | 720 | 980 | 850 | 145 | 170 | 77 | 135 | 185 | 126 | 255 | 195 | 180 | 200 |

## ※ 2.5 Air Force Transport Aircraft Characteristics

Use operational data shown below as a planning guide only. Changes in weather, altitude, humidity, and other conditions will cause the values to vary.
a. Passenger, Cargo Load, and Flight Capabilities. ${ }^{\text {a }}$

|  | (C-46F Commando) | C-47D (Skytrain) | C-54G (Skymaster) | C-74 (Globemaster) | C-97C (Stratofreighter) | $\begin{gathered} \mathrm{C}-118 \mathrm{~A} \\ (\mathrm{DC}-6) \end{gathered}$ | C-119G <br> (Packet) | $\begin{aligned} & \text { C-121A } \\ & \text { (Con- } \\ & \text { stella- } \\ & \text { tion) } \end{aligned}$ | C-121C (Con-stellation) | YC- <br> 121 F <br> (Super- <br> Con-stellation) | C-123B | C-124C (Globemaster II) | $\mathrm{C}-130 \mathrm{~A}$ (Her- cules) | C-131A (Samaritan) | $\begin{gathered} \text { Convair } \\ 880 \end{gathered}$ | C-133A (Cargo master) | $\begin{gathered} \text { Boeing } \\ 707 \end{gathered}$ | DC-8 | $\begin{gathered} \text { Electra } \\ 188 \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Personnel: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Crew, normal.---....- <br> Paratroops | 4 | 6 27 | 5 | 9 | 5 | 4 | 5 42 | 6 | 4 | 5 | 2 | 5 12 | 4 | 2 | 5 | 4 | 4 | --.-- | 5 |
| Troops. | 50 | 27 | 49 | 125 | 130 | 76 | 62 | 21 | 72 | 106 | 61 | 200 | 92 | 37 | 109 | 128 | 162 | 176 | 88 |
| Litters | 24 | 24 | 36 | 116 | 79 | 60 | 35 | 14 | 47 | 73 | 50 | 127 | 74 | 27 |  | 64 |  |  |  |
| Max range without payload: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Kilometers. | 3,150 | 2,540 | 6,680 | 10,050 | 7,140 | 7,780 | 3,890 | 6,670 | 6,860 | 5,100 | 3,100 | 7,970 | 5,190 | 3,430 | 4,820+ | 8.110 | $8,380+$ | 9,180+ | ,460+ |
| Nutical miles-.-.-. - | 1.700 | 1.370 | 3,550 | 5,425 | 3.850 | 4.200 | 2,100 | 3,600 | 3,700 | 2,750 | 1,625 | 4,300 | 2,800 | 1,860 | 2,600+ | 4,376 | 4,620+ | $4,960+$ | $2,400+$ |
| Max payload (lb) . . . . - - - | 19,900 | 12,160 | 28,666 | 66,000 | 68,000 | 42,000 | 26,760 | 16,500 | 31,640 | 34,400 | 24,400 | 76.486 | 35,000 | 7,100 | 34,900 | 115.418 | 42,000 | 35,680 | 26.600 |
| Avg payload (lb) va range : <br> Nautical |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| miles Kilometers |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 500927 | 8,000 | 9,500 | 19,265 | 55,586 | 46,000 |  | 18,000 | 16,000 | 22,500 | 28,800 | 19,125 | 56,286 | 35,000 | 7,100 | ( ${ }^{\text {a }}$ | 95,418 | (c) | (0) | (c) |
|  | 17,500 | 11,400 | 28,565 | 65,000 | 67,600 | 42.000 | 23,250 | 16,500 | 31,640 | 34,400 | 21,800 | 76,486 |  |  |  | 115,418 |  |  |  |
| $1,000 \quad 1,853$ | 5,870 | 7,800 | 19,265 | 55,000 | 46,000 |  | 15,250 | 15,750 | 22,500 | 28,800 | 16,000 | 55,000 | 35,000 | 7,100 |  | 95,418 |  |  |  |
|  | 14,750 | 9.800 | 28,566 | 59,000 | 67,500 | 42.000 | 19.500 | 16,500 | 31,640 | 34,400 | 18.200 | 76,486 |  |  |  | 115.418 |  |  |  |
| $1.500 \quad 2.780$ | 3,625 |  | 16,500 | 48,000 | 44,000 |  | 11.750 | 15,500 | 22,500 | 28,800 | 3.750 | 47,000 | 35,000 | 7,100 |  |  |  |  |  |
|  | 7.500 |  | 27,300 | 52.500 | 64,000 | 42.000 | 15,250 | 16,500 | 31,640 | 34,400 | 3.000 | 69,000 |  |  |  | 101,000 |  |  |  |
| $2.000 \quad 3.707$ |  |  | 13.100 | 42,500 | 37,000 |  | 3,250 | 12,750 | 22,500 | 25,200 |  | 38,000 | 32.500 |  |  | 81,000 |  |  |  |
|  |  |  | 24, 000 | 46,000 | 56.000 | 41,000 | 3,250 | 16,500 | 31,640 | 34,400 |  | 60.000 |  |  |  | 88,000 |  |  |  |
| 2,5.50 4,634 |  |  | 10,100 | 36,000 | 31,000 |  |  | 8,000 | 19,000 | 16,000 |  | 32,000 | 16,250 |  |  | 68,000 |  |  |  |
|  |  |  | 20,800 | 40.000 | 49,000 | 35.000 |  | 12,500 | 31,640 | 16,000 |  | 52,000 |  |  |  | 74,000 |  |  |  |
| $3.000 \quad 5.560$ |  |  | 7,600 | 30,000 | 24,500 |  |  | 4,000 | 14,600 |  |  | 24,000 |  |  |  | 65.000 |  |  |  |
|  |  |  | 11,500 | 34,000 | 29.000 | 24,500 |  | 8,000 | 27,400 |  |  | 44,000 |  |  |  | 61,000 |  |  |  |
| 3,500 6,486 |  |  | 1,000 | 24,000 | 9,000 |  |  | 600 | 7,400 |  |  | 17,500 |  |  |  | 42,000 |  |  |  |
|  |  |  | 1,200 | 28,000 | 10.000 | 14,000 |  | 1.250 | 9,200 |  |  | 27,000 |  |  |  | 48,000 |  |  |  |
| 4,000 7,413 |  |  |  | 18,000 |  |  |  |  |  |  |  | 9,000 |  |  |  | 22,000 |  |  |  |
|  |  |  |  | 22,000 |  | 3.000 |  |  |  |  |  | 9,000 |  |  |  | 22,000 |  |  |  |
| 4,500 8,340 |  |  |  | 13,000 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | 17,000 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| $5.000 \quad 9.266$ |  |  |  | 8,000 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5,500 10.193 |  |  |  | 12.000 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cruise speed d: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Knots------------.- | 148 | 146 | 161 | 178 | 210 | 231 | 154 | 190 | 217 | 314 | 138 | 194 | 294 | 285 | 534 | 285 | 525 | 512 | 351 |
| Miles per hour----.-- | 170 | 168 | 186 | 205 | 242 | 266 | 177 | 219 | 250 | 362 | 159 | 223 | 339 | 328 | 615 | 328 | 605 | 689 | 405 |
| Kilometers per hour - - | 275 | 271 | 299 | 330 | 390 | 428 | 286 | 352 | 403 | 583 | 256 | 360 | 545 | 529 | 990 | 629 | 974 | 949 | 651 |
| $T^{\text {ake-off }}$ distance at sea leveld: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Feet-.------------- | $1.750-$ 2,700 | $\begin{aligned} & 1,650- \\ & 2,900 \end{aligned}$ | 1,400 2.780 | $1,950-$ 3,400 | 2,700 6,600 | $2,670-$ 6,050 | $1,820-$ 3,180 | 2,550-1 | 2,500- 3, 390 | 2.275- | $\xrightarrow{350-}$ | $3,000-$ 5,520 | $1,410-$ 2,540 | $\begin{aligned} & 1,830- \\ & 2,880 \end{aligned}$ | 7,000 | $3,800-$ | 8,600 | 8,410 | 6,820 |


a Some sircraft, no longer standard in the U. S. Air Force, are shown because they sre in use by one or more allied nations.
Upper figure represents normal operation; bottom figure represents overload.
c Primsrily passenger-type aircraft.
d Variable, depending on losd, headwind, altitude, temperature, etc. Average cruising speed is shown.

## b. Cargo Loading and Lashing.



[^0]
 cargo-door dimensions should be measured carefully. A 5 -inch clearance should be allowed for cargo that may have to be put through the door at an angle because of ramp loading. See paragraph 2.6 for door dimensions.
b Primarily passenger-type aircraft.

- Unless noted otherwise, thrusts may be applied in any direction
d At $45^{\circ}$ angle.
- Vertical.
' Forward or aft.
B Forward.
b Vertical or sideward.
${ }^{1}$ Aft.
; To determine the number of lashings required to secure a piece of cargo with a prescribed angle of tie againgt one thrust direction, complete the following relationship:
Weight of cargo in pounds $\times$ reatraint safety factor $\times 100$
Number of lashings $=\overline{\text { Tensile strength of lashing in pounds } \times \text { percent effectiveness of the system }}$


## c. Weight and Balance Factors.

|  | C-46F | C-47D | C-54G | C-74 | C-97C | C-118A | C-119G | C-121A | C-121C | $\underset{121 F}{Y C-}$ | C-123B | C-124C | C-130A | C-131A | $\left\lvert\, \begin{gathered} \text { Convair } \\ 880 \end{gathered}\right.$ | C-183A | $\begin{aligned} & \text { Boeing } \\ & 707 \end{aligned}$ | DC-8 | $\begin{array}{\|c} \text { Electra } \\ 188 \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Basic wt (lb) .-.------------- | 81.600 | 18, 185 | 39,400 | 89.339 | 78,250 | 59,084 | 41,170 | 63,976 | 75.132 | 74,681 | 31.218 | 103.014 | 59.328 | 28,538 | ------ | 117.000 |  | 130,092 | 57,000 |
| Normal max gross wt (lb). | 45.000 | 31,000 | 69,000 | 165, 000 | 150,000 | 107, 000 | 68,300 | 102, 000 | 133,000 | 150.000 | 56.100 | 185,000 | 124,200 | 46,955 | 189,500 | 275,000 | 296,000 | 287, 500 | 113.000 |
| Emergency max gross wt (h) .-- | 55,000 | 33,000 | 73,000 | 170,000 | 175,000 | 129,400 | 72,700 | 107,000 | 145,000 | 167,875 | 58,800 | 216,400 |  |  |  | 282,000 |  |  |  |
| Max landing wt (lb) ----------- | 55.000 | 38.000 | 73,000 | 160,000 | 160.000 | 108.000 | 72.700 | 89.500 | 122.000 | 125,000 |  | 168,000 | 124,200 | 41,500 | 145,000 | 245,000 | 195,000 | 194,000 | 95.650 |
| Center of gravity : |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Max forward ----------- | 309 | 239.6 | 382 | 549 | 513 |  | 318 |  |  |  | 323 | 556.5 |  |  |  |  |  |  |  |
| Desirahle | 316 | 256.2 | 397 | 564 584 | 534 |  | 330 335 |  |  |  | 335 $\mathbf{3 5 1}$ | 572 588 |  |  |  |  |  |  |  |
| Max aft | 331 | 263.1 |  |  |  |  |  |  |  |  | 351 | 688 |  |  |  |  |  |  |  |

Shown in inches from the reference datum line

### 2.6 Air Force Trensport Cargo Capacities

a. C-46F (Commando).
(1) Main compartment. Length-48 ft.; width- 9.8 ft .; height- 7 ft .
(2) Belly cargo compartments. Forward3,450 lb.; aft, 3, 000 lb .
(3) Main loading door. Height-6.8 ft.; width- 8.1 ft .; height from ground- 8 ft .
(4) Special loading equipment.
(d) Loading platform (part of floor extending beyond door).
(b) Two loading ramps.
b. C-47D (Skytrain) (Navy Equivalent: R4D). (1) Cargo compartment. Length-30.1 ft.; width-7.4 ft.; height-6.4 ft.; floor bearing strength- $125 \mathrm{lb} / \mathrm{sq} . \mathrm{ft}$.
(2) Main loading door. Height forward5.9 ft .; height aft- 4.6 ft .; width- 7 ft. ; height from ground- 4.7 ft .
(3) Special loading equipment. Sectionalized loading ramp with a loading platform. c. C-54G (Skymaster) (Navy Equivalent: R-5D5).
(1) Main compartment. Length-49.7 ft.; width-8.6 ft.; height-7.8 ft.; floor bearing strength- $200 \mathrm{lb} . / \mathrm{sq} . \mathrm{ft}$.
(2) Cargo sections.

| Designation | Width (in.) | Lenoth (in.) | Cargo capacity (cu fi) |
| :---: | :---: | :---: | :---: |
| C | 103.2 | 59.5 | 155.1 |
| D | 103.2 | 61.0 | 156.2 |
| E | 103.2 | 58.5 | 153.4 |
| F | 103.2 | 61.5 | 159.9 |
| G | 103.2 | 59.0 | 154.8 |
| H | 103.0 | 61.0 | 156.0 |
| I | 101.0 | 59.375 | 153.3 |
| J | 101.0 | 61.625 | $78.3^{1}$ |
| K | 92.8 | 64.125 | $68.1^{1}$ |

${ }^{1}$ Reduced capacity caused by reserving left half of cargo section for passageway and life-raft storage.
(3) Belly cargo compartments. Forward-126 cu. ft.; aft-126 cu.ft.
(4) Main loading door. Height-5.6 ft.; width-7.9 ft.; height above ground8.8 ft .
(5) Special loading equipment. Cargo hoist, 2,000-lb. cap.
d. C-74 (Globemaster).
(1) Main compartment. Length-71.4 ft.; width-11.1 ft.; height-8.3 ft.; floor bearing strength- $104 \mathrm{lb} . / \mathrm{sq} . \mathrm{ft}$.
(2) Main loading door. Length-10.4 ft.; height-10 ft.; height from ground-11.9 ft.
(3) Lower carg. compartments. Total cube$816 \mathrm{cu} . \mathrm{ft}$.; maximum load density- 14 $\mathrm{lb} / \mathrm{cu} . \mathrm{ft}$.
(4) Belly loading doors. Width-40 in.; depth-35in.
(5) Cargo loading well. Length-12.9 ft.; width-7.1 ft.
(6) Special loading equipment.
(a) One fixed hoist and two traveling crane hoists (each $8,000 \mathrm{lb}$. cap.) in main cargo compartment.
(b) Loading platform that can be used as elevator.
e. C-97C (Stratofreighter).
(1) Main compartment. Cu. ft.-4,309; sq. ft.-559.
(2) Lower compartment. Cu. ft.-1,618; sq. ft.-222.
(3) Treadways (single-axle load). Capacity $-12,700 \mathrm{lb}$.
(4) Electrict hoist capacity. With snatch block-5,000 lb.; with hoisting hook$2,500 \mathrm{lb}$..
(5) Loading ramp capacity. On each of 2 treads- $12,700 \mathrm{lb}$.
(6) Floor bearing strength. . Main deck-200 lb./sq. ft.; lower deck-100 lb./sq. ft.
(7) Clearances.
(a) Main cabin. Height-8 ft.; length63.6 ft .; width at floor level- 8.8 ft .
(b) Main loading door. Length- 14.3 ft .; width (fore $/ \mathrm{aft}$ ) $-9.3 \mathrm{ft} . / 6.4 \mathrm{ft}$.; height from ground (fore $/ \mathrm{aft}$ ) $-7.8 \mathrm{ft} . / 9.6 \mathrm{ft}$.
(c) Cargo door. Height-6.5 ft.; width6.7 ft .
(8) Special loading equipment.
(a) Folding ramp.
(b) Monorail loading system, including power hoist. (Eighty-five $300-\mathrm{lb}$. or fifteen $1,500-\mathrm{lb}$. A-22 containers.)
(c) Floor-level conveyors: drop capacity limited only by allowable cargo load.
f. C-118A (Liftmaster) (Navy Equivalent: R6D).
(1) Main compartment. Length-68 ft.; width at floor- 8.75 ft .; height- 7.75 ft. ; volume- $4,307 \mathrm{cu}$. ft.; floor area- 558 sq. ft.
(2) Lower compartment. Forward-213 cu. ft.; aft - $247 \mathrm{cu} . \mathrm{ft}$.
(3) Clearances.
(a) Main loading door. Length- $10.3 \mathrm{ft} . ;$ width- $6.5 \mathrm{ft} . ;$ height above ground8.9 ft .
(b) Forward loading door. Length-7.6 ft.; width- 5.6 ft .; height above ground8.8 ft .
(c) Lower cargo door. Length-3.8 ft.; width- 3.1 ft .
(4) Special loading equipment. Self-powered loading elevator ( $4,000-\mathrm{lb}$. cap.) may be attached to front or rear cargo door. Folds for storage.
g. C-119G (Packet) (Navy Equivalent: R4Q-2).
(1) Main compartment. Maximum cube$3,150 \mathrm{cu} . \mathrm{ft}$.; cube w/o cargo doors2,850 cu. ft.; floor area- 353 sq. ft.; floor bearing capacity- $200 \mathrm{lb} . / \mathrm{sq}$. ft.; overall length- 36.9 ft .; maximum width- 9.8 ft.; minimum width -9.2 ft .; maximum height- 8 ft .; height clear under trolley7.7 ft .
(2) Clearances.
(a) Main cargo door. Height-8 ft.; maximum width-- 9.8 ft .; minimum width- 9.2 ft .; height from ground- 4 ft.
(b) Jump doors. Height-6 ft.; width-3 ft.
(3) Special loading equipment.
(a) Ramp (2 treadways).
(b) Jack posts to support rear of aircraft during loading.
(c) Swiveling hitch for block and tackle can be attached to floor at front or rear of cargo compartment.
(d) Floor roller at aft end of cargo compartment.
h. C-121C (Super Constellation) (Navy Equivalent: $W V-2)$.
(1) Main compartment. Maximum cube$4,875 \mathrm{cu} . \mathrm{ft} . ;$ minimum cube- $3,031 \mathrm{cu}$ ft.; floor area- 744 sq. ft.; overall length $-83.3 \mathrm{ft} . ;$ width— 11.6 ft .; height— 6.7 ft .
(2) Aft lower compartment. 424 cu. ft.
(3) Forward lower compartment. $269 \mathrm{cu} . \mathrm{ft}$.
(4) Main cargo door. Width- 9.3 ft .; height -6.1 ft .
(5) Forward cargo door. Width-5.1 ft.
(6) Special loading equipment.
(a) Aerolift (cargo elevator).
(b) Litter lift.
(c) Pulley block (conveyor to move cargo within aircraft).
i. YC-121F (Super Star Constellation). Capacities and cargo loading provisions are identical to
those of the C-121C ( $h$ above) except that the cube of the aft lower compartment is 194 cu ft .
j. C-123B (Provider).
(1) Main compartment. Length-36.7 ft.; width-9.2 ft.; height-8.2 ft.; cubic feet- 3,750 ; floor area- 450 sq. ft.; floor bearing strength- $200 \mathrm{lb} . / \mathrm{sq} . \mathrm{ft}$.
(2) Main cargo door. Height-8.2 ft.; width -9.2 ft .; height from ground- 2.6 ft .
(3) Special loading equipment.
(a) Loading ramp. Power operated. Can be positioned from ground to any truck-bed height.
(b) Jacks. Two jacks support rear of aircraft during loading.
(c) Opening for winch cable. This opening is located in nose of aircraft. To assist in loading, a truck winch cable can be threaded through this opening.
k. C-124C (Globemaster II).
(1) Main compartment. Useable height11.5 ft .; overall length- $77 \mathrm{ft} . ;$ width at floor level- 11.3 ft .; cube- $10,000 \mathrm{cu} \mathrm{ft}$.
(2) Main loading door. Height-11.6 ft.; top width- $11.3 \mathrm{ft} . ;$ bottom width- 8.9 ft.; height from ground- 8.2 ft .
(3) Elevator well. Length- 13.3 ft .; width7.7 ft .; ground to fuselage- 13 ft .
(4) Floor load capacity. Main deck-183 lb/sq. ft.; second deck-43 lb./sq. ft.; treadway area-4,300-7,200 lb./sq. ft.
(5) Special loading equipment.
(a) Ramp. Loading incline- $17^{\circ}$; singleaxle load- $20,000 \mathrm{lb} . ; 2$ treadways, each with capacity of $10,000-\mathrm{lb}$. wheel load.
(b) Elevator hoist. Capacity-9,300 lb.
(c) Traveling hoists. Two, each with $8,000-\mathrm{lb}$. lift capacity, mounted on overhead rails in cargo compartment.
(d) Loading pulleys. Capacity of 40,000 lb . Located at aft fuselage.
l. C-130A (Hercules).
(1) Main compartment. Length-41.5 ft.; width-10.3 ft.; height- 9.1 ft .; cube3,870 cu. ft.
(2) Main loading door. Width-10 ft.; height-9.2 ft.; height from ground3.75 ft .
(3) Side cargo donr. Width-7.25 ft.; height -6 ft .; height from ground- -3.4 ft .
(4) Jump door. Width-3 ft.; height-6 ft.; height from ground- 3.4 ft .
(5) Cargo floor capacity.
(a) Between stations 337 and 682: singleaxle load- $13,000 \mathrm{lb}$.; single-wheel load- $6,500 \mathrm{lb}$.; bearing surface- 1,080 lb./sq. ft.
(b) Forward of station 337, aft of station 682, including ramp: single-axle load$6,000 \mathrm{lb} . ;$ single-wheel load- $3,000 \mathrm{lb}$.
(6) Special loading equipment.
(a) Ramp. Single-axle load- $13,000 \mathrm{lb} . ;$ single-wheel load-6,500 lb.
(b) Loading pulley and winch. 25,000-lb. capacity.
(c) Roller conveyors.
m. C-133A (Cargomaster).
(1) Main compartment. Length- 97.3 ft .; width ( 2 in . above floor)- 12 ft .; width (floor level)- 11.85 ft .; useable height-

12 ft .; height under rear spar-12 ft.; maximum single-axle capacity-20,000 lb.; maximum dual-axle capacity-44,000 lb.; maximum track capacity - $76,000 \mathrm{lb} . ;$ total cube-13,028 cu. ft.; floor bearing capacity- $300 \mathrm{lb} / \mathrm{sq} . \mathrm{ft}$.
(2) Rear loading door. Height-12.7 ft.; width-12.1 ft.; height above ground4.2 ft .
(3) Side loading door. Height-8.3 ft.; width -8.8 ft ; height above ground- -4.2 ft .
(4) Special loading equipment.
(a) Ramp. Hydraulically operated and integral with rear loading door; $9^{\circ}$ ramp incline; $15^{\circ}$ toe incline.
(b) Loading sheaves. Cable loads up to $20,000 \mathrm{lb}$.
(c) Portable electric winch. Cable loads up to $15,000 \mathrm{lb}$.

## Section III. OPERATIONS

### 2.7 Outline Síanding 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 requirements. Responsibilities for, timing, format, procedures, and policies affecting submission of advance and firm requirements for air movement of supplies and personnel.
(2) Air tonnage allocations. Controlling agency; procedures for application, allocation, and use of allocations; 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 aerial ports.
(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. 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 aerial ports. Procedures and responsibilities for the movement of units and individuals to aerial ports 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.

### 2.8 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.

### 2.9 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 ( $C G$ ). 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 a quantity multiplied by its arm. Moments may be expressed in inch-pounds or foot-pounds; for example, 2 pounds (weight) $\times 10$ inches (arm) $=20$ inch-pounds (moment).
g. Allowable Cargo Load. The amount of cargo and troops, determined by weight, cubic displacement, and distances to be flown, which may be transported by aircraft.
h. Basic Weight. The weight of the aircraft, including its operating equipment and trapped fuel and oils, but excluding crew, oil, fuel, and cargo. The basic weight varies with modifications and changes in operating equipment.
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.
$k$. Normal (Design) Gross Weight. The gross weight on which the aircraft design is based. It is the maximum weight at which the aircraft can be flown and still not exceed the load and safety factors established by design specifications.
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.

### 2.10 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) Establish a 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 movement 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 mul-tiple-piece loads the moment which applies to the point of load concentration is equal to the sum of the moments for each piece.
(8) Verify that the load will fit into the aircraft at the desired station.
b. For accurate weight and balance determina-
tion, see the -10 manual of the TM $55-$ series for the appropriate aircraft.

### 2.11 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 par. 7.17). Each air movement designator consists of code symbols in sequence as shown in the following example and as explained below.


## Type of Traffic

a. $S U U$-Indicates the MATS airport of origin of the traffic; in this example, "Travis AFB."
b. TAW-Indicates the MATS 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" (par. 2.12).
d. EL-Indicates the type of traffic (i.e., whether passenger or cargo moved; in this example, "PassengerEmergency 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."

### 2.12 Cargo Priorities

| Number | Type | Description |
| :---: | :---: | :---: |
| 1 | Emergency $\ldots \ldots$ | Need so acute that precedence |
| should be given over all other |  |  |
| traffic. |  |  |

### 2.13 Lashing Terms

a. Applied Load. The total stress or load imposed upon one cargo tiedown fitting. The applied load equals the tensile strength of all the cargo tiedown devices attached to one cargo tiedown fitting.
b. Cargo Tiedown Pattern. The location and spacing of the cargo tiedown fittings in the floor, ceiling, or walls of an aircraft.
c. Load Spreader. Wooden planks or similar material placed on the cargo compartment flooring of an aircraft to distribute the load reactions of the cargo over a greater area and reduce the floor bearing pressure.
d. Rated Strength. The safe-load capacity of a cargo tiedown fitting or lashing with an applied safety factor. In many cases, the rated strength of a cargo tiedown fitting is restricted by the angle of application of the load.

### 2.14 Lashing Strengths

All lashings should be secured at an angle of $45^{\circ}$ with the cargo floor and $45^{\circ}$ in the direction of expected thrust (fig. 2.16) or with the long axis of the cargo compartment, except for assault-type aircraft. Cargo in the $\mathrm{C}-123$ and $\mathrm{C}-130$ aircraft should be secured at an angle of $30^{\circ}$ with the cargo floor and $30^{\circ}$ in the direction of the expected thrust. The strength of tiedown fittings must be kept in mind. The strongest lashing is no stronger than the fitting to which it is attached. If a lashing is stretched to its breaking point, the fitting is
stressed an amount equal to the full tensile strength of the lashing.
a. Flexible lashings secured at angles of $45^{\circ}$ with the cargo floor and in the direction of expected thrust will hold approximately 70 percent of their rated tensile strength against forward and rearward thrusts, 70 percent of their rated tensile strength against vertical thrusts, and 0 percent of their rated tensile strength against sideward thrusts.
b. Flexible lashings secured at angles of $45^{\circ}$ with the cargo floor and $45^{\circ}$ with the main axis of the cargo compartment will hold approximately 50 percent of their rated tensile strength against forward or rearward thrusts, 50 percent of their rated tensile strength against sideward thrusts, and 70 percent of their rated tensile strength against vertical thrusts. In this type of lashing arrangement, only the lashings for forward and rearward thrusts need be computed. The lashings used to hold the equipment against forward and rearward thrusts are more than enough to secure the load against sideward and vertical thrusts.
c. Flexible lashings secured at angles of $30^{\circ}$ with the cargo floor and $30^{\circ}$ with the main axis of the cargo compartment will hold approximately 75

(4) tiedown fitting

Figure 2.16. Lashings at $45^{\circ}$ and $30^{\circ}$ angles.
percent of their rated tensile strength against forward and rearward thrust, 50 percent of their rated tensile strength against vertical thrust, and 43 percent of their rated tensile strength against sideward thrust. Lashings computed at $30^{\circ}$ angles need only be computed for sideward thrust be-
cause the lashings used to hold the equipment against sideward thrust are enough to secure the load against forward, rearward, and vertical thrusts.
d. For a further discussion of loading and lashing, see TM 57-210.

### 2.15 Lashing Constants and Formulas

a. Restraint Constants Per 1,000 Pounds of Cargo.

| - Strength of tiedown system | Angle of tie |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $45^{\circ}-45^{\circ}$ |  |  |  |  |  |  | $30^{\circ}-30^{\circ}$ |  |
|  | Restraint safety fsctors |  |  |  |  |  |  | Restrsint safety fsctors |  |
|  | 1.5G | 2.0 G | 2.25 G | 3.0 G | 4.0 G | 4.5 G | 8.0G | 2.0G | 8.0 G |
| 25,000-lb (D-1 or MB-2 device). $25,000-\mathrm{lb}$ fitting. | 0.12 | 0.16 | 0.18 | 0.24 | 0.32 | 0.36 | 0.64 | 0.11 | 0.43 |
| 10,000-lb fitting-...----- | . 3 | . 4 | . 5 | . 6 | . 8 | . 9 | 1.6 | . 27 | 1.1 |
| $7,000-\mathrm{lb}$ (C-2 or MB-1 device). 7,000-lb fitting. | . 5 | . 6 | . 7 | . 9 | 1.2 | 1.3 | 2.3 | 3.82 | 15.3 |
| $5,000-\mathrm{lb}$ (B-1 or MC-1 device). $5,000-\mathrm{lb}$ fitting. | . 6. | . 8 | . 9 | 1.2 | 1.6 | 1.8 | 3.2 | . 53 | 2.1 |
| 2,000-lb ( $1 / 2-\mathrm{in}$. rope). <br> 5,000-lb fitting | 1.5 | 2.0 | 2.3 | 3.0 | 4.0 | 4.5 | 8.0 | 1.3 | 5.3 |
| 1,250-lb (A-1 device). |  |  |  |  |  |  |  |  |  |
| 1,250-lb fitting. | 2.4 | 3.2 | 3.6 | 4.8 | 6.4 | 7.2 | 12.8 | 2.14 | 8.54 |
| 1,150-lb device and fitting........ | 2.7 | 3.5 | 4.0 | 5.3 | 7.0 | 7.9 | 14.0 | 2.33 | 9.28 |

This table was derived for forward and rearward thrusts from the formula:

$$
\mathrm{K}=\frac{1,000 \times \mathrm{G} \times 100}{\mathrm{R} \times \mathrm{E}}
$$

where
$K=$ constant per $1,000 \mathrm{lbs}$ of load
$\mathbf{G}=$ number of $G$ 's involved (restraint safety factor)
$\mathrm{R}=$ rated tensile strength of lashing
$\mathbf{E}=$ percent effectiveness of lashing system ( 50 percent for $45^{\circ}-45^{\circ}$ angle and 75 percent for $30^{\circ}-30^{\circ}$ angle of tie)
b. Formula for Computing Number of Lashings Required.

$$
\text { Number of lashings }=\frac{W \times K \text { for } 1 \text { direction of thrust }}{1,000}
$$

where $\mathrm{K}=$ constant from table above
W = weight of cargo in pounds

### 2.16 Tiedown Devices

The following table gives the number of tiedown devices, by type, which the Air Force will furnish on each aircraft listed:

| Type | $\underset{C-47}{C-46}$ | C-54 | C-74 | C-97 | C-119 | C-121 | C-123 | C-124 | $\mathrm{c}_{\mathrm{C}}^{\mathrm{C}-130 \mathrm{~A}} \mathrm{C}$ | C-133A |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Tiedown cargo $\operatorname{strap}$ A1A, 1,250-lb cap. | 15 | 40 | 60 | 60 | 25 | 25 | 20 | 60 | 10 | 0 |
| Tiedown cable B-1, 5,000-lb cap... | 5 | 5 | 15 | 12 | 10 | 5 | 10 | 50 | 0 | 0 |
| Tiedown chain C-2, 10,000-lb cap. - | 0 | 8 | 20 | 20 | 28 | 0 | 35 | 24 | 24 | (*) |
| Tiedown chain D-1, 25,000-lb cap.- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 14 | (*) |
| Tiedown device MC-1, 5,000-lb cap. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | (*) |
| Tiedown device MB-1, 10,000-lb cap. | 0 | - 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | (*) |
| Tiedown device MB-2, 25,000-lb cap- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 0 |
| Cargo net, steel cable, A2, 10,000-lb cap. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |

*Must be requisitioned from Squadron Supply for each specific mission.

### 2.17 Typical Loads

See TM 57-210 or TM 1-series ( -9 Loading Instruction) for the applicable aircraft for typical loads. One typical load is shown in paragraph 2.5.

### 2.18 Standard Parachutes and Carrying Capacities

| Parachute | Diameter (fi) | Maximum Load capability (lb) |
| :---: | :---: | :---: |
| G-1, G-1A | 24 | 300 |
| G-12 | 64 | 2,200 |
| G-13. | 32.4 | 500 |
| G-11, G-11A | 100 | 3,500 |

### 2.19 Aerial Delivery Containers and Typical Loads

| Container | A verage safe load (lb) | Typical load |
| :---: | :---: | :---: |
| A-7A | 100-500 | Packaged nonfragile supplies |
| A-21 | 100-500 | Fragile and nonfragile supplies |
| A-22 | 500-2,200 | Fragile and nonfragile supplie |

### 2.20 Loading or Unloading Time for Army Aircraft

a. Rotary-Wing Aircraft.
(1) Troops- 3 minutes.
(2) Casualties- 10 minutes.
(3) Cargo, in fuselage- 5 minutes.
(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 ( $\mathrm{CH}-21$ and $\mathrm{CH}-34$ ) 15 minutes.
(d) Medium transport ( $\mathrm{CH}-37$ ) $-20 \mathrm{~min}-$ utes.
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- 10 seconds.
(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.

### 2.21 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.

| Aircraft | On-load bases (hours) | Destination bases (offloading and reloading hours) |
| :---: | :---: | :---: |
| C-54 | 2.5 | 3 |
| C-97. | 4.5 | 6 |
| C-119 | 2.5 | 3 |
| C-123. | 2.5 | 3 |
| C-124. | 4.5 | 6 |
| C-130A \& B | 3.5 | 4 |
| C-133A | 4.0 | 5 |

b. Passenger Flights. Air Force aircraft have maximum ground times of 2.5 hours at on-load bases and 3 hours at destination bases for off-loading and reloading.

### 2.22 Aircraft Landing Sites

See FM 57-35, FM 1-100, and TM 5-251.

### 2.23 Estimating Army Aircraft Movement Capability

a. General. To assess capability to move personnel and supplies by Army aircraft, the analyst must make certain assumptions and consider the various factors involved. Some or all of the factors will apply to a particular problem, depending primarily upon the type of aircraft employed. Helicopters, although inferior to fixed-wing aircraft in speed and range, are especially valuable because of landing, takeoff, and hovering capabilities. They can operate in areas that are inaccessible to fixed-wing aircraft and be loaded and unloaded in less time than fixed-wing aircraft. On the other hand, fixed-wing aircraft can generally operate more hours per day with a higher sustained availability. Assumptions, factors involved, and methods of making capability estimates are given below.
b. Assumptions.
(1) Air and ground crews are proficient.
(2) Adequate landing and takeoff sites are available.
(3) Ground handling equipment is adequate.
(4) Aircraft are used only on tactical missions.
c. 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) Miles in the hour. Speed plus loading, unloading, and flying time will determine miles in the hour. Operational hours and distance can then be used to compute the number of round trips each aircraft can make. The average loading and unloading times are shown below.

|  | $\begin{gathered} \text { Helicopter } \\ \text { Loadorunload } \\ \text { (min.) } \end{gathered}$ | Fixed-win <br> Load <br> (min.) | aircraft Unload (min.) |
| :---: | :---: | :---: | :---: |
| Troop | 3 | 2-3 | 1 |
| Casualties | 10 | 10 | 10 |
| Cargo inside | 5 | 10-30 | 5-15 |
| Cargo on slings | 0.5 | ----- | ---- |
| Wing loads. | -- | 10 | 10 |

(5) Daily round trips per aircraft. This is obtained by multiplying operating hours by miles in the hour and dividing the product by distance.
(6) 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.

|  | $\underset{(\text { percent })}{\text { Sustained }}$ | $\underset{(\text { percent })}{\text { Short-ierm }}$ |
| :---: | :---: | :---: |
| Helicopters. | 67 | 90 |
| Fixed-wing aircraft | 75 | 90 |

(7) Aircraft requirement. The aircraft required to accomplish a mission is determined by two factors- the basic requirement and the type of operation.
(a) Basic. 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 as follows:

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 requirement 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.
d. 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
$\mathrm{A}=$ daily tonnage capability
$B=$ daily round trips flown per aircraft
C = payload of one aircraft
D = aircraft employed
(2) Movement by helicopter.
(a) Problem.

What is the daily lift capacity of $\mathbf{2 5}$ 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 for each aircraft
$0.9=$ availability of 90 percent
(b) Solution.
$B=\frac{4 \times 90 \mathrm{mih},}{75 \text { miles }}$ or $\frac{4 \times 144.8 \mathrm{kmih}}{120.7 \text { kilometers }}$
$=5$ round trips per aircraft
$\mathrm{A}=5 \times 1.4 \times 25 \times 0.9=157$ 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 where1.1 = 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
(b) Solution.
$500 \times 1.1=550$ (adjusted tonnage for combat loading)
$B=\frac{6 \times 80 \mathrm{mih}}{2 \times 35 \text { miles }}$ or $\frac{6 \times 128.7 \mathrm{kmih}}{2 \times 56.3 \text { kilometers }}$
$=7$ round trips per aircraft
$D=\frac{550 \times 1.5}{7 \times 1.4}=\begin{aligned} & 84 \text { aircraft for sustained opera- } \\ & \text { tions }\end{aligned}$

Section IV. MAINTENANCE AND SUPPLY

### 2.24 Availability of Army Aircraft

Availability factors for Army aircraft are operational targets which will be revised as more experience is accumulated in aircraft operation, maintenance, and attendant availability factors. The appropriate supply bulletin (SB 1-1 and SB $1-2$ ) should be consulted for the latest availability factors.

### 2.25 Maintenance Man-Hour Requirements Per Flying Hour

Maintenance man-hour requirements per flying hour are developed by the Chief of Transportation. These requirements are periodically revised, as more experience is accumulated in aircraft operation and maintenance. SB 1-2 should be consulted for the latest available maintenance manhour requirements per flying hour and SB 1-1 should be consulted for the annual Army Aircraft Flying-Hour Program.

### 2.26 Direct Productive Maintenance ManHour Analysis for a Given Period

The following examples show a direct productive maintenance man-hour analysis for a given period (a period of 1 month is used for purposes of this manual):
a. Determination of man-hour requirement, where-

$$
\begin{aligned}
20= & \text { number of aircraft } \\
3= & \text { organizational maintenance man-hours } \\
& \text { required to produce } 1 \text { flying hour }
\end{aligned}
$$

$26=$ monthly programed flying hours
$20 \times 3 \times 26=1,560$ minimum maintenance man-hours required per month
b. Determination of maintenance man-hours available, where-

8 = number of direct maintenance personnel available
8 = hours per workday
$20=$ workdays per month
$24=$ percent of time off due to leave, KP, guard, sickness, etc. (based on local situation and specific period of time)
$8 \times 8 \times 20=1,280$ maintenance man-hours per month
$0.24 \times 1,280=307$ maintenance man-hours not available
$1,280-307=973$ maintenance man-hours available
c. Comparison of maintenance capability with maintenance workload, using results computed in $a$ and $b$ above.
$973-1,560=-587$, which shows a deficit, or shortage, in the number of man-hours available
d. Computation of direct maintenance personnel requirements, using the following formula:

| Direct maintenance |
| :---: |
| personnel required |$=\frac{$|  No. of acft $\times \text { man-hours per flying }$ |
| :--- |
|  hour $\times \text { monthly programed flying }$ |
|  hours  |}{|  Maintenance hours available per  |
| :---: |
|  man per month  |}

EXAMPLE: Determine the number of direct 'maintenance personnel required to perform field maintenance on $20 \mathrm{CH}-34$ (Choctaw) aircraft under the following conditions:
$40=$ monthly programed flying hours
26 = workdays per month
12 = working hours per day
5.7 = man-hours per flying hour
$24=$ percent time off due to leave, KP, etc. (leaves 76 percent available)

Direct maihtenance personnel

$$
=\frac{20 \times 5.7 \times 40}{12 \times 26 \times 0.76}=20
$$

### 2.27 Helicopter Planning Factors

a. Hours of Operation. Four hours per 24-hour day.
b. Operating Speed. Number of statute miles or kilometers traveled in 1 hour equals normal cruising speed less 15 miles ( 24 kilometers) per hour. This allows for reduction in speed prior to landing and immediately after takeoff.

## CHAPTER 3 <br> MOTOR

## Section I. ORGANIZATION

### 3.1 Organization

$U n i t$
Headquarters and headquar-
ters company, transporta-
tion motor transport com- mand.

Headquarters and headquar-
ters detachment, transportation truck group.
Headquarters and headquar-
ters detachment, trans-
portation truck battalion.
Transportation light truck
company.a 55-17

| Transportation cargo carrier <br> company (tracked). | $55-27$ |
| :--- | :--- |
|  |  |
| Transportation heavy truck <br> company. | $55-28$ |

Mission and/or capability
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 linehaul operation.
To command, plan, and control operations of transportation truck, amphibious truck, or tracked vehicle battalions.

To command and supervise units engaged in all types of motor transport, such as direct support of tactical units, port or beach clearance, depot and terminal operations, and linehauls.

To provide truck transportation for movement of personnel and general cargo, using either $21 / 2$-ton or 5 -ton cargo trucks.

To transport, by semitrailer of type required, general cargo, bulk petroleum products, refrigerated cargo, and missiles.

To transport personnel and light cargo by light motor vehicles.

To transport personnel and cargo in tactical or logistical operations in arctic regions where conventional vehicles cannot be used.
To transport heavy or bulky vehicles and/or outsized cargo.

## Asaigmmens

To an army or to a theater army logistical command.

To an army, COMMZ, or logistical command. May be attached to a highway transport command headquarters, but may operate separately under appropriate staff transportation officer.
To a field army or COMMZ. May beattached toa transportation truck group headquarters or a highway transport command headquarters, but may operate separately under appropriate transportation staff officer.
To logistical command or field army. Normally attached to a transportation truck battalion, but may operate separately under appropriate staff transportation officer.
To a logistical command or field army. Normally attached to a transportation truck battalion, but may operate separately under appropriate staff transportation officer.
To a transportation truck battalion, a theater headquarters, an army corps, airborne corps, or logistical command, but may operate separately under appropriate transportation officer.
To an infantry division, or field army, or logistical command for arctic operations.

To logistical command or field army. Normally attached to a transportation truck battalion, but may operate separately under appropriate staff transportation officer.

- May be adapted to use non-U. S. personnel; see type B column of appropriate TOE.

Unil
Headquarters and headquarters detachment, transportation tactical carrier battalion.
Transportation tactical carrier company.

ROCID:
Infantry division, transportation battalion.

Headquarters and headquarters company, infantry division, transportation battalion.
Truck transport company, infantry division, transportation battalion.

Armored carrier company, infantry division, transportation battalion.

## ROAD:

Transportation motor transport company, armored or mechanized division supply and transport battalion.
Transportation motor transport company, infantry division supply and transport battalion.
Transportation motor transport company, airborne division supply and transport battalion.
Team GF, trailer transfer point, operating. ${ }^{\text {c }}$

Team GG, highway regulation point.
b Recapitulation of TOE of subordinate units.

- See TOE 55-500 for additional motor transport teams.

To provide command and administration for transportation tactical carrier companies.

To provide protected tactical mobility and resupply, and to supplement Army medical service evacuation of casualties in direct support of combat elements of the infantry division or special task forces.

To provide tactical mobility to assault elements of an infantry division for pursuit, exploitation, and other tactical task-force type requirements.
To provide command and administration for assigned units.

To provide transportation for the tactical and logistical movement of personnel and cargo of an infantry division.
To provide certain combat elements of the infantry division with protected tactical mobility. Capable of operating on roadways or crosscountry.

To provide transportation for unit distribution of all classes of supply except class $V$.

To provide transportation for unit distribution of all classes of supply except class $V$.

To provide transportation for unit distribution of all classes of supply except class $V$.

To operate a trailer transfer point in conjunction with a linehaul operation (250 12-ton trailer units in-and-out per day).
To operate a highway regulation point on a 24 -hour-per-day basis to avoid congestion and conflict of traffic.

## Assignment

To a corps or field army (normally 2 per corps).

To a corps or field army, normally in a transportation tactical carrier battalion, but may operate separately under appropriate staff transportation officer.

Organic to infantry division, TOE 7 (ROCID).

Organic to infantry division, transportation battalion TOE 55-75.

Organic to infantry division, transportation battalion, TOE 55-75.

Organic to infantry division, transportation battalion, TOE 55-75.

Organic to armored or mechanized division supply and transport battalion (TOE 2965).

Organic to infantry division supply and transport battalion (TOE 29-5).

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

To transportation highway transport command (1 per trailer transfer point in operation).
To a logistical command or field army, with attachment to transportation truck group. Normally 1 team assigned for each 30 to 40 miles of road net along which highway regulation is maintained.

### 3.2 Vehicle Characteristics

| Type <br> (May be assigned to U. S. or allied motor transport units) | Combination ${ }^{2}$ | Vehicle class | Dimensions (in.) |  |  | $\begin{gathered} \text { Net } \\ \text { weight } \\ (\mathrm{lb}) \end{gathered}$ | $\begin{gathered} \text { Pax } \\ \text { Band } \\ \text { equip } \end{gathered}$ | Shipping dimensions (uncrated) |  |  | Fuel loaded (mpg) | Fuel tank $\underset{\text { (gal.) }}{\text { cap. }}$ | Cooling system <br>  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Length | Width | Height <br> (max.) |  |  | Cuft | Sq ft | MT |  |  |  |
| Automobile, sedan, lt, Chev |  | 2 | 197 | 74 | 66 | 3,220 | 4 | 550 | 100 | 13.7 | 14 | 16 | 16 |
| Automobile, sedan, med, Buick |  | 2 | 204 | 80 | 64 | 3,786 | 4 | 596 | 112 | 14.9 | 13 | 19 | 15 |
| Bus, 37-pax, $4 \times 2$, M37RC. |  | 13 | 411 | 96 | 120 | 16,300 | 37 | 2,740 | 274 | 68.5 | 4 | 75 | 36 |
| Carrier, cargo, amph, 11/2T, T46E1 |  | 6 | 193 | 98 | 104 | 8,813 | 8 | 1,180 | 132 | 29.5 | 2.3 | 70 |  |
| Carrier, cargo, M29. |  | 3 | 126 | 61 | 71 | 4,077 |  | 337 | 57 | 8.4 | 5 | 35 | 13 |
| Carrier, cargo, amph, M29C |  | 3 | 193 | 68 | 71 | 4,778 |  | 524 | 90 | 13.1 | 5 | 35 | 13 |
| Carrier, cargo, amph, M76 |  | 6 | 188 | 98 | 108 | 11,000 |  | 1,139 | 132 | 28.5 | 2.3 | 70 |  |
| Carrier, pers, full-tracked, armd, M59 |  | 19 | 221 | 129 | 94 | 39,504 | 11 | 1,520 | 186 | 38.1 | 1 | 136 | 56 |
| Carrier, pers, full-tracked, armd, M75 |  | 20 | 205 | 120 | 120 | 36,669 | 11 | 1,438 | 159 | 36 | 0.8 | 150 |  |
| Carrier, pers, full-tracked, armd, M113 (T113E2) |  | 9 | 192 | 106 | 99 | 19,755 | 12 | 1,025 | 141 | 25.6 | 2.5 | 80 | 38 |
| Dolly, tlr converter, 6T, 2W, M197A1 |  |  | 108 | 93 | 52 | 2,970 |  | 306 | 73 | 7.7 |  |  |  |
| Dolly, tlr converter, 8T, 2W, M198A1 |  | 2 | 115 | 97 | 56 | 3,500 |  | 351 | 81 | 8.8 |  |  |  |
| Dolly, tlr converter, 18T, 4W, M119 |  | 4 |  | 115 | 59 | 7,700 |  | 579 | 120 | 14.5 |  |  |  |
| Landing vehicle, tracked, Mk 4, LVT(4) |  | 16 | 314 | 128 | 99 | 27,400 |  | 2,290 | 279 | 57.4 | 0.9 | 140 |  |
| Station wagon, 8-pax, M2119 |  | 2 | 198 | 74 | 70 | 3,580 | 8 | 593 | 102 | 14.8 | 12 | 16 | 16 |
| Stlr, cargo, stake, 6T, 2W, M118A1 | 7 | 11 | 276 | 93 | 133 | 7,140 | --- | 1,534 | 180 | 38.4 |  |  |  |
| Stlr, cargo, van, 6T, 2W, M119A1. | 7 | 10 | 275 | 93 | 104 | 7,180 |  | 2,076 | 184 | 51.8 |  |  |  |
| Stlr, tanker, 6T, 2W, M30. | 9 | 9 | 240 | 96 | 93 | 6,750 |  | 1,790 | 161 | 44.7 |  |  |  |
| Stlr, refrig, van, $71 / 2 \mathrm{~T}, 2 \mathrm{~W}, \mathrm{M} 349 \mathrm{~A} 1$ | 7, 9 | 10 | 284 | 97 | 130 | 7,000 |  | 1,668 | 169 | 41.8 |  |  |  |
| Stlr, cargo, stake, 10T, 2W, SKD2361 | 9 | 14 | 307 | 96 | 108 | 9,430 |  | 1,785 | 204 | 44.7 |  |  |  |
| Stlr, low-bed, wrecker, 12T, 4W, M269A1. | 9 | 22 | 410 | 97 | 121 | 14,200 |  | 1,316 | 275 | 45.4 |  |  |  |
| Stlr, low-bed, wrecker, 12T, 4W, M270A1. | 9 | 24 | 591 | 97 | 121 | 17,500 |  | 2,612 | 393 | 65.3 |  |  |  |
| Stlr, cargo, stake, 12T, 4W, M127A1. | 9 | 25 | 344 | 97 | 109 | 13,500 |  | 2,070 | 230 | 51.8 |  |  |  |
| Stlr, tanker, gasoline, 12T, 4W, M131 | 9 | 21 | 361 | 96 | 111 | 14,850 |  | 2, 121 | 237 | 53.1 |  |  |  |
| Stlr, tanker, gasoline, 12T, 4W, M131A1 \& M131A1C | 9 | 21 | 352 | 97 | 114 | 14,280 |  | 2,236 | 236 | 55.9 |  |  |  |
| Stlr, tanker, gasoline, 12T, 4W, M131A2 | 9 | 21 | 389 | 97 | 114 | 12,400 |  | 2,250 | 252 | 56.3 |  |  |  |
| Stlr, cargo, van, 12T, 4W, M128A1 | 9 | 21 | 350 | 97 | 143 | 14,695 |  | 1,807 | 236 | 45.2 |  |  |  |
| Stlr, low-bed, 15T, 4W, M172. | - 9 | ---- | 404 | 116 | 64 | 15, 500 |  | 1,719 | 322 | 43 |  |  |  |
| Stlr, tank transporter, 45T, 8W, M15A1. | 14, 15 | 59 | 462 | 150 | 105 | 42,370 | --- | 3,490 | 398 | 87.5 |  |  |  |
| Stlr, tank transporter, 50T, 8W, M15A2 | 14, 15 | 78 | 462 | 150 | 105 | 42,600 | ----- | 3,490 | 398 | 87.5 |  |  |  |
| Tlr, cargo, amph, $2 \mathrm{~W}, \mathrm{M100}, 1 / 4 \mathrm{~T}$ | 1 | ----- | 109 | 57 | 42 | 565 |  | 156 | 44 | 3.9 |  |  |  |
| TIr, cargo, 3/4T, 2W, M101 | 2 | ---- | 147 | 74 | 83 | 1,340 | ----- | 520 | 74 | 13 |  |  |  |
| Tlr, cargo, 1T, 2W, T6. | 2 |  | 146 | 72 | 73 | 1,300 | ----- | 437 | 72 | 11 |  |  |  |
| Tlr, cargo, 11/2T, 2W, M104A1. | 3, 4, 5, 6, 8 | 6 | 166 | 83 | 100 | 2,730 | ---- | 446 | 96 | 11.1 |  |  |  |
| Tlr, cargo, $11 / 2 \mathrm{~T}, 2 \mathrm{~W}, \mathrm{M} 105 \mathrm{~A} 2$. | 3, 4, 5, 6, 8 | 6 | 160 | 83 | 96 | 2,650 |  | 430 | 96 | 10.8 |  |  |  |
| Tlr, tank, water, $400 \mathrm{gal}, 11 / 2 \mathrm{~T}, 2 \mathrm{~W}, \mathrm{M} 106 \mathrm{~A} 1$ | $3,4,5,6,8$ | 4 | 167 | 93 | 80 | 2,360 | ----- | 700 | 105 | 17.5 |  |  |  |
| Tlr, tank, water, 400 gal., 112T, 2W, M107A2. | $3,4,5,6,8$ | 4 | 160 | 83 | 77 | 2,289 | ----- | 597 | 94 | 14.9 |  |  |  |
| Tlr, flat-bed, guided missile, M261A1. | 3, 4, 5, 6, 8 | 6 | 308 | 95 | 47 | 7,694 |  | 1,888 | 307 | 47.2 |  |  |  |



|  |  |
| :---: | :---: |
|  |  |
|  <br> జ్ర్య N్య్రు |  |
|  |  |



| 11,260 |
| ---: |
| 1,700 |
| 2,140 |
| 2,690 |
| 3,330 |
| 7,150 |
| 5,917 |
| 3,240 |
| 5,675 |
| 8,150 |
| 12,465 |
| 8,337 |
| 10,350 |
| 12,880 |
| 12,330 |
| 11,775 |
| 13,500 |
| 13,170 |
| 15,165 |
| 14,050 |
| 14,460 |
| 15,038 |
| 14,805 |
| 13,955 |
| 14,100 |
| 11,913 |
| 11,430 |
| 11,695 |
| 11,179 |
| 10,100 |
| 15,231 |
| 15,085 |
| 19,785 |
| 23,960 |
| 11,660 |
| 12,100 |
| 18,813 |
| 32,830 |
| 33,675 |
| 19,119 |
| 19,230 |
| 19,945 |
| 24,064 |
| 21,981 |
| 30,000 |
| 31,600 |


-






See footnotes on page 46 .

| Typel <br> (May be assigned to U. S. or allied motor transport units) | Combination ${ }^{2}$ | Vehicle | Dimensions (in.) |  |  | $\underset{\substack{\text { weight } \\(\mathrm{lb})}}{\text { Net }}$ | $\begin{gathered} \text { Pax } \\ \text { Pand } \\ \text { equip } \end{gathered}$ | Shipping dimensions (uncrated) |  |  | $\underset{\substack{\text { Fuel } \\ \text { loaded } \\ \text { (mpg) }}}{\text { and }}$ | Fuel cap. (gal.) | Cooling system (qt) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Length | Width | Height (max.) |  |  | Cuft | Sq ft | MT |  |  |  |
| Trk, tractor, 10T, $6 \times 6, \mathrm{M} 123 \mathrm{C}$. | 13 | 18 | 280 | 114 | 113 | 32,250 | 1 | 2,070 | 221 | 51.8 | 1.8 | 166 | 64 |
| Trk, tractor, 12T, $6 \times 6, \mathrm{M} 26 \mathrm{~A} 2$. | 14 | 28 | 306 | 131 | 123 | 48,895 |  | 2,957 | 278 | 74 | 1 | 120 | 56 |
| Trk, tractor, 15T, $8 \times 8$, M194 $\ldots-\ldots-\ldots-{ }_{-}$ | 15 | 48 | 338 | 124 | 109 | 45,000 | ------ | 2,500 | 291 | 62.5 |  |  |  |

 : Trailers and semitrailers will form combinations with trucks having the same number.
${ }^{1}$ Does not include crew.

- See paragraph 7.11 for antifreeze applications.

| Typel <br> (May be assigned to U. S. or allied motor transport units) | $\text { POL for } 100 \text { miles (losded) }(161 \mathrm{~km})$ |  |  |  | Towed loads (lb) |  | Payloads (lb) |  | Cargo carrying dimensions (in.) |  |  | $\begin{gathered} \text { Loading } \\ \text { height } \\ \text { (in.) } \end{gathered}$ | Cruising range (losded) |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fuel (gal.) | $\begin{aligned} & \text { Oil } \\ & \text { (gal.) } \end{aligned}$ | Lube (lb) | Grease (lb) | Hwy opns | Inferior rosds | Hwy opas | Inferior roads | Length | Width | Height |  | Miles | Kilometers |
| Automobile, sedan, It, Chev_ | 7.2 | 0.2 | 0.1 | 0.1 |  |  | 800 |  |  |  |  |  | 224 | 361 |
| Automobile, sedan, med, Buick | 7.7 | 0.2 | 0.1 | 0.1 |  |  | 750 |  |  |  |  |  | 247 | 397 |
| Bus, 37-pax, $4 \times 2, \mathrm{M} 37 \mathrm{RC}$ | 25.0 | 0.6 | 0.3 | 0.4 |  |  | 8,700 |  |  |  |  |  | 300 | 483 |
| Carrier, cargo, amph, $11 / 2 \mathrm{~T}, \mathrm{~T} 46 \mathrm{El}$ | 43.4 | 2.8 | 1.9 | 0.9 | 6,000 | 6,000 | 3,000 | 3,000 | 91 | 68 | 58 |  | 161 | 259 |
| Carrier, cargo, M29. | 20.0 | 1.4 | 0.9 | 0.5 | 3,800 | 3,800 | 1,200 | 1,200 |  |  |  |  | 175 | 282 |
| Carrier, cargo, amph, M29C | 20.0 | 1.4 | 0.9 | 0.5 | 3,800 | 3,800 | 1,200 | 1,200 |  |  |  |  | 175 | 282 |
| Carrier, cargo, amph, M76. | 43.4 | 1.6 | 1.0 | 1.6 | 6,000 | 6,000 | 1,160 | 1,160 |  |  |  |  | 161 | 259 |
| Carrier, pers, full-tracked, armd, M59. | 100.0 | 2.0 | 2.5 | 2.0 | 14,000 | 14,000 | 3,100 | 3,100 |  |  |  |  | 136 | 218 |
| Carrier, pers, full-tracked, armd, M75. | 125.0 | 2.0 | 2.5 | 2.0 | 14,000 | 14,000 | 5,300 | 5,300 |  |  |  |  | 120 | 193 |
| Carrier, pers, full-tracked, armd, M113 (T113E2) | 40.0 | 1.8 | 2.0 | 1.8 | 24,000 | 24,000 | 3,860 | 3,860 |  |  |  |  | 200 | 322 |
| Dolly, tlr converter, 6T, 2W, M197A1--..------- |  |  |  | 0.1 |  |  | 12,000 |  |  |  |  | 52 |  |  |
| Dolly, tlr converter, 8T, 2W, M198A1. |  |  |  | 0.1 |  |  | 16,000 |  |  |  |  | 56 |  |  |
| Dolly, tlr, converter, 18T, 4W, M119.---------- |  |  |  | 0.1 |  |  | 36,000 |  |  |  |  | 59 |  |  |
| Landing vehicle, tracked, Mk 4, LVT(4)......... | 111.0 |  |  |  | 30,000 | 30,000 | 9,000 | 9,000 |  |  |  |  | 126 | 203 |
|  | 8.3 | 0.2 | 0.1 | 0.1 | ------- | ----.- | 1,400 |  |  |  |  |  | 192 | 309 |
| Stlr, cargo, stake, 6T, 2W, M118A1------------1 |  |  |  |  |  |  | 16,200 | 12,000 | 266 | 88 | 48 | 48 |  |  |
| Stlr, cargo, van, 6T, 2W, M119A1 |  |  |  |  |  |  | 16,200 | 12,000 | 266 | 87 | 55 | 47 |  |  |
| Stlr, tanker, 6T, 2W, M30. |  |  |  |  |  |  | 12,200 |  |  |  |  |  |  |  |
| Stlr, refrig, van, 71/2T, 2W, M349A1. |  |  |  |  |  |  | 15,000 |  | 244 | 85 | 56 | 50 |  |  |
| Stlr, cargo, stake, 10T, 2W, SKD2361. |  |  |  |  |  |  | 22,000 | 20,000 | 300 | 87 | 48 | 53 |  |  |
| Stlr, low-bed, wrecker, 12T, 4W, M269A1 |  |  |  |  |  |  | 40,000 | 24,000 | 300 | 96 | ------ | 49 |  |  |
| Stlr, low-bed, wrecker, 12T, 4W, M270A1. |  |  |  |  |  |  | 40,000 | 24,000 | 480 | 96 |  | 49 |  |  |
| Stlr, cargo, stake, 12T, 4W, M127A1. |  |  |  |  |  |  | 36,000 | 24,000 | 335 | 88 | 48 | 61 |  |  |
| Stlr, tanker, gasoline, 12T, 4W, M131. |  |  |  |  |  |  | 30,540 | 19,620 | ---- | --- |  | 109 |  |  |
| Stlr, tanker, gasoline, 12T, 4W, M131A1, M131A1C |  |  |  |  |  |  | 30,500 | 19,645 | ---- | --- |  | 109 |  |  |
| Stlr, tanker, gasoline, 12T, 4W, M131A2. |  |  |  |  |  |  | 30,500 | 20,344 |  |  |  | 109 |  |  |
| Stlr, cargo, van, 12T, 4W, M128A1 |  |  |  |  |  |  | 36,000 | 24,000 |  |  |  | . 49 |  |  |
| Stlr, low-bed, 15T, 4W, M172. |  |  |  |  |  |  | 30,000 |  | 248 | 115 |  | 35 |  |  |



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| 90,000 |
| ---: |
| 100,000 |
| 750 |
| 2,250 |
| 3,000 |
| 5,500 |
| 4,500 |
| 3,335 |
| 3,335 |
| 3,245 |
| 26,000 |
| 1,000 |
| 1,200 |
| 1,200 |
| 1,270 |
| 1,400 |
| 2,000 |
| 2,060 |
| 6,825 |
| 4,800 |
| 10,000 |
| 7,000 |
| 10,000 |
| 10,000 |
| 10,000 |
| 10,000 |
| 10,000 |
| 10,000 |
| 10,000 |
| 10,000 |
| 9,000 |
| 8,500 |
| 8,000 |
| 8,000 |
| 8,500 |
| 15,400 |


| 90,000 |  |
| :---: | :---: |
| 100,000 |  |
| 750 | 500 |
| 2,250 | 1,500 |
| 3,000 | 2,000 |
| 5,500 | 3,000 |
| 4,500 | 3,000 |
| 3,335 | 3,335 |
| 3,335 | 3,335 |
| 3,245 | 3,245 |
| 26,000 | 20,000 |
| 1,000 | 850 |
| 1,200 | 800 |
| 1,200 | 800 |
| 1,270 |  |
| 1,400 |  |
| 2,000 | 1,500 |
| 2,060 |  |
| 6,825 | 3,000 |
| 4,800 | 3,350 |
| 10,000 | 5,000 |
| 7,000 | 5,000 |
| 10,000 | 5,350 |
| 10,000 | 5,000 |
| 10,000 | 5,000 |
| 10,000 | 5,000 |
| 10,000 | 5,000 |
| 10,000 | 5,000 |
| 10,000 | 5,000 |
| 10,000 | 5,000 |
| 9,000 | 3,750 |
| 8,500 | 3,500 |
| 8,000 | 5,000 |
| 8,000 | 5,000 |
| 8,500 | 3,500 |
|  | 5,350 |
| 12,000 | 7,000 |
| 12,000 | 7,000 |
| 12,000 | 7,000 |
| 9,200 | 5,350 |
| 7,500 | 5,000 |
| 7,500 | 5,000 |
| 3,500 | 1,500 |
| 3,500 | 1,500 |
| 9,350 |  |
| 15,400 | 13,000 |




See footnotes on page 50 .

| Type ${ }^{1}$ | POL for $\underset{\text { (loaded) }}{100 \text { miles }}(161 \mathrm{~km})$ |  |  |  | Towed loads (lb) |  | $\underset{(\mathrm{lb})}{\text { Payloads }}$ |  | Cargo carrying dimensions (in.) |  |  | $\begin{array}{\|l\|l} \text { Loading } \\ \text { height } \\ \text { (in.) } \end{array}$ | Cruising range(loaded) |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & \text { Fuel } \\ & \text { (gal.) } \end{aligned}$ | $\underset{(\mathrm{gal} .)}{\mathrm{Oil}}$ | $\begin{aligned} & \text { Lube } \\ & \text { (lb) } \end{aligned}$ | $\begin{gathered} \text { Grease } \\ (\mathrm{lb}) \end{gathered}$ | $\begin{gathered} \mathrm{H}_{\mathrm{opy}} \end{gathered}$ | Inferior roads | $\begin{gathered} \mathrm{H}_{\mathrm{opn}} \end{gathered}$ | Inferior roads | Length | Width | Height |  | Miles | Kilometers |
| Trk, tractor, 5T, $6 \times 6, \mathrm{M} 52$ | 22.7 | 0.6 | 0.9 | 0.8 | 55,000 | 30,000 | 25,000 | 15,000 |  |  |  |  | 484 | 779 |
| Trk, tractor-wrecker, LWB, w/w, 5T, $6 \times 6$, M246 | 22.7 | 0.8 | 0.4 | 0.5 | 46,000 | 37,500 | 16,000 | 12,000 |  |  |  |  | 343 | 552 |
| Trk, wrecker, med, $5 \mathrm{~T}, 6 \times 6, \mathrm{M} 62$. | 37.0 | 0.8 | 0.4 | 0.5 | 30,000 | 20,000 | 12,000 | 7,000 |  |  |  |  | 211 | 339 |
| Trk, cargo, 5T, $6 \times 6$, M41 | 22.7 | 0.8 | 0.4 | 0.5 | 30,000 | 15,000 | 15,000 | 10,000 | 168 | 88 | 60 | 55 | 343 | 552 |
| Trk, cargo, 5T, $6 \times 6, \mathrm{M} 54$ | 37.0 | 0.8 | 0.4 | 0.5 | 30,000 | 15,000 | 20,350 | 10,350 | 168 | 88 | 60 | 55 | 211 | 339 |
| Trk, cargo, LWB, 5T, $6 \times 6, \mathrm{w} / \mathrm{w}, \mathrm{M} 54$ | 37.0 | 0.9 | 0.4 | 0.5 | 30,000 | 15,000 | 20,350 | 10,350 | 168 | 88 | 60 | 55 | 211 | 339 |
| Trk, cargo, 5T, $6 \times 6$, M55. | 37.0 | 0.9 | 0.5 | 0.6 | 30,000 | 15,000 | 20,000 | 10,000 | 244 | 88 | 60 | 57 | 211 | 339 |
| Trk, dump, 5T, $6 \times 6$ M 51 | 22.7 | 0.8 | 0.4 | 0.5 | 30,000 | 15,000 | 20,000 | 10,000 | 125 | 82 | 23 | 58 | 484 | 779 |
| Trk, wrecker, 6T, $6 \times 6, \mathrm{M} 1 \mathrm{~A} 1$ | 50.0 | 0.8 | 0.4 | 0.5 | 60,000 | 40,000 | 8,000 |  |  |  |  |  | 200 | 322 |
| Trk, cargo, 10T, $6 \times 6, \mathrm{M} 125$. | 33.3 | 0.8 | 0.4 | 0.5 | 50,000 | 30,000 | 30,000 | 20,000 | 178 |  |  | 66 | 330 | 531 |
| Trk, tractor, $10 \mathrm{~T}, 6 \times 6$, M123C. | 55.0 | 1.5 | 0.9 | 1.1 | 135, 000 | 80,000 | 35,000 | 30,000 |  |  |  |  | 300 | 483 |
| Trk, tractor, 12T, $6 \times 6$, M26A2. | 100.0 | 1.5 | 0.9 | 1.1 | 117,500 |  | 60,000 |  |  |  |  |  | 120 | 193 |
| Trk, tractor, $15 \mathrm{~T}, 8 \times 8$, M194 |  | 1.7 | 1.1 | 1.3 | 150,000 |  | 51,000 |  |  |  |  |  |  |  |


| (May be assigned to U. S. or allied motor transport unita) | $\begin{aligned} & \text { Cargo } \\ & \begin{array}{c} \text { space } \\ \text { (cu ft) } \end{array} \end{aligned}$ | $\underset{\substack{\text { Ideal stowage } \\ \text { factor }}}{\text { b }}$ |  | $\underset{\text { (in.) }}{\substack{\text { Fordability }}}$ |  | $\begin{gathered} \text { Max. } \\ \text { grade } \\ \text { ability } \\ (\%)^{\prime} \end{gathered}$ | Tirea |  |  |  | Max. recommended |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\underset{\text { Opus }}{\text { Oquy }}$ | Inferior roads | w/kit | wo/kit |  | $\begin{aligned} & \text { Number } \\ & \text { ground } \end{aligned}$ | $\underset{\substack{\text { pressure } \\(\text { pai })}}{\text { Max }}$ | Ply | Size | $\underset{\text { per hour }}{\text { Miles. }}$ | Kilometera per hour |
| Automobile, sedan, lt, Chev |  |  |  |  | 15 | 35 | 4 | 24 | 4 | $6.70 \times 15$ | 70 | 112 |
| Automobile, sedan, med, Buick |  |  |  |  | 15 | 48 | 4 | 24 | 4 | $7.60 \times 15$ | 70 | 112 |
| Bus, 37 -pax, $4 \times 2$ M 37 RC . |  |  |  |  | 20 | 20 | 6 |  | 12 | $10.00 \times 20$ | 60 | 96 |
| Carrier, cargo, amph, $11 / 2$ T, T46E1 ${ }^{8}$ | 209 | 156 | 156 |  |  | 60 |  |  |  |  | 28 | 45 |
| Carrier, cargo, M298 |  |  |  |  |  | 65 |  |  |  |  | 34 | 54 |
| Carrier, cargo, amph, M29C8 |  |  |  |  |  | 65 |  |  |  |  | 36 | 57 |
| Carrier, cargo, amph, M76 ${ }^{8}$ |  |  |  |  |  | 60 |  |  |  |  | 28 | 45 |
| Carrier, pers, full-tracked, armd, M598 |  |  |  |  |  | 60 |  |  |  |  | 32 | 51 |
| Carrier, pers, full-tracked, armd, M75 |  |  |  |  | 48 | 60 |  |  |  |  | 44 | 70 |
| Carrier, pers, full-tracked, armd, M113 (T113E2)8 |  |  |  |  |  | 60 |  |  |  |  | 40 | 64 |
| Dolly, tlr converter, 6T, 2W, M197A1. |  |  |  |  |  |  | 4 | 40 | 8 | $9.00 \times 20$ |  |  |
| Dolly, tlr converter, 8T, 2W, M198A1. |  |  |  |  |  |  | 4 | 50 | 10 | $11.00 \times 20$ |  |  |
| Dolly, tlr converter, 18T, 4W, M119. |  |  |  |  |  |  | 8 | 85 | 12 | $14.00 \times 20$ |  |  |
| Landing vehicle, tracked, Mk 4, LVT(4)8. |  |  |  |  |  | 60 |  |  |  |  | 15 | 24 |
| Station wagon, 8-pax, M2119------ |  |  |  |  | 13 | 30 | 4 | 30 | 6 | $6.70 \times 15$ | 65 | 104 |
| Stlr, cargo, stake, 6T, 2W, M118A1 | 649 | 90 | 121 |  |  |  | 4 | 40 | 8 | $9.00 \times 20$ |  |  |
| Stlr, cargo, van, 6T, 2W, M119A1. | 736 | 102 | 137 |  |  |  | 4 | 40 | 8 | $9.00 \times 20$ |  |  |
| Stlr, tanker, 6T, 2W, M30 |  |  |  |  |  |  | 4 | 65 | 12 | $9.00 \times 20$ |  |  |
| Stlr, refrig, van, $71 / 2 \mathrm{~T}, 2 \mathrm{~W}, \mathrm{M} 349 \mathrm{~A} 1$. | 671 | 100 |  |  |  |  | 4 | 40 | 8 | $9.00 \times 20$ |  |  |
| Stlr, cargo, stake, 10T, 2W, SKD2361 | 726 | 74 | 81 |  |  |  | 4 | 80 | 14 | $11.00 \times 20$ |  |  |
| Stlr, low-bed, wrecker, 12T, 4W, M269A1. |  |  |  |  |  |  | 8 | 70 | 12 | $11.00 \times 20$ |  |  |


| Stlr, low-bed, wrecker, 12T, 4W, M270A1. Stlr, cargo, stake, $12 \mathrm{~T}, 4 \mathrm{~W}, \mathrm{M} 127 \mathrm{~A} 1 . . . .$. | 818 | 51 | 76 |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\stackrel{\checkmark}{\text { b }}$ Stlr, tanker, gasoline, 12T, 4W, M131 |  |  |  |  | 56 |  |
| \% Stlr, tanker, gasoline, 12T, 4W, M131A1 \& M131A1C |  |  |  |  | 56 |  |
| Stlr, tanker, gasoline, 12T, 4W, M131A2 |  |  |  |  | 24 |  |
| Stlr, cargo, van, 12T, 4W, M128A1 |  |  |  |  | 55 |  |
| Stlr, low-bed, 15T, 4W, M172 |  |  |  |  | 36 |  |
| Stlr, tank, transporter, 45T, 8W, M15A1 |  |  |  |  |  |  |
| Stlr, tank transporter, 50T, 8W, M15A2 |  |  |  |  |  |  |
| Tlr, cargo, amph, 1/4T, 2W, M100 | 28 | 84 | 126 |  |  |  |
| Tlr, cargo, 3/4T, 2W, M101. | 183 | 182 | 273 |  |  |  |
| Tlr, cargo, 1T, 2W, T6. | 112 | 84 | 125 |  |  |  |
| Tlr, cargo, 11/2T, 2W, M104A1 | 282 | 115 | 210 |  |  |  |
| Tlr, cargo, 11/2T, 2W, M105A2 | 282 | 141 | 210 |  |  |  |
| Tlr, tank, water, 400 gal., $11 / 2 \mathrm{~T}, 2 \mathrm{~W}, \mathrm{M} 106 \mathrm{~A} 1$. |  |  |  |  |  |  |
| Tlr, tank, water, 400 gal., $11 / 2 \mathrm{~T}, 2 \mathrm{~W}, \mathrm{M} 107 \mathrm{~A} 2$. |  |  |  |  |  |  |
| Tlr, flat-bed, guided missile, M261A1 |  |  |  |  |  |  |
| Tlr, flat-bed, 10T, 4W, M345 |  |  |  |  |  |  |
| Trk, util, 1/4T, $4 \times 4$, lt, M422 |  |  |  | 60 | 21 | 60 |
| Trk, util, $1 / 4 \mathrm{~T}, 4 \times 4, \mathrm{M} 151$. |  |  |  |  | 20 | 65 |
| Trk, util, 1/4T, $4 \times 4, \mathrm{M} 38 \mathrm{Al}$. |  |  |  | 79 |  | 69 |
| Trk, pickup, Chev, $1 / 2 \mathrm{~T}, 4 \times 2$, M3104 | 36 | 64 |  |  | 18 | 31 |
| Trk, ambulance, $3 / 4 \mathrm{~T}, 4 \times 4$, M43 |  |  |  |  |  | 68 |
| Trk, cargo, 3/4T, $4 \times 4, \mathrm{M} 37 \mathrm{~B} 1$. | 159 | 178 | 238 | 84 | 42 | 65 |
| Trk, pickup, 1T, $4 \times 4, \mathrm{M} 4-73-4 \mathrm{WD}$. | 28 | 31 |  |  | 18 | 41 |
| Trk, cargo, stake, $11 / 2 \mathrm{~T}, 4 \times 2$, Chev, M4409 | 248 | 81 | 185 |  | 22 | 37 |
| Trk, cargo, $11 / 2 \mathrm{~T}, 4 \times 4$, G7127. | 431 | 201 | 288 |  | 29 | 65 |
| Trk, cargo, LWB, $21 / 2 \mathrm{~T}, \mathrm{M} 35$. | 441 | 101 | 201 | 72 |  | 64 |
| Trk, cargo, stake, $21 / 2 \mathrm{~T}, \mathrm{M}-\mathrm{K} 7$. | 420 | 135 | 188 |  | 26 | 39 |
| Trk, cargo, SWB, $21 / 2$ T, $6 \times 6$, CCKW352 | 360 | 81 | 151 |  | 30 | 65 |
| Trk, cargo, LWB, w/w, $21 / 2 \mathrm{~T}, 6 \times 6, \mathrm{M} 35$. | 449 | 101 | 201 | 72 |  | 64 |
| Trk, cargo, wo/w, $21 / 2 \mathrm{~T}, 6 \times 6$ M135 | 408 | 91 | 183 |  | 30 | 60 |
| Trk, cargo, $21 / 2 \mathrm{~T}, 6 \times 6$ M 34. | 408 | 91 | 183 | 72 |  | 64 |
| Trk, cargo, $21 / 2 \mathrm{~T}, 6 \times 6, \mathrm{M} 36 \mathrm{C}$ | 623 | 140 | 280 | 72 |  | 64 |
| Trk, cargo, $21 / 2 \mathrm{~T}, 6 \times 6$, M211. | 449 | 101 | 201 |  | 30 | 60 |
| Trk, cargo, dump, $21 / 2 \mathrm{~T}, 6 \times 6$, M342 | 70 | 157 | 314 | 72 | 40 | 64 |
| Trk, dump, $21 / 2 \mathrm{~T}, 6 \times 6$, M59 | 70 | 16 | 31 | 72 | 40 | 63 |
| Trk, dump, $21 / 2 \mathrm{~T}, 6 \times 6$, M215. | 70 | 17 | 42 | 80 | 30 | 66 |
| Trk, tank, water, 1,000 gal., $21 / 2 \mathrm{~T}, 6 \times 6, \mathrm{M} 50$. |  |  |  | 72 | 40 | 57 |
| Trk, tank, gasoline, $1,200 \mathrm{gal}$, , $21 / 2 \mathrm{~T}, 6 \times 6$, M217C |  |  |  | 80 | 30 | 67 |
| Trk, tank, gasoline, 1,200 gal., $21 / 1 \mathrm{~T}, 6 \times 6, \mathrm{M} 49 \mathrm{C}$ |  |  |  | 72 | 40 | 62 |
| Trk, tank, water, 1,000 gal., $21 / 2 \mathrm{~T}, 6 \times 6, \mathrm{M} 222$. |  |  |  | 80 | 30 | 66 |
| Trk, tank, water, $21 / 2 \mathrm{~T}, 6 \times 6$, CCKW353. |  |  |  |  | 30 | 65 |
| Trk, tractor, $21 / 2 \mathrm{~T}, 6 \times 6$, M48.. |  |  |  |  | 30 | 40 |
| Trk, tractor, $21 / 2 \mathrm{~T}, 6 \times 6, \mathrm{M} 221$. |  |  |  |  | 30 | 52 |
| Trk, tractor, $21 / 2 \mathrm{~T}, 6 \times 6$, M275. |  |  |  |  | 30 | 57 |

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See footnotes on page 50.

| (May be assigned to U. S. or allied motor transport units) | $\begin{aligned} & \text { Cargo } \\ & \text { space } \\ & \text { (cu It } \end{aligned}$ | Ideal atowagefactor $^{\text {a }}$ |  | $\underset{\text { (in.) })^{\text {Fordiability }}}{ }$ |  | $\begin{aligned} & \text { Max. } \\ & \text { grade- } \\ & \text { ability } \\ & (\%)^{2} \end{aligned}$ | Tiree |  |  |  | Max. recommended |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Hwy <br> opns | Inferior roads | w/kit | wo/kit |  | Number ground | $\underset{\substack{\text { pressure } \\(\text { psi) }}}{\text { Max }}$ | Ply | Size | Miles per hour per hour | Kilometers per bour |
| Trk, van, shop, $21 / 2 \mathrm{~T}, 6 \times 6$, CCKW353. | 432 | 105 | 181 |  | 30 | 65 | 10 | 55 | 8 | $7.50 \times 20$ | 45 | 72 |
| Trk, van, shop, $21 / 2 \mathrm{~T}, 6 \times 6$, M109 $\ldots-{ }^{\text {c }}$ |  |  |  | 72 | 40 | 57 | 10 | 45 | 8 | $9.00 \times 20$ | 58 | 93 |
| Trk, van, shop, $21 / 2 \mathrm{~T}, 6 \times 6, \mathrm{M} 220$. |  |  |  | 80 | 30 | 66 | 10 | 45 | 8 | $9.00 \times 20$ | 55 | 88 |
| Trk, wrecker, crane, $21 / 2 \mathrm{~T}, 6 \times 6$, M108. |  |  |  | 72 | 40 | 63 | 10 | 45 | 8 | $9.00 \times 20$ | 62 | 99 |
| Trk, wrecker, lt, $21 / 2 \mathrm{~T}, 6 \times 6, \mathrm{M} 60 \ldots$ |  |  |  | 72 | 40 | 63 | 10 | 45 | 8 | $9.00 \times 20$ | 60 | 96 |
| Trk, tractor, 4-5T, $4 \times 4, \mathrm{M} 444 \mathrm{~T}$. |  |  |  |  | 24 | 52 | 6 | 65 | 10 | $9.00 \times 20$ | 41 | 66 |
| Trk, tractor, $5 \mathrm{~T}, 4 \times 2$ M 426 |  |  |  |  | 35 | 25 | 6 | 70 | 14 | $11.00 \times 20$ | 38 | 61 |
| Trk, tractor, $5 \mathrm{~T}, 6 \times 6, \mathrm{M} 52$. |  |  |  |  | 30 | 77 | 10 | 70 | 12 | $11.00 \times 20$ | 52 | 83 |
| Trk, tractor-wrecker, LWB, w/w, 5T, $6 \times 6, \mathrm{M} 246$ |  |  |  |  | 30 | 47 | 10 | 70 | 12 | $11.00 \times 20$ | 52 | 83 |
| Trk, wrecker, med, $5 \mathrm{~T}, 6 \times 6, \mathrm{M} 62 \ldots \ldots \ldots$ |  |  |  | 78 |  | 36 | 10 | 70 | 12 | $11.00 \times 20$ | 52 | 83 |
|  | 513 | 77 | 115 |  | 30 | 68 | 6 | 45 | 12 | $14.00 \times 20$ | 59 | 95 |
| Trk, cargo, $5 \mathrm{~T}, 6 \times 6, \mathrm{M} 54$. | 513 | 57 | 111 | 78 | 30 | 51 | 10 | 70 | 12 | $11.00 \times 20$ | 52 | 83 |
| Trk, cargo, LWB, 5 T, $6 \times 6$, w/w, M54 | 513 | 57 | 111 | 78 | 30 | 51 | 10 | 70 | 12 | $11.00 \times 20$ | 52 | 83 |
| Trk, cargo, 5T, $6 \times 6$, M $55-\ldots-\ldots$ | 746 | 84 | 167 | 78 | 30 | 65 | 10 | 70 | 12 | $11.00 \times 20$ | 152 | 83 |
| Trk, dump, $5 \mathrm{~T}, 6 \times 6$, M51. | 137 | 15 | 30 | 78 | 30 | 70 | 10 | 70 | 12 | $11.00 \times 20$ | 52 | 83 |
| Trk, wrecker, 6T, $6 \times 6$, M1A1 |  |  |  |  | 40 | 54 | 10 | 70 | 12 | $11.00 \times 20$ | 45 | 72 |
| Trk, cargo, 10T, $6 \times 6, \mathrm{M} 125$ |  |  |  | 78 | 30 | 60 | 10 | 90 | 20 | $14.00 \times 24$ | 42 | 67 |
| Trk, tractor, $10 \mathrm{~T}, 6 \times 6, \mathrm{M} 23 \mathrm{C}$ |  |  |  |  |  | 60 | 10 | 90 | 20 | $14.00 \times 24$ | 42 | 67 |
| Trk, tractor, 12T, $6 \times 6, \mathrm{M} 26 \mathrm{~A} 2$. |  |  |  |  | 56 | 30 | 10 | 90 | 20 | $14.00 \times 24$ | 28 | 45 |
| Trk, tractor, 15T, $8 \times 8, \mathrm{M} 194$ |  |  |  |  |  |  |  |  |  |  |  |  |

- Cargo with higher atowage factor does not utilize all of vehicle weight-carrying capacity. Cargo with lower stowage factor does not utilize sll of vehicle cubic capacity.
- Fordability and speed of trailers partly depend upon limitations of the prime mover (see column (2) for proper combinations). After fording, follow instructions contained in the vehicle technical manual.
${ }^{3}$ Assuming good traction.
${ }^{\text {8 G G }}$ Ground pressure (psi): T46E1, 2.08; M29, 2.9; M29C, 1.91; M76, 2.1; M59, 7.1; M75, 8.2; M113, 7.3; LVT(4), 8.5.
(See page 46 for footnotes 1-4.)


### 3.3 Typical Truck Equipment for Motor Transport Units

a. On-Equipment Material (OEM). Equipment listed is typical but subject to change. For exact quantities the latest authorizations must be checked.

| Items $\quad 1 / 4 T$ |  | ck $236 T$ | 6T |
| :---: | :---: | :---: | :---: |
|  | 1 | 1 | 1 |
| Bracket, drum, flammable----------1 | 1 | 1 | 1 |
| Bracket, tool, pioneer equip. | 1 | --- |  |
| Chain, tow, $7 / 16 \mathrm{in}$. $\times 16 \mathrm{ft}$ | - - | 1* |  |
| Chain, tow, $5 / 8 \mathrm{in}$. $\times 16 \mathrm{ft}$. |  | --- | 1 |
| Handle, wheel stud nut...--.--------1 | 1 | 1 | 1 |
| Hose, tire inflation | --- | 1 | 1 |
| Jack, 11/2-ton capacity.........-.-.-.... 1 | --- | --- |  |
| Jack, 3-ton capacity | 1 | 1 |  |
| Jack, 8-ton capacity |  | --- | 1 |
| Pliers, comb, slip joint, 8 in.........- 1 | 1 | 1 | 1 |
| Screwdri ver, common, hv duty, 4 in... | 1 | -- |  |



- Isвued on truck with winch.
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-.------As required by local weather conditions
Extinguisher, fire, 1-qt _-.....As authorized by AR 385-55
Kit, deepwater fording ...... When authorized by theater
Kit, winterization of operations comma nder

## 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.
(1) Highway regulations. 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.

### 3.5 Outline of Standing Operating Procedure for Motor Transpurt 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.
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) (orgn) (phone)
(3) To transport (tons) (type of cargo) (no. pers). Cube $\qquad$ Peculiarities (shape, etc.) From To
(4) Recommended number and type of vehicles
(5) Terminal capabilities. Origin $\qquad$
$\qquad$ Destination ___ Est unload time -
(6) Vehicles report to: (name, rank, title)

Location__. Phone
Time and date: Spot ___ Move $\qquad$ _.
(7) On arrival at destination, report to: (name, rank, titte), location
Phone
c. Coordinating Instructions.
(1) Type commitment:

One-time:__Recurring: If recurring, from $\qquad$ through
(2) Road information:(Apecial routing, weather effecte, limitations, etc.)
(3) Shipment (has) (has not) been coordinated with consignor and consignee, 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. orgn) Phone
(5) Trailer pickup, movement, and delivery schedule.
(spot) (pickup) trailers at origin at (datatime)
Move trailer from to
By date-time
Move trailer from_ to to
By date-time
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:
e. Command and Signal.
(1) Reports required:
(2) Highway clearance requested (date-time), received (datetime), clearance number
(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 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-egress routes is not maintained, the capability of main routes may be limited to the capability of the access or egress facilities.
c. Circulation plans show such information as open, supervised, express, dispatch, and reserved routes; light lines; area boundaries; distance between important points; bridge and other weight limitations; restrictions on speed, density, etc.; and location of dumps, depots, traffic control posts, and regulation points. Road information shown on circulation plans applies throughout the length of road between points shown by the symbol "U."
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.

### 3.8 Bivouac Defense, Truck Company

a Standard Pattern. Company standing operating procedure 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. Figures 3.2 and 3.3 show typical temporary bivouac areas for a light truck company. Figure 3.2 illustrates a situation where there is no guerrilla activity and emphasis is placed upon passive defense. Figure 3.3 depicts a situation in which a light truck company, organized primarily for ground defense to provide some dispersion for defense against air attack, has modified its area to fit the situation and terrain. In both situations, dispersion and camouflage serve as the primary defense against air attack.
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


Figure 3.1. Traffic circulation plan.
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 meters) between trucks or groups. Trucks are camouflaged and parked facing nearest exit road.
d. Mines and Flares. If available and authorized, a protective minefield consisting of fragmen-tation-type antipersonnel mines and trip flares is placed around the outer rim of the perimeter, about 200 yards ( 183 meters) in front of the foxholes and machine-gun 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 and Rocket Launchers and Machine Guns. Grenade and rocket launchers are used to


Figure 3.2. Schematic diagram, typical bivouac area, light truck company-passive defense emphasized.
protect areas most likely or suitable for enemy mechanized attack. Machine guns 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.

### 3.9 Typical Truck Terminal

Figure 3.4 shows a typical truck terminal. Arrangement of facilities may deviate from the illustration, but the facilities indicated should be considered the minimum.

### 3.10 Reconnaissance

a. General. While some of the requirements outlined below may apply only to a particular reconnaissance, the entire list should be used to make sure no important factor is overlooked. In addition, when appropriate, the reconnaissance report should include special items such as weather conditions, information of value to other services, etc. For additional information, see FM 5-36.
b. Route Reconnaissance. This type of reconnaissance, which may be made from a map, is general in nature and is usually accompained by a more detailed road reconnaissance ( $c$ below). The purpose of route reconnaissance is to gain information which will aid in the selection of a route or routes to be used for the movement of troops, troop equipment, and supplies in military operations.


Figure 3.s. Schematic diagram, typical bivouac area, light truck company-organized primarily for ground defense.


A. LOCAL DISPATCH (IN A OUT)
B. LINE•HAUL DISPATCH (IN B OUT)
I. HIGHWAY REGULATION POINT
2. RELEASE AREA
3. REFUELING AREA
4. MAINTENANCE SERVICE
5. READY-TO-ROLL AREA
6. CONVOY FORMATION AREA
7. TRANSPORTATION MOVEMENT OFFICE


Figure 3.4. Typical truck terminal.

The route reconnaissance report includes the following information:
(1) Date of reconnaissance; location and name, or number, of route.
(2) Types of roads and distances between important points.
(3) Type of terrain, including ruling grades of 7 percent or more.
(4) Artificial obstacles, such as minefields, underpasses, narrow roads, narrow or low bridges, and tunnels, curves with radii less than 100 feet, etc.
(5) Natural obstacles, such as swamps, mountains, streams, rivers, and obstacles peculiar to desert, jungle, and arctic areas.
(6) Suitability and location of natural camouflage.
(7) Effect of excessive snow and water and other weather extremes.
(8) Alternate routes available.
c. Road Reconnaissance. Road reconnaissance is performed to obtain the information about existing roads upon which to base road classifications, primarily in support of the establishment of a route. It is concerned with the conditions of existing roads for immediate use and not for maintenance operations. The information obtained is used to estimate the quantity and kind of traffic and loads that a road can accommodate in its present condition. A road reconnaissance carried out by an officer or NCO other than an Engineer may require supplementation by an Engineer reconnaissance to provide additional data necessary for complete classification of the road. Although road reconnaissance should be made on the ground, it may be supplemented by aerial reconnaissance. Road reconnaissance reports are made on DA Forms 1248 through 1252, plus additional sheets as necessary, and are accompained by appropriate data concerning bridges, tunnels, fords, ferries, obstructions, and bottlenecks. The following information is included:
(1) Roads.
(a) Date and time of reconnaissance.
(b) Roadway name, number, and length.
(c) Type, including character of road surface, number and dimensions of useable lanes, width and condition of shoulders, location and degree of curves, and location and percent of grades.
(d) Type and condition of road base and subsoil.
(e) Details of important junctions, access and egress roads, bypass routes, detours, railroad crossings, and railheads.
(f) Details, including dates, of new construction or improvements planned or underway.
(g) Location, type, condition, and restriction of communications facilities.
(h) Condition of terrain, size, and drainage of adjacent areas, including halt, bivouac, and dump sites.
(i) Distances (miles and kilometers) between all important points.
( $j$ ) Location, length, and maximum interval between turnouts or passing places on one-way roads.
(k) Obstructions, such as craters, roadblocks, mines, and destroyed culverts and bridges.
( $l$ ) Defiles and possible bypasses.
(m) Drainage provisions.
( $n$ ) Visibility to enemy ground observers; vulnerability to nuclear weapons.
(o) Traffic statistics, including monthly and annual traffic data by type of vehicle (car, truck, bus, etc.); location, time, and duration of peak loads; restrictions, including maximum permissible load; extent to which road is needed for civilian traffic.
(p) Estimate of operating capacity of the road.
(2) Bridges.
(a) Date and time of reconnaissance.
(b) Name or number of bridge; location; load classification; length and width; clearance (vertical, side, and under bridge).
(c) Type of bridge.

1. Floating. Type of floating element (pneumatic float or boat), spacing between floating elements, means for fastening superstructure, curbs and handrails, roadway width, anchoring of bridge, dimensions, load capacity, maximum speed for crossing, vehicle spacing required, and type of traffic (foot or vehicular).
2. Fixed. Characteristics of stringer, girder, suspension, truss, etc.
(d) Number of spans, length, length of panels, anchoring methods.
(e) Number of lanes and widths of each; separate walkway.
(f) Type of abutments, material, dimensions, type of soil.
(g) Location of dams, locks, and similar structures nearby.
(h) Depth of stream or river, width, current velocity, type of bottom and its bearing capacity, description of banks.
(i) Type of intermediate supports, material, number, location, spacing, sizes and placement of members.
(j) Charges or fares for toil bridges.
(k) Number of stringers per span, type, material, size, spacing.
(l) Safety and security features; bypass conditions.
( $m$ ) Type of flooring material, roadway clearance, thickness, number of layers (for plank floor), and thickness and direction of each layer.
( $n$ ) Description and condition of approaches.
(o) Physical condition of the structure and apparatus, including condition of welding, rivets, bolts; requirements for major repairs or improvements.
( $p$ ) Vulnerability to damage by flood or ice, including possible flanking of abutments by erosion.
(q) Drawbridges: type and dimensions; clearance width(s), allowing for fenders and for navigation of passageway; clearance height of lift spans when raised (specify stage of river); details of operating machinery; practicability of hand operation, including time required to open and close; time required to open and close by machinery; how frequently the span is normally opened; how frequently it would have to be opened to handle water traffic deemed essential under theater policies; availability of trained and trustworthy operators.
(3) Tunnels.
(a) Date and time of reconnaissance.
(b) Route name, number, and section.
(c) Tunnel name, number, or other identification.
(d) Coordinates and distance in miles or kilometers from an easily identified reference point.
(e) Nearest town identifiable on a map or photograph.
(f) Description and condition of approaches.
(g) Type of earth or rock through which tunnel passes.
(h) Type of roadway surface, condition, and traffic lanes.
(i) Truck traffic clearances, including useable roadway width, minimum vertical clearance, minimum radius of curvature, and maximum roadway gradient.
(j) Volume of traffic by type.
(k) Type and adequacy of drainage, lighting (power source), and ventilation (ventilating plant).
(l) Details of repair, storage, and parking facilities within tunnel or vicinity.
( $m$ ) Nature and condition of supporting walls, ceiling, lining, portals, and demolition chambers.
( $n$ ) Detours available and distances involved.
(o) Map, photographic, and basic document references, including design specifications and clearance or cross-sectional diagrams showing overall dimensions and minimum clearances for truck traffic.
(p) Vulnerability to nuclear weapons, including suitability as shelter from these weapons.
(4) Fords.
(a) Date and time of reconnaissance.
(b) Route name or number, name or number of ford, and locations.
(c) Alinement, gradient, and condition of banks and approaches.
(d) Length of ford or width of streambed.
(e) Type of roadway surface, useable width, traffic lanes, and condition.
(f) Depth of water and velocity of current at different seasons. (Good fords are less than 2 feet deep and have less than 3 miles per hour currents.)
(g) Limiting factors (load and speed restrictions, etc.), normal crossing time, and periods unuseable.
(h) Detours and alternate crossing sites, including evaluation of streambed above and below the ford.
(i) General suitability for foot, wheeled, and tracked crossing.
(j) Map and photographic references, plans, charts, and diagrams.
(5) Ferries.
(a) Date and time of reconnaissance.
(b) Location, identification, route name or number, name of terminals.
(c) Water distance between terminals.
(d) Water depths, velocity of current, tide data, and navigational aids and hazards.
(e) Description and condition of approaches.
(f) Possible alternate routes or crossing points.
(g) Name, age, and condition of ferries in service, including statement of capacities in short tons and in number of passengers and vehicles, by sizes.
(h) Technical details of ferry including length, beam, and draft; type of propulsion (poles, oars, pulleys, hand, winches, propellers, etc.); type of power (steam, gasoline, diesel, etc.) and horsepower; fuel capacity and source; method of unloading (side or end); deck dimensions.
(i) Number, type, and efficiency of operating personnel.
(j) Largest and heaviest vehicles or loads handled and techniques employed.
(k) Crossing time (light and loaded) and round-trip time, including loading, unloading, and docking time.
(l) Number of trips actually made per day.
( $m$ ) Effect of seasonal conditions (snow, ice, flood, etc.).
( $n$ ) Periods not operational and causes.
(o) Operating capacity and limiting factors of terminals, including handling, storage, fueling, repair, maintenance, loading or clearance facilities, equipment, and personnel.
( $p$ ) Type of landing (pier, wharf, beach, etc.).
(q) Potentialities for military transportation use.
(6) Additional information. Including information of value to other services, special items, weather conditions at time of reconnaissance, etc.

### 3.11 Route and Road Classification

a. Route Classification. The general classifica-
tion of a route is designed to aid in planning motor transport movements. It includes the minimum width, type, and load capacity of roads and bridges on the route and indicates obstructions and weather effects.
(1) Types of routes. For the purpose of classification, high way routes are classified X, Y , or Z as defined below.
(a) Type $X$ (all-weather). This type of route has strong foundations and a waterproof surface of concrete, bituminous concrete, brick, or stone. With normal maintenance, it can be used all year by a volume of traffic which approximates its dry-weather capacity. The only weather effects which may cause the route to be closed are snow and flood.
(b) Type $Y$ (all-weather). This type usually does not have a waterproof surface and is characterized by moderate foundations and surfaces of crushed rock, waterbound macadam, gravel, or bituminous-surface treatment. With normal maintenance, it can be used all year by a volume of traffic which is considerably less than its dry weather capacity. In addition to the effects of flood and snow, this route is also affected by rain, frost, or thaw. Heavy use during adverse weather conditions may lead to complete failure.
(c) Type Z (fair-weather). A route which quickly fails in bad weather and can only be kept open by major repairs and reconstruction. This type is so seriously affected by rain, frost, and thaw that traffic must be discontinued for long periods. It is characterized by weak foundations and surfaces of natural or stabilized soil, sand, clay, shell, cinders, or disintegrated granite.
(2) Method of classification. The general classification of a route is usually made by the Corps of Engineers, which assesses the classification in accordance with information contained in road classification ( $b$ below). Routes are classified according to width, type, load capacity, obstructions, snow blockage, and flooding.
(a) Width. This is expressed in meters or
feet and refers to the width of the most narrow road on the route.
(b) Type. Type refers to the worst type of $\operatorname{road}(X, Y$, or $Z)$ on the route.
(c) Load capacity. This refers to the maximum class of vehicle which can use the route in convoy; normally, this is the bridge classification of the weakest bridge on the route.
(d) Obstructions. The effect of a single or a temporary obstruction on a route should not be the limiting factor for classifying the route but should be noted in the formula for route classification by the symbol ( Ob ) and described completely in an accompanying report or on an overlay.
(e) Snow blockage. The effects of snow on military traffic depend upon snow clearance capability, which in turn depends upon such factors as the availability of machines and operators and the severity of the season. If snow blockage is regular, recurrent, and serious, the formula classifying the route is followed by ( T ).
(f) Flooding. If flooding is regular, recurrent, and serious, the formula classifying the route is followed by (W).
(3) Examples of route-classification formulas.
(a) $20 \mathrm{ft} Y 50(\mathrm{Ob})$. This describes an allweather route without a waterproof surface which is useable all year for limited traffic only. The route has a minimum width of 20 feet, can accommodate vehicles up to class 50 , and has an obstruction.
(b) $10.5 \mathrm{~m} X 70(T)$. This describes an allweather, first-class route which has a minimum width of 10.5 meters. It can accommodate vehicles up to class 70, but is subject to serious snow blockage.
(c) $7 \mathrm{ft} Z 3(W)$. This describes a poor route that requires good weather for any type of operation. It has a minimum width of 7 feet and can accommodate vehicles up to class 3 , but is subject to serious flooding.
b. Road Classification. A detailed classification of a road is necessary when general route classification will not provide sufficient information for the planner or operator of motor-transport equipment.

Road classification is used for a specific operation and is in addition to the general classification of the route. Basic factors involved and examples of road-classification formulas are shown below.
(1) Basic factors.
(a) Limiting factors. Limiting factors are curves, gradients, drainage, foundation, surface condition, and camber or superelevation as discussed below. Symbols used in classification formulas are shown in parentheses.

1. Curves (c). Sharp curves with radii of less than 100 feet or 30 meters which cause some slowing of convoy traffic. (As discussed in a above, these are are also reported as obstructions.)
2. Gradients (g). Steep gradients of 7 percent and above which cause some slowing of convoy traffic. (These are also reported as obstructions.)
3. Drainage (d). Poor drainage caused by inadequate ditches, crown, or culverts, etc.
4. Foundation (f). Weak foundation caused by unstable, loose, or easily displaced material.
5. Surface (s). A rough surface with bumps, ruts, or potholes which may reduce convoy speed.
6. Camber or superelevation ( $j$ ). Excessive camber or superelevation which falls away so sharply that heavy vehicles may skid or drag toward the roadside.
(b) Width. The width of the road (travelled way) is expressed in feet or meters followed by a slash (/) and the combined width of the travelled way and. shoulders. The shoulders of a road may be classified as unuseable, useable in an emergency, or useable after improvement. A separate note should be made in the report giving the surface of the shoulders (grass, gravel, etc.), condition, width, vegetation, and critical side slopes.
(c) Construction material. Various kinds of materials used for the normal route types ( $X, Y$, and $Z$ ) and the symbols to be used in road-classification formulas are shown below. When normal route type has not been specifically designated as $X, Y$, or $Z$ (road-
classification symbols $r b, n b, b$, or $v$ ), the analyst must make this determination. This will depend primarily upon the condition of facilities along the route. If the $v$ symbol is used, a detailed description of the material must be included.

| Normal route type | Material | Symbol |
| :---: | :---: | :---: |
| X | Concrete | k |
| X | Bituminous or asphaltic concrete (bituminous plant mix). | kb |
| $\cdots \mathrm{X}$ | Paving brick or stone.-------- | p |
| $\mathbf{X}$ or $\mathbf{Y}$ | Bitumen-penetrated macadam and waterbound macadam with superficial asphalt or tar cover. | rb |
| Y | Waterbound macadam, crushed rock, or coral. | r |
| Y | Gravel or lightly metalled.......- | 1 |
| Y or Z | Bituminous-surface treatment on natural earth, stabilized soil, sand-clay or other select material. | nb |
| Z | Natural earth, stabilized soil, sandclay, shell, cinders, disintegrated granite, or other select material. | n |
| X, Y, or Z | Use for bituminous surface when the type of bituminous construction cannot be determined. | b |
| $\mathbf{X}, \mathbf{Y}$, or Z | Material not mentioned above . . | v |

(d) Length. The length of the road is expressed in miles (mi) or kilometers (km). When included in the formula, the figure indicating the length of the road is placed in parentheses next to last item.
(e) Obstructions. In addition to showing an obstruction by ( Ob ) in the classification formula, the following obstructions which affect the traffic capacity of a road are reported, showing details of the obstruction and the location. When possible, these obstructions are shown by symbols on maps or overlays. Symbols conform to those shown in figure 3.5 below.

1. Overhead clearances which are less than 14 feet ( 4.25 meters) for tunnels, bridges, overhead wires, overhanging buildings, trees, or any other obstruction. (In areas where the overhead clearance is other than 14 feet, this other figure must be specified.)
2. Reductions in road widths, such as craters, narrow bridges, archways,
and buildings, which limit traffic capacity. (Critical road widths are specified by the commander concerned.)
3. Excessive gradients ( 7 percent and above) and excessive changes in gradients.
4. Curves which probably cannot be negotiated by heavy vehicles with trailers (radii of less than 100 feet or 30 meters).
5. Fords, indicating length and width of crossing and depth and nature of bottom.
6. Ferries, indicating length and width of crossing and capacity.
(f) Snow blockage and flooding. When these conditions are regular, recurrent, and serious, they are shown last in the road-classification formula as indicated for routes in $a$ above.
(g) Bridge information. Bridge information is reported by the use of appropriate symbols and descriptions on a map or overlay.
(h) Road designation. Civil or military road numbers or other designations should be included in the information reported. On maps or overlays, the road number or other designation is placed as shown in figure 3.5.
(i) Cover. Cover suitable for parking and camouflage should be included in the information reported. When shown on maps or overlays, the symbols used for cover conform to those shown in figure 3.5.
(j) Leaving road. The ability to drive off the road (including shoulders) is included in the information reported. Normally, the information is needed only in conjunction with cover and is indicated by an arrow superimposed on the cover symbol as shown in figure 3.5. It may not be possible to leave the road because of embankments, cuttings, deep ditches, etc.
(2) Road-classification formula. The characteristics of the road are expressed in the order of limiting factors, width, construction material, length (if desired), obstructions, and snow blockage or flooding. The formula is prefixed by the symbol $A$ if
there are no limiting factors and by the symbol $B$ if there are limiting factors. If a limiting factor is unknown, it is expressed by placing a question mark after the appropriate symbol, thus: (f?). On maps and overlays, the terminal points of the road sector described are indicated by the symbol $V$.

## c. Obstruction Symbols.

(1) $A 5.0 / 6.2 m k$. This describes a road with no limiting factors, 5.0 meters wide in the travelled way, 6.2 meters wide including shoulders, and constructed of concrete.
(2) A $12 / 14 \mathrm{ft} \mathrm{kb}(O b)$. This describes a road with no limiting factors, 12 feet wide in the travelled way, 14 feet wide including shoulders, constructed of bituminous concrete, and having at least one obstruction not listed as a limiting factor.
(3) Bgs 14/16 ft 1 (Ob). This describes a road with obstructions (steep gradients above 7 percent), a rough surface, 14 feet wide in the travelled way, 16 feet wide including shoulders, and constructed of gravel or lightly metalled material.
(4) Bc (f?) $3.2 / 4.8 m \mathrm{p}$ ( 4.3 km ) ( Ob ) ( $T$ ). This describes a road with obstructions (sharp curves), unknown foundation, 3.2 meters wide in the travelled way, 4.8 meters wide with shoulders, constructed of paving brick or stone, 4.3 kilometers long, and subject to snow blockage.

### 3.12 Bridge Signs

a. Circular Signs (figs. 3.6 and 3.7). 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. 3.8 and 3.9). 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.

### 3.13 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 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 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 3.10.
c. Determining Vehicle Classes. The class of each standard vehicle and combination can be found in FM 5-36 and other Department of the Army publications on the subject such as training circulars and technical bulletins.

### 3.14 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 Europe.
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. 3.11). 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 2 feet 11.4 inches ( 0.90 of a meter), and, for the reduced size, not less than 1 foot 11.6 inches ( 0.60 of a meter). Signs are not more than 7 feet 2.6 inches ( 2.20 meters) above the ground at the highest point. Away from built-up areas, they are not less than 1 foot 11.6 inches ( 0.60 of a meter) above the ground at the lowest point.


Figure 3.5. Symbols used to represent obstructions.

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 either in the nature of a prohibition or an obligation (fig. 3.12). They are circular with a diameter of at least 1 foot 11.6 inches ( 0.60 of a meter) for
signs of standard size, and at least 1 foot 3.7 inches ( 0.40 of a meter) 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 meters) above the ground at the highest point, and not less than 1 foot 11.6


Figure 3.6. Typical bridge-class and information signs.


Figure 3.7. Typical dual-class bridge signs.
inches ( 0.60 of a meter) 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). 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 (fig. 3.13). These signs have blue backgrounds, except those indicating priority roads which 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 of a meter) for the standard size, and at least 1 foot 3.7 inches ( 0.40 of a meter) for the reduced size. For signs repeated within built-up areas, the side of the square is 9.8 inches ( 0.25 of a meter).


Figure 3.8. Typical arrangement of road-guide, information, and tio-lane bridge-class signs.


Figure 3.9. Typical arrangement of road-guide, information, single-lane bridge-class signs.


Figure 9.10. Vehicle weight classification marking.
(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 meters) and 820 feet ( 250 meters) from the intersection on normal roads. On special roads; e.g., concrete multilane roads, this distance is increased to 1,640 feet (500 meters). 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.

### 3.15 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 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 (par. 3.14) and others not included in the Geneva Convention. Standard signs include hazard signs, regulatory signs, and guide signs. Examples are shown in figure 3.14.
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) or host country's system has a yellow background with the legend or symbol in black. If the sign is included in the International or host country's system, the International or host-country 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. 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, noentry signs, and signs erected by the military for the control of civilians under specified circumstances.
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 described 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 meters) 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


UNEVEN ROAD


DANGEROUS BEND


RIGHT GEND

roao intersection


SLIPPERY ROAD


INTERSECTION WITH NON-PRIORITY ROAD


LEFT GEND


DOUBLE GEND (first to the right)


OPENING BRIDGE


CHILDREN


LEVEL R.R. CROSSING WITH GATES


LEVEL CROSSING WITHOUT GATES (APPROACH SIGN)


DANGEROUS HILL


Figure 3.11. International road signs-danger.


STOP AT INTERSECTION

BICYGLES PROHIBITED



NO RIGHT TURN
no entry for vehicles HAVING OVERALL WIDTH exceeding $\qquad$ meters



STOP. CUSTOMS


NO STOPPING OR WAITING


NO ENTRY FOR VEHICLES HAVING OVERALL HEIGHT EXCEEDING___METERS


NO ENTRY FOR VEHICLES EXCEEDING $\quad$ GROSS WEIGHT


NO ENTRY FOR GOODS CARRYING VEHICLES EXCEEDING $\qquad$ TONS LADEN WEIGHT


NO ENTRY FOR ALL VEHICLES



NO ENTRY FOR ALL VEHICLES EXCEPT MOTORCYCLES W/O SIDECARS

closed TO ALL vehicles

Figure 3.12. International road signs-definite instructions.




PRIORITY ROAD



APPROACH TO END OF
PRIORITY ROAD


FILLING STATION


END OF PRIORITY ROAD

Figure 3.19. International road signs-informative.

## Stockholm 17

## 

DISTANCE SIGNS


LOCALITY SIGNS


DIRECTION
SIGNS
Milestone



B


C


D

SUPPLEAAENTARY RAILWAY SIGNS
IF SIGN A OR SIGN B IS DISPLAYED, IT MUST BE FOLLOWED BY 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 3.13.-Continued.


Figure 3.i4. NATO military road signs.

DIRECTIONAL DISK


STRAIGHT AHEAD


TURN RIGHT

## ROUTE



AXIAL ROUTE 205
TO FRONT, STRAIGHT AHEAD


AXIAL ROUTE 205 TO FRONT, TURN RIGHT


LATERAL ROUTE 202 NORTH-BOUND TRAFFIC TO FRONT, FORK RIGHT


FORK LEFT


SHARP TURN TO RIGHT REAR


AXIAL ROUTE 205
TO REAR, STRAIGHT AHEAD


AXIAL ROUTE 205 TO REAR, TURN LEFT


DETOUR

## CASUALTY EVACUATION ROUTE


(ALL MEDICAL UNITS EXCEPT TURKISH) (TURKISH MEDICAL UNITS)
Figure 3.14.-Continued.
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 crossshaped 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.

### 3.16 NATO Markings for Military Vehicles

a. General. The armed forces of NATO have agreed to use the standard markings for vehicles described below. 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 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. 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 there use.
f. Air-Ground 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 (front lines, 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 mudguards 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. 3.15). A single priority sign may be used if visible from both front and rear. The size of a


Figure 3.15. Vehicle priority sign.
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. Movement Serials.
(1) A movement serial is an element or group of elements within a series which is given a numerical or alphabetical designation for convenience in planning, scheduling, or controlling vehicle movements.
(2) The leading vehicle of each movement serial carries a blue flag.
(3) The rear vehicle in the movement serial carries a green flag.
(4) The vehicle of a movement serial commander displays a flag that is bisected by a diagonal line to form two triangles. The upper triangle is white; the lower is black.
(5) 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.
(6) Flags are approximately 12 inches by 18 inches ( 30 cm by 45.7 cm ).
(7) The number or letter assigned to a movement serial is marked on the front and on both sides of each vehicle in the serial. The marking is placed so that it is clearly visible from the ground and does not interfere with other prescribed markings.
l. Illumination of Vehicle Markings. The condition under which military traffic moves at night is determined by the local command. The enemy threat and, so far as possible, the regulations of the host country are considered when deciding whether the illumination will be normal, reduced, or blacked out. Under normal lighting conditions, the military registration or identification number at the rear of a motor vehicle or trailer is so illuminated that it is readable at a minimum distance of 20 yards ( 18 meters). The local commander prescribes either reduced lighting or blackout when necessary.

### 3.17 Arm and Hand Signals

$a$. The safe operation of motor vehicles often depends upon the driver knowing and using the arm and hand signals shown in figure 3.16.
$b$. The current concept of tacticall 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 double-headed arrow are continuous until acknowledged or executed. For additional information, see FM 21-60.

### 3.18 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.

$$
\mathrm{R}=\frac{\mathrm{D}}{\mathrm{~T}} \quad \mathrm{~T}=\frac{\mathrm{D}}{\mathrm{R}} \quad \mathrm{D}=\mathrm{RT}
$$

## b. Rate Factors.

Rate (yards per minute) $=\frac{\text { length (yards) }}{\text { time length (minutes) }}$
Rate (meters per minute)

$$
=\frac{\text { length (meters) }}{\text { time length (minutes) }}
$$

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.

Time length (minutes) $=\frac{\text { length (yards) }}{\text { rate (yards per minute) }}$

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

Time lead (minutes) $=\frac{\text { lead (yards) }}{\text { rate (yards per minute) }}$

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

[^3]\[

$$
\begin{aligned}
\text { Time gap (minutes) } & =\frac{\text { gap (yards) }}{\text { rate (yards per minute) }} \\
& =\frac{\text { gap (meters) }}{\text { rate (meters per minute })}
\end{aligned}
$$
\]

Time space (hours) $=\frac{\text { road space (miles) }}{\text { rate (mih) }}$

$$
=\frac{\text { road space }(\text { kilometers })}{\text { rate }(\mathrm{kmih})}
$$

Time distance (hours)

$$
\begin{aligned}
& =\frac{\text { road distance }(\text { miles })}{\text { rate }(\mathrm{mih})} \\
& =\frac{\text { road distance }(\text { kilometers })}{\text { rate }(\mathrm{kmih})}
\end{aligned}
$$

d. Distance Factors.

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

(1)

RIGHT TURN

(4) OPEN UP

(2) STOP

(5) CLOSE UP

(3) LEFT TURN

(6) PASS ANO KEEP GOING

Figure 3.16. Driver arm and hand signals.

(1) Go; or Forward; or

Move out; or Increase speed; or Double time. The light is moved several times vertically in front of the body.

(4) Start engine(s). light is so moved as to describe the figure 8 (on its side) in a vertical plane in front of the body of the individual giving the signal.

(2) Turn right. The light is rotated clockwise (from the individual giving the signal).
 light is held at shoulder level and blinked several times toward the vehicle.

(3) Turn left. The light is rotated counterclockwise (from the individual giving the signal).

(6) $\frac{\text { Stop; or Stop engine(s) }}{\text { Tight is moved horizontally }}$ back and forth several times across the path of approaching traffic to stop traffic. The same signal is used to stop engines.

A. ATTENTION

E. MOUNT


1. INCREASE SPEED; OR DOUBLE TIME; OR RUSH

M. MOVE AHEAD; OR JOLN ME; OR FOLLOW ME

Q. HALT; OR STOP

B. ASSEMBLE

F. DISMOUNT

J. DECREASE SPEED (Vehicles)

N. MOVE IN REVERSE

R. CLOSE UP AND STOP

C. READY

G. START ENGINE(S); OR PREPARE TO MOVE

K. RIGHT TURN; OR

O. EXTEND (From Turret, Ground, or Open Vehicle)

S. DISREGARD PREVIOUS COMMAND; OR AS YOU WERE

D. FORWARD; OR TO THE REAR (Vehicles or individusIs turn simultsneously)

H. STOP ENGINE (S)

L. LEFT TURN; OR COLUMN LEFT

P. CLOSE UP (From Turret, Ground or Open Vehicle)

T. VEHICLE OUT OF ACTION

Figure 3.18. Motor march hand and arm signals.

Road space (miles) $=$ rate ( mih )
$X$ time space (hours)
Road space (kilometers) $=$ rate (kmih)
$\times$ time space (hours)
Road distance (miles) $=$ rate (mih)
$\times$ time distance (hours)
Road distance (kilometers) $=$ rate (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 travelled can be quickly determined from a time-distance graph (fig. 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 travelled 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 travelled.
(3) Determining the point at which these two
lines intersect and reading the distance in miles or kilometers from the scale along the bottom (miles) or top (kilometers) margin of the graph. For this example, the distance travelled would be 30 miles ( 48.27 km ).

## f. Conversions.

(1) The following factors may be converted into distance, rate, or time by arithmetic:
Length + gap = lead
Time length + time gap = time lead
Distance (miles) $\times 1,760=$ distance (yards)
Distance (kilometers) $\times 1,000$

$$
=\text { distance }(\text { meters })
$$

Time (hours) $\times 60=$ time (minutes)
Rate (mih) $\times 30=$ approximate rate or speed (yards per minute)
Rate (kmih) $\times 17=$ approximate rate or speed (meters per minute)


Figure 3.19. Space and time factors.


Figure 3.20. Time-distance graph.
(2) These factors are substituted in the basic formulas in $a$ through $d$ above. For example:

Time length (minutes)

$$
\begin{aligned}
& =\frac{\text { miles } \times 1,760}{\operatorname{mih} \times 30} \\
& =\frac{\text { kilometers } \times 1,000}{\text { kmih } \times 17}
\end{aligned}
$$

Speed (yards per minute)

$$
=\frac{\text { miles } \times 1,760}{\text { hours } \times 60}
$$

Speed (meters per minute)

$$
=\frac{\text { kilometers } \times 1,000}{\text { hours } \times 60}
$$

### 3.19 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 purpose the average length of 1 motor transport vehicle is 10 yards (approximately 9 meters).

### 3.20 Road-Movement Graph

a. Definition. 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 kilometers) on the vertical scale), leaving 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 line representing the place of departure (Mount Royal at 25 miles 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) and at the destination (1130) will be shown the schedule of the tail of the column past all points on 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, 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) Time length. A horizontal line connecting the head and tail lines, measured by the scale of hours, will show the planned time length 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 con-
-. gestion 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:
(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 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.


Figure 3.21. Road-movement graph.
(d) Serial C. At 1200 it became obvious that if serial C continued on schedule it would conflict with the delayed lateral movement at about 1730 . Serial C also had lost priority, because of the arrival of serial Bat Dundalk with critically needed supplies. Therefore, serial C was halted for 2 hours ( $1200-$ 1400). It continued at a slower rate of march until 1700 , 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.

### 3.21 Traffic Density

$a$. Traffic density is the average number of vehicles occupying a specified length of roadway at a given instant or the number of vehicles passing a given point at constant speed in a specified period of time. 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:

| $\frac{1 \text { mile in yards }}{\frac{\text { Desired intervehicular gap in yards }}{+ \text { avg length of } 1 \text { veh }}}$ | $=$vehicles <br> per mile |
| :---: | :---: |
| $\frac{1 \text { kilometer in meters }}{\text { Desired intervehicular gap in meters }}$ |  |
| + avg length of 1 veh |  |$\quad$| vehicles |
| :---: |
| ometer |

EXAMPLE: If vehicles are dispersed every 100 yards ( 91.4 meters), 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:



Figure 3.22. Deviations from schedules.
\(\left.\frac{1 kilometer in meters}{\frac{Speed in kmph \times speedometer multiplier)}{}}=\begin{array}{l}veh <br>

per avg length of 1 veh\end{array}\right)\)| kilo- |
| :--- |
| meter |

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:

$$
\frac{1,760}{(20 \times 2)+10}=35 \text { vehicles per mile }
$$

$\frac{1,000}{(32.19 \times 1.2)+9}=21$ vehicles per kilometer
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:

Vehicles per hour passing point
Speed in miles per hour

Vehicles per hour passing point
Speed in kilometers per hour

$$
=\text { vehicles per kilometer }
$$

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

$$
\frac{1,000}{20}=50 \text { vehicles per mile }
$$

$$
\frac{1,000}{32.19}=31 \text { vehicles per kilometer }
$$

### 3.22 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
$\qquad$
Operation Order No. $\qquad$
Maps

| 1. Average speed <br> 2. Traffic density <br> 3. Halts |  | 4. Routes (between start points and release points may be indicated by code-red, green, etc.) | 5. Critical points ${ }^{1}$ <br> a. Start points <br> b. Release points <br> c. Other critical points |  |  | 6. Main routes to start points <br> 7. Main routes from release points |  |  | These routes and points are here described by grid references, codewords, etc., and if necessary, numbered or lettered for ease of reference in the columns below. |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Numb | Load |  |  |  | Rout | Critical | oints ${ }^{1}$ |  | Route |  |
| Serial: ${ }^{2}$ <br> (a) | Date <br> (b) | Unit/Formation <br> (c) | of of <br> (d) | heaviest vehicle <br> (e) | From <br> (I) | (g) | Route | to start point <br> (i) | $\underset{(\mathrm{j})}{\text { Location }}$ | Due $\left(\begin{array}{l}\text { (h) } \\ \text { (k) }\end{array}\right.$ ( | $\underset{\substack{\text { Clear } \\(\text { (1r) } \\ \text { (1) }}}{\text { ctic }}$ | release point (m) | Remarks' <br> ( n ) |
| 1 | 1 Sep |  | 142 | 21 | Alfa | Bravo | Red | 71 | RJ 620 (SP) CR 212 CR 427 CR 442 (RP) | 0001 0021 0041 0118 | 0019 0039 0059 0136 | 11 | None |

 ment may occur or where timing is critical.
${ }^{2}$ A movement serial ia defined as an element or group of elements within a series and in this tahle has a numerical deaignation for convenience in planning, scheduling, or control of movement.
3 Information which is common to two or more serials will be given in the beginning of the table, items 1-7.
SAMPLE ROAD MOVEMENT TABLE
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.

### 3.23 Combined Order, Log, and Strip Map

 (fig. 3.23)In some situations it may be advantageous to combine on one sheet an operation order, a log of road movement, and a strip map, as shown in figure 3.23 .

### 3.24 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.

1. Where is start point?

Release
point?
2. What route is to be used?
3. Has reconnaissance been made and condition of route determined?
4. Can bridges and defiles safely accommodate all loaded and/or tracked vehicles?
5. Are critical points known and listed on strip maps?
6. Has the size of serials been determined?
7. Has the size of march units been determined?
8. What will be the rate of march?
9. What is the vehicle interval on open road?

In built-up areas? .-. . . . At halt?
10. Type of column
11. Has provision been made for refueling, if required?
12. Has a suitable bivouac site been selected, if required?
13. Have suitable rest and mess halt areas been selected, if required?
14. Is road-movement table needed? Prepared? Submitted?
15. Have convoy clearances been obtained? . - . . What number? . . . . What date?
16. Is escort required and has it been requested?
17. Are spare trucks available for emergencies?
18. Are vehicles fully serviced, clean, and ready for loading?
19. Is load proper, neat, and balanced?
20. Are drivers properly briefed?

By whom, when?
Strip maps furnished?
21. Is convoy marked front and rear of each march unit?
22. Are guides in place? Have arrangements been made to post guides?
23. Are blackout lights functioning?
24. Are maintenance services alerted?
25. Is maintenance truck in rear?

Are medics in rear?
Plan for
casualties?
26. Are all interested parties advised of ETA?
27. Is officer at rear of convoy ready to take necessary corrective action, such as changing loads, investigating accidents and unusual incidents? - --------------- Who is trail officer?
28. Is there an entrucking plan?

Who is responsible?
29. Is there a detrucking plan?

Who is responsible?
30. Has a plan been made for feeding personnel?
31. Have times been established for entrucking or loading?
32. Has time been established for formation of convoy?
33. Have times been established for detrucking
or unloading?
34. Has time been established for releasing trucks?
Who is responsible?
35. Is there a carefully conceived plan known to all personnel in the convoy that it can be used in case of attack?

36. Is a written operation order on hand, if required? $\qquad$

Opno I
Map: Strip map.
CI Na. 5-080109
2420 Trans Co
l. (d) No change.
(D) 400TT bn displ vic Melun.
2. 2420TTCo displ vic Melun $a$ Mov cl I and $Y \sup$ FWD.
3. (d) See $\log$ of march.
(b) Ist plat loaded w/ cl I.
(c) 2d plat looded w/ cl l .
(d) 3d plat looded w/ cl V.
(e) Max speed $35 \mathrm{mph}(56.3 \mathrm{Kmph}$ ).
(f) SP-100724 Mar CR 108.
4. (a) SOP.
(b) Medics afchd trail.
5. (a) SOP.
(b) CP head 2d plat

Acknowledgment. Whith Capt.
$\qquad$
Note: On strip mop, Kilometers are shown in parentheses.


Figure 3.28. Sample combined order, log, and strip map.
37. Will a log of road movement be required at end of trip?
Are the necessary forms on hand?
38. Has weather forecast been obtained?
39. Do all personnel have proper clothing and equipment?
40. Is there a communications plan?

### 3.25 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) 4401 Trans Co (Lt Trk) |  |  |
| 7A26FEB23 | Twelve $21 / 2$-ton | 16 Feb 62 |
| (Convoy No.) | (No. and type of task vehicles) | (Date) |
| TIME: |  |  |
| Convoy departed SP.------- 0621 |  |  |
| Convoy departed 1st loading point.-.-.-.-.-------- 0800 |  |  |
| Convoy arrived at 1st loading point.--------------- 0630 |  |  |
| Time at ist loading point...-.-.---.-. 1 hr .30 min . |  |  |
| Arrived at HRP..-----.-.-- 1200 |  |  |
| Departed HRP.---------- 1205 |  |  |
| Departed 1st unloading point 1245 |  |  |
| Arrived at 1st unloading point.-.-.-.-.-.-.-.-.-.-.-. 1212 |  |  |
| Time at 1st unloading point. $-\ldots .-\ldots . .-33 \mathrm{~min}$. |  |  |
| SUPPLIES AND PERSONNEL: |  |  |
| Cargo (short tons).----.-. . 50.2 |  |  |
| Class of supplies..---.-.-.... |  |  |
| Personnel---------------- 0 |  |  |
| DISTANCE:* |  |  |
| Speedometer reading of lead <br> vehicle (1st loading pt)....-21, 324 |  |  |
| Speedometer reading of lead <br> vehicle (SP) ................21, 322 |  |  |
| Total forward (no load) -...----.-.----- 2 |  |  |
| Speedometer reading of lead <br> vehicle (1st unloading pt) _ 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 unload- |  |  |
|  |  |  |
| ing point. |  |  |

## RETURN LOAD

## TIME:

Departed 2d loading point_-- 1300
Arrived at 2d loading point (same as 1st unloading


Time at 2d loading point................. 15 min .
Departed 2d unloading point----....-.-.....-.-. 1415
Arrived at 2d unloading point------------------- 1400
Time at 2 d unloading point.-.-................ 15 min.
SUPPLIES AND PERSONNEL:
Cargo (short tons).......--- 10
Class of supplies.---........- II \& IV
Personnel.-.-------.-...---- 120
DISTANCE:*
Speedometer reading of lead vehicle (2d unloading pt)._ 21,396
Speedometer reading of lead vehicle ( 2 d loading pt) $\ldots$... 21,381
Total return (loaded)
Speedometer reading of lead vehicle (SP) - ---------.-. 21, 436
Total return (no load)....-................ 40
REMARKS:
Road in excellent condition between 2d loading point and SP

ROUND-TRIP DATA
TIME:
Time returned to SP
Total round-trip time.--------------10 hr. 33 min.
Total travel time (including
halts)----------------------------- 8 hr .


SUPPLIES AND PERSONNEL:
Cargo (short tons of C1 I).-- $\quad 50.2$
(short tons of C1 II
\& IV).----------- 10
Personnel.-.--------.-.-.-.-. 120
DISTANCE:*
Total distance (loaded) .--.-. $\quad 72$
Total distance (unloaded) . - $\quad 42$
Total round-trip distance..-- 114
REMARKS:

* Distances shown are in miles (multiply by 1.609 to convert to kilometers). Average rate of march $=14.2$ $\mathrm{mih}=22.9 \mathrm{kmih}$. Ton-miles: Forward-2,861; Re-turn-150. Passenger-miles: Forward-0; Return1,800.
$\frac{\text { s/Thomas A. Young }}{\text { (Signature-convoy commander) }}$
$\frac{\text { 2d Lt. } 4401 \text { Trans Co (Lt Trk) }}{\text { (Rank or grade and organisation) }}$


### 3.26 Convoy Clearance

A convoy clearance request is usually required from a unit or organization that is planning a move by convoy. The information required varies according to local SOP's 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: 40 Off 98 EM
Total No. of vehicles: 51 trks, 31 tlrs
Type and number of vehicles: $381 / 4$-ton trks, $251 / 4$-ton tlrs, 3/4-ton trk, $411 / 2$-ton trks, 8 21/2-ton trks, 61 -ton tlrs
No. of serials: 3
Vehicles by type and number in serials (do not show control, mess, or maintenance vehicles):
(1) $221 / 2$-ton trks, $121 / 4$-ton trks, $11 / 2$-ton trk, 21 -ton tlrs, $81 / 4$-ton tlrs
(2) Same as 1st serial
(3) Same as 1st serial

Intervehicular gap: $\quad \frac{60}{\text { (yarda) }} \quad \frac{55}{\text { (metera) }}$
Average length of vehicles and/or combinations:


Cargo and tonnage ${ }^{1}$ : 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: $20 \quad 32$
Scheduled halts: 15 min . RJ 261; 1 hr Kennedy; 15 min . Kleburg
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 at 261015 Oct 61 . Clearance granted by Lt Brown, office of staff transportation officer at 261230 Oct 61 .

[^4]| Critical points: | Name of Polnt | ETA | ETD |
| :---: | :---: | :---: | :---: |
|  | RJ 261 | 0900 | 0915 |
|  | Kennedy | 1215 | 1315 |
|  | Kleburg | 1615 | 1630 |
|  | Exeter | 1900 |  |

Remarks²: 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's and with all highway regulation and control procedures issued by competent authority.

s/George A. Harkins<br>(Signsture)<br>GEORGE A. HARKINS<br>Name (printed or typed)<br>Capt, S3 1429 TTBn<br>Grade, title, and organization

### 3.27 Traffic Headquarters

a. Mission. The traffic headquarters regulates traffic that is moving into and out of the corps and division areas. It coordinates routes and schedules in order to obtain schedules to pass convoys into the army rear. Lateral traffic is coordinated by the traffic headquarters involved. The higher headquarters settles disputes in any schedule conflict.
b. Functions. The traffic headquarters coordinates the movement of all units assigned or attached; maintains liaison with traffic headquarters of higher and lower commands; prepares the traffic circulation plan and the motor transport portion of other plans and orders issued by the headquarters; and prepares and maintains up-todate road-movement tables to support army, corps, or division emergency plans.
c. Organization. The transportation officer at army headquarters has operational control of the Army traffic headquarters. Transportation officers at corps and division levels have operational control over their respective traffic headquarters, and each is under the supervision of the appropriate higher headquarters. The traffic headquarters is organized by the staff transportation officers at all three levels and comes under the general staff supervision of the G-4.

### 3.28 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.

[^5]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

5. LIMITATIONS (SPECIAL SCHEDULING): (a) LGTH NA (b) WIDTH NA (c) HGT NA (d) WGT NA
6. (a) No. SERIALS 3 (b) INTERVAL 5 min . (c) No. MARCH UNITS 9 (d) INTERVAL 2 min (within serials)
(e) TIME LENGT $\overline{\mathrm{H}} 28 \mathrm{~min}$. (f) RATE OF $M A R C H 20 \mathrm{mih}$ (g) TYP $\bar{E}$ CARGO None (training mission)
(h) TONS None
7. CONVOY COMMANDER 1st Lt James E. Brown
8. ROUTE AND SCHEDULE

| (a) Critical points | (b) A rrive | (c) Clear | (d) Route | (e) MP escort 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:
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)
```


### 3.29 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 it won't 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, or rain.
(5) If possible, place barrels and drums on their sides-parallel with the length of the truck-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.


WRONG


RIGHT

The right vehicle for the right job.


WRONG
This overloads trailerrear wheels, brakes won't 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, frame won't twist and loosen crossmember rivets.


WRONG


RIGHT

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

Figure 3.24. How to load a truck.
(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.

### 3.30 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.
a. Local and Line Hauls.

| Type of equipment | Avg load veh trip | Loading loading time (hr) trip | Local haular |  |  | Line hauls |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Avgdistanceforward |  | $\begin{aligned} & \text { Round } \\ & \text { trips } \\ & \text { per veh } \\ & \text { per day } \end{aligned}$ | Distancein the in thehr |  | Avg daily distance capsbility |  |
|  |  |  | Mi | Km |  | Mi | Km | Mi | Km |
| Truck, carg : |  |  |  |  |  |  |  |  |  |
| $21 / 2 \mathrm{~T}, 6 \times 6$. | 4 tons | 21/2 | 15 | 24 | 4 | 15 | 24 | 125 | 201 |
| $5 \mathrm{~T}, 6 \times 6$ | 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, 4 W | 5,000 gal. | 21/2 | 15 | 24 | 4 | 15 | 24 | 125 | 201 |
| Refrg, 71⁄2T, 2W | 6 tons | 21/2 | 15 | 24 | 4 | 15 | 24 | 125 | 201 |
| Low-bed wrecker, 12T, | 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 |

[^6]b. Payload Capacities.

| Type of equipment | Maximum cargo loads |  | Men$w /$ indiv equip-ment |
| :---: | :---: | :---: | :---: |
|  | Off road | Highway |  |
| Truck, cargo: |  |  |  |
| $21 / 2 \mathrm{~T}, 6 \times 6$ | 21/2 tons | 5 tons | 16 |
| $5 \mathrm{~T}, 6 \times 6$ | 5 tons | 10 tons | 18 |
| Semitrailer: |  |  |  |
| 12T, S\&P | 12 tons ${ }^{\text {b }}$ | 18 tons | $50^{\circ}$ |
| Gas tank, 12T, 4W .-. | $3,000 \mathrm{gal}$. | $5,000 \mathrm{gal}$. | NA |
| Refrg, $71 / 2 \mathrm{~T}, 2 \mathrm{~W}_{\text {-....- }}$ | 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 |

- Does not include driver. For diatance greater than 75 miles, the figure should be reduced.
b Not generally used for this type operation.
- Recommended for emergency use only.
c. Vehicle Availability. In advance highway transport planning, availability means the average number, or percent, of vehicles is a unit that
d. Capabilities of Truck Compal ies.
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.

| Unit | Task vehiclesassigned assigned | Vehicle availability |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Advance planning ${ }^{1}$ | $\begin{gathered} \text { Target } \\ (24-\text { hour } / \\ \text { day) } \end{gathered}$ | Spot taeks |
| 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 number | 75\% | $83 \%$ | 95\% |

${ }^{1}$ Also used when involved in particularly rigorous operations remote from adequate maintenance, or when actual operating conditions cannot be determined.
1 With well trained and disciplined personnel, good operating conditions, and adequate maintenance support.

| Type of equipment | Type haul |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Locals |  | Line ${ }^{\text {b }}$ |  |  |
|  | $\begin{gathered} \text { Short } \\ \text { tong } \\ \text { daily } \end{gathered}$ | Metric tons daily | Short ton-miles daily | Metric ton- <br> kilometers daily | Short tonkilometers daily |
| Truck, cagro: |  |  |  |  |  |
| $21 / 2 \mathrm{~T}, 6 \times 6$ | 720 | 653 | 22,500 | 32,843 | 36,180 |
| $5 \mathrm{~T}, 6 \times 6$. | 1,080 | 980 | 33,750 | 49,264 | 54,270 |
| Semitrailer: |  |  |  |  |  |
| 12T, S\&P. | 2,160 | 1,960 | 67,500 | 98,528 | 108,540 |
| (ras tank, 12T, 4W- | 900,000 gal. ${ }^{\text {c }}$ | 3,406, 500 | 84,375d | 123,161 | 135,000 |
| Refrg, 71/2T, 2W. | 1,080 | 980 | 33,750 | 49,264 | 54,270 |
| Low-bed wrecker, 12T, 4W. | 40 large missiles ${ }^{\circ}$ |  | 20 large missiles ${ }^{\circ}$ |  |  |
| Tank trans, 50T--------- | 3,600 | 3,266 | 81,000 | 118,234 | 130,500 |

a Based on vehicle availability $\times$ avg load per veh trip $\times$ round trips per veh per day.
b Based on vehicle availability $\times$ avg load per veh trip $\times$ avg daily distance capability.

- Tonnage figures not applicable.
d Based on liquid POL weighing $6 \mathrm{lb}(2.7216 \mathrm{~kg})$ per gal.


### 3.31 Vehicle Unitized-Load Capacities

| Load | Vehicle |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | 21/9 ${ }^{\text {c }}$ cargo truck ${ }^{\text {a }}$ |  | 10 T stake and platiorm trailer |  |
|  | Sides in place, crane-loaded | Sidea removed, fork-lift-loaded | Sides in place, crane-loaded | Sides removed fork-lift-loaded |
| Cargo net | 3 | Not recommended | 6 | Not recommended |
| Cargo transporter, type 2 | 1 lengthwise | 1 lengthwise | 3 lengthwise | 4 crosswise ${ }^{\text {b }}$ |
| Stevedore pallet. | 2 crosswise | 4 lengthwise | 6 crosswise | 8 lengthwise: 2 rows of $4^{\circ}$ |
| Unitized pallet. | 3 crosswise | 5: 4 leng thwise; 1 crosswise. | 7 crosswise | 10 leng thwise: 2 rows of $5^{\circ}$ |
| Warehouse $4 \times 4$ pallet. - | 3 | 3 | 6 | 12: 2 rows of 6 |

[^7]

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 rear axle 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

Figure 3.24.-Continued.

### 3.32 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 meters) 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 meters) 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. Routes selected, if possible, 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 before transporting in temperatures below $32^{\circ} \mathrm{F}$. If necessary, insulated vans must be used.

### 3.33 Vehicle Alissile-Carrying Capobiliiies

The missile-carrying capabilities of certain types of vehicles normally found in highway units are given in $a$ and $b$ 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. Subparagraph $c$ shows some of the special equipment used to transport one complete round or the major components thereof. In the tables, column A indicates the number of packaged missiles or indicated component 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).

| Vehicles | $\begin{aligned} & \text { Nike- } \\ & \text { Ajax } \end{aligned}$ |  | $\underbrace{\substack{\text { Nercules }}}_{\text {Nike- }}$ |  | ${ }_{\text {Little }}$ |  | Lacrosse |  | Sergeant |  | $\begin{gathered} \text { Honest } \\ \text { John } \\ \text { (M31) } \end{gathered}$ |  | Corporal |  | Pershing |  | Redstone |  | SS-10 |  | SS-11 |  | Mauler |  | Hawt |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B |
| Trailer: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cargo, 1/4T, 2W, M100. |  |  |  |  | -- |  |  |  |  |  |  |  |  |  |  |  |  |  | 2 | 1 | 2 | 1 |  |  |  |  |
| Cargo, 1T, 2W. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 6 | 1 | 8 | 1 | 14 | 1 |  |  |
| Cargo, 11/2T, 2W, M104 |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  | 16 | 1 | 14 | 1 | 21 | 1 |  |  |
| Flat-bed, guided missile, M261, 3, 245 lb |  | 2 |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  | 17 | 1 | 20 | 1 | 23 | 1 | 1 | 1 |
| Truck: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cargo, $21 / 2 \mathrm{~T}, 6 \times 6, \mathrm{M} 35 \ldots$ |  |  |  |  | 2 | 1 |  | 2 |  |  |  |  |  |  |  |  |  |  | 26 | 1 | 28 | 1 | 35 | 1 |  |  |
| Cargo, 21/2T, $6 \times 6, \mathrm{M135}$. |  |  |  |  | 2 | 1 |  | 2 | ---- |  |  |  |  |  |  |  |  |  | 20 | 1 | 20 | 1 | 35 | 1 |  |  |
| Cargo, 5T, $6 \times 6$ M 54 |  |  |  | 3 | 2 | 1 | 1 | 1 |  | 2 | 1 | 1 |  |  |  | 4 |  |  | 30 | 1 | 32 | 1 | 74 | 1 | 3 | 1 |
| Cargo, 5T, $6 \times 6, \mathrm{M} 55{ }_{\text {- }}$ | 1 | 1 |  | 3 | - 4 | 1 | 1 | 1 | ---- | 2 | 1 | 1 |  |  | -- | 3 | --- |  | 48 | 1 | 48 | 1 | 71 | 1 | 3 | 1 |

b. Transportation Medium Truck Company (TOE 55-18).

Semitrailer:
6T, 2W, S\&P, M118.
10T, 2W, S\&P
Cargo, 12T, 4W, M127
Low-bed wrecker, 12T, 4W M269
Low-bed wrecker, 12T, 4 W , M270----.-.----------
Low-bed, 25T, 4W, M172

| 1 | 1 |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | 1 | 1 | 1 | 6 | 1 | 2 |
| 2 | 1 | 1 | 1 | 6 | 1 | 3 |
| 2 | 1 | 1 | 1 | 10 | 1 | 4 |
| 4 | 1 | 1 | 1 | 10 | 1 | 4 |
| 4 | 1 | 1 | 1 | 12 | 1 | 3 |

c. Special Transport Equipment. ${ }^{2}$

Trailer, rocket, XM449
Truck, $21 / 2$ T, $6 \times 6$, M45E3, with launcher, XM398E1
Semitrailer (Sergeant warhead and forebody)
Semitrailer (Sergeant motor), guidance, and fin)
Truck-mounted launcher, M289 (Honest John rocket)

| Vehicles | NikeAjax |  | NikeHercules |  | Little John |  | Lacrosse |  | Sergeant |  | Honest John <br> (M31) |  | Corporal |  | Pershing |  | Redstone |  | SS-10 |  | SS-11 |  | Mauler |  | Hswk |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B |
| Truck-mounted launcher, M386 (Honest John rocket) |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Erector, self-propelled, M2 (Corporal) |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| Erector-launcher, GM transporta- <br> ble (Pershing) |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| Redstone missile transporter (warhead unit) ${ }^{3}$. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |
| Redstone missile transporter (thrust unit) ${ }^{3}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |
| Redstone missile transporter (aft unit) ${ }^{3}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |

I Requires special authorization. Normslly asaigned to Ordnsnce specisl smmunition companles.
${ }^{2}$ Equipment shown does not include all ground servicing equipment.
 than $21 / 2$-ton trucks are not recommended.

### 3.34 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 to be lifted
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 $X$ 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:

$$
\left.\begin{array}{l}
\begin{array}{rl}
12= & \text { tons per vehicle } \\
45= & \text { vehicle availability per company } \\
20 & =\text { hours operating time daily } \\
10 & =\text { miles in the hour }
\end{array} \\
1=
\end{array} \quad \begin{array}{rl}
\text { (average } 1 \text { terminal per } 125 \text { miles) }
\end{array}\right\}
$$

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:

$$
4=\text { tons per vehicle }
$$

$45=$ vehicle availability per company
$20=$ hours operating time daily
$2.5=$ hours for loading and unloading
$16=$ ḳilometers in the hour
First, compute operating turnaround time:
$\mathrm{TT}=\frac{\text { round trip distance }}{\text { rate of march }}+$ loading and unload -

$$
\begin{aligned}
\text { ing time } & =\frac{52}{16}+2.5 \\
= & 5.75 \text { hours }
\end{aligned}
$$

Then, substitute in the formula:

$$
\frac{5,000 \times 5.75}{4 \times 45 \times 20}=7.9 \text { or } 8 \text { companies }
$$

### 3.35 Mołor Movement in Snow

Depth of anow
(inches)
3
9
6-18

18 or more

Special measures required for movernent
None.
Rear chains.
Chains on all wheels; traction devices on leading vehicles to break the trail. Under some snow conditions, a snowplow may be required to break a path for wheeled vehicles.
Snowplow required.

### 3.36 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 actualexperience figures are not available.

|  | Minutes |  |
| :---: | :---: | :---: |
|  | Daylight | Darkness |
| Class I |  |  |
| Unloading rations for one division at class I distributing point and prepare for distribution to battle groups or units of similar size. | 100 | 125 |
| Distribution of class I supplies to battle group or unit of similar size by higher echelon at one distributing point. ... | 20 | 20 |
| Distribution of class I supplies to separate battalion or unit of similar size by higher echelon. | 15 | 15 |
| Preparation of 1 day's class I supplies for issue at battle group or battalion class I distributing point. | 30 | 45 |
| Physical distribution by battle group or battalion supply agencies of 1 day's class I supplies (transfer of loads) to kitchen | 15 | 20 |
| Unloading kitchen equipment from trucks, set up, and be prepared to begin cooking (or vice versa).-.-.-.- | 20 | 20 |
| Breakdown of subsistence into three meals at kitchen (breakdown accomplished by mess personnel) $\qquad$ | 15 | 20 |
| Preparing, cooking, and being ready to serve a hot meal, starting with a hot kitchen. (Issue of subsistence for cold noon meal included if hot meal being prepared is breakfast.) | 120 | 150 |
| Serving a hot meal to troops from a kitchen truck with majority of men being served at the truck | 45 | 60 |
| Serving a hot meal to troops by means of carrying parties (when kitchen is located within a 1,000 -yard radius of company) | 90 | 120 |
| Class II and IV* |  |  |
| To load $21 / 2$-ton trucks at distributing or supply points: |  |  |
| Class II and IV . | 30 | 30 |
| Fortification materials, class IV .-- | 50 | 50 |
| To load $11 / 2$-ton trailers: Class II and IV | 12 | 12 |
| Fortification materials, class IV Class $V^{*}$ | 30 | 30 |
| To load $21 / 2$-ton trucks at ammunition distributing or supply points. | 30 | 50 |
| To load $11 / 2$-ton trailers. | 12 | 30 |
| To unload $21 / 2$-ton ammunition vehicles. | 15 | 30 |
| To unload 11/2-ton trailers. | 6 | 12 |

- When trucks and trailers are overloaded, increase the time by the percentage of the overload.


### 3.37 Water Supply

a. Water Requirements. Values given are for planning purposes in temperate zones. For extremes of heat or cold, requirements vary considerably.

| Truck | Terrain | Gallons per day |
| :---: | :---: | :---: |
| $21 / 2$-ton, $6 \times 6 \ldots$ | Level, rolling. | 1/2 |
|  | Mountainous. | $1 / 2$ to 1 |
| 5-ton, $6 \times 6 \ldots$ | Level, rolling. | 1 |
|  | Mountainous... | 1 to 2 |

b. Vehicle Carrying Capacities. A full 5-gallon water can weighs 50 pounds; the volume of the can is 1.4 cubic feet.


### 3.38 Highway Capability Estimates

a. Definitions. The following definitions are applicable to this discussion of capacity and capability:
(1) 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.
(2) 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 casualities, driver changes, and essential preventive maintenance en route.
(3) Practical daily capacity. The maximum number of vehicles that can pass over a highway per day, considering highway characteristics and operating conditions.
(4) 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. 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 and $d$ 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 the table in $e$ below may be used when specific and detailed highway information is not available.
c. Basic Factors.
(1) Surface type (table I). The types of road surfaces and basic and operational capacities are shown in table I. 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.
(2) Surface and shoulder width (table II). 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 II-A is used if the widths of the surface and shoulder are not given separately and the width of the travelled way only is known. This may
occur in connection with gravel or earth roads.
(3) Curve and gradient (table III). 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 ratio of the vertical rise to the horizontal distance travelled. The ruling grade of a road is the gradient used.
(4) Moisture and temperature (table IV). 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 IV and VI 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.
(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 II 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 I are for all traffic, the ad-
justed 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 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 II.
(6) Operational.
(a) Turning and cross movements. Although the turning and cross movement factors varies 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 is usually determined by the hours of daylight or darkness. In no case should the running time for a 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, this is normally 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 $V$ can be used.

## d. Making the Estimate.

(1) General. Since conditions dictate the factors which must be used when esti-
mating a highway's capacity, the analyst must consider each probelm separately. In some situations 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 I) successively by each of the following factors that is applicable: width of surface and shoulder, curve and gradient, moisture and temperature, base thickness, and operational. 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: Working hours in day 24
2. If making a strategic-type 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: Daylight hours in day 24
Adjust the figure further to show movement in one direction only by dividing by 2 if a two-way movement. If movement is one-way, no further reduction is necessary since the all-traffic 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 is 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 VI).
(3) Highway capability checklist. In order to eliminate or minimize the omission of important considerations when estimating highway capability, the following checklist may be used as a guide.
(a) Technical planning information.
3. Origin and destination.
4. Surface type and width.
5. Vehicle type and average load.
6. Shoulder type and width.
7. Base type and thickness.
8. Alinement (curvature and gradient).
9. Subsoil type and condition.
10. Traffic and bridge data.
(b) Planning guide factors.
11. Operational or basic capacity (vehicles per day).
12. Surface and shoulder width.
13. Curve and gradient.
14. Pavement deterioration (moisture and temperature).
15. Base thickness.
16. Operational factors.
(c) Planning estimate.
17. Practical daily capacity (vehicles per day).
18. Capability (short tons per day).
(4) Examples. (Slide-rule calculations are sufficiently accurate for these estimates.)
(a) Bituminous-surface treatment.
19. 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 bitumi-nous-surface treatment is 16,900 vehicles per day (table I). 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 II) 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 III). The moisture factor is 0.6 for bituminous-surface treatment in dry weather with clay subsoil (table IV). 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 a graveled-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 I). A two-way movement is planned because the surface is 18 feet wide and no alternate routes are available. According to table II, the surface-width factor is 0.75 ; the shoulder-width factor is 0.8 . The curve and gradient factor is 0.5 (table III). Table IV 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 24hour day. Using a 14 -hour working day, the net capability is $\frac{14}{24} \times 255$ or 149 short tons per day for sustained operations.
(c) Four-lane, 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 capa-
city of 16,900 vehicles per day for a cement concrete surface as the basic figure for the computation (table I). 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 II). The curve and gradient factor (table III) is 0.95 for 4 -percent grades. The moisture factor for cement concrete with clay subsoil in dry condition is 1.0 (table IV). 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 34,100 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 four-lane, divided highway.
3. Problem. What is the maximum movement capability of the fourlane, divided highway described in (c) above?
4. Solution. Procedure is the same as that outlined in (c) above except basic capacity is used instead of operational capacity (table I), 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, $42,600 \times \frac{20}{24} \div 2$ 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 in dry weather could be
maintained on a maximum basis for 30 days (table VI), giving a total projected capability on a maximum or "crash" basis of $1,593,000$ short tons.

Table I. Highway daily capacity: basic and operational.

| Surface type | Vehicle type(highway tonnage ratings) | Average speed |  | Vehicle interval |  | Capacity in vehiclea per 24-hours for all traffic ${ }^{*}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | (mph) | (kmph) | (ft) | (meters) | Basic* | Operational |
| Cement concrete, bituminous concrete, intermediate bituminous and bitumi-nous-surface treated. | 3 T trk (avg for 2-axle). | 25 | 40 | 300 | 91 | 21,100 | 16,900 |
|  | 5T trk. | 25 | 40 | 300 | 91 | 21,100 | 16,900 |
|  | 10T trk or stlr | 25 | 40 | 325 | 99 | 19,200 | 15,400 |
|  | 18T stlr. | 25 | 40 | 375 | 114 | 16,800 | 13,400 |
|  | 50T stlr | 20 | 32 | 400 | 122 | 12,500 | 10,000 |
|  | admin veh. | 25 | 40 | 250 | 76 | 25,200 | 20,200 |
| Waterbound macadam, gravel, and crushed stone. | 3T trk (avg for 2-axle) | 20 | 32 | ( ) 600 | 183 | 8,400 | 6,700 |
|  | 5T trk | 20 | 32 | 600 | 183 | 8,400 | 6,700 |
|  | 10T trk or stlr | 20 | 32 | 700 | 213 | 7,700 | 6,200 |
|  | 18 T stlr. | 20 | 32 | 700 | 213 | 7,700 | 6,200 |
|  | 50T stlr. | 15 | 24 | 700 | 213 | 5,800 | 4,600 |
|  | admin veh | 20 | 32 | 500 | 152 | 10,600 | 8,500 |
|  | 3T trk (avg for 2-axle).-. <br> 5 T trk <br> 10T trk or stlr $\qquad$ <br> 18T stlr <br> 50T stlr. $\qquad$ <br> admin veh $\qquad$ | 20 | 32 | ${ }^{(0)}$ | 244 | 6,300 | 5,000 |
|  |  |  |  |  |  |  |  |
|  |  | 20 | 32 | 800 | 244 | 6,300 | 5,000 |
|  |  | 20 | 32 | 800 | 244 | 6,300 | 5,000 |
|  |  | 20 | 32 | 800 | 244 | 6,300 | 5,000 |
|  |  | 15 | 24 | 800 | 244 | 5,000 | 4,000 |
|  |  | 20 | 32 | 700 | 213 | 7,700 | 6,200 |
| Unimproved earth. | 3T trk (avg for 2-axle)... | 15 | 24 | $\left.{ }^{\circ}\right)$$1.000$ | 305 | 3,800 | 3,000 |
|  |  |  |  |  |  |  |  |
|  | 5T trk . .-. | 10 | 16 | 1,000 | 305 | 2,500 | 2,000 |
|  | 10T trk or stlr | 10 | 16 | 1,000 | 305 | 2,500 | 2,000 |
|  | 18T stir. | 10 | 16 | 1,000 | 305 | 2,500 | 2,000 |
|  | 50T stlr | 10 | 16 | 1,000 | 305 | 2,500 | 2,000 |
|  | admin veh. | 15 | 24 | 1,000 | 305 | 3,800 | 3,000 |

- Basic capacity is based upon the assumptions that a 24 -foot surfsce 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.
b Operational capacity is approximately 80 percent of basic capacity.
- Intervals increase as quality of surface decreases due primarily to the dust hazard.

Table II. Surface and shoulder width factors.

| Type of movement | Number of lanes | Surface |  |  | Shoulder |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Widtb (ft) | Factor |  | Width (ft) | Factor |  |
|  |  |  | . $\begin{gathered}\text { Divided } \\ \text { highway }\end{gathered}$ | Undivided highway |  | 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 |

Table II. Surface and shoulder width factors-Continued.

| Type of movement |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |

- For pavement widths between 12 and 18 feet, consider $1 / 5$ the width over 12 feet as additional sboulder width.
b For one-way movements on pavements more than 18 feet in width, the factor for balf the actual pavement width will be selected, and will then be doubled to reflect the two lines of traffic that can effectively use pavementa 18 feet or more in width.
- 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.

Table IIA. Combined surface and shoulder factors when only width of travelled way is known.

| Width of travelled way (feet) | Factor |  |
| :---: | :---: | :---: |
|  | One-way movement | Two-way movement |
| 8 | 0.33 |  |
| 9 | 0.36 |  |
| 10 | 0.39 |  |
| 11 | 0.42 |  |
| 12 | 0.45 |  |
| 13 | 0.46 |  |
| 14 | 0.47 |  |
| 15 | 0.48 |  |
| 16 | 0.53 |  |
| 17 | 0.58 |  |
| 18 | 0.62 | 0.52 |
| 19 | 0.65 | 0.55 |
| 20 | 0.675 | 0.575 |
| 21 | 0.675 | 0.60 |
| 22 | 0.675 | 0.63 |
| 23 |  | 0.66 |
| 24 |  | 0.68 |

Table II-A. Combined surface and shoulder factors when only width of travelled way is known-Continued.

| Width of travelled way |
| :---: | :---: | :---: |
| (feet) |

Table III. Curve and gradient factors.*

| Radius of Curvature |  |  |  |  |  |  | Gradient |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \text { Curve } \\ \text { radius } \\ \text { (ft) } \end{gathered}$ | Factora |  |  |  |  |  | $\begin{aligned} & \text { Per- } \\ & \text { cent } \end{aligned}$ | Factora |  |  |  |  |  |
|  | 3-T Trk | 5-T Tris | $\begin{aligned} & 10-\mathrm{T} \text { Stlr } \\ & \text { or trik } \end{aligned}$ | 8-T Stlr | 50-T Stlr | $\begin{aligned} & \text { Admin } \\ & \text { yeh } \end{aligned}$ |  | 3-T Trk | 5-T Trk | 10-T Stir or trk | 18-T Stlr | 50-T Sti | $\underset{\text { veh }}{\text { Admin }}$ |
|  |  |  |  |  |  | \% | < 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 |
| 50 | 0.40 | 0.40 | 0.20 | . 20 | . 20 | . 65 | 21/8 | 1.00 | 1.00 | 1.00 | 1.00 | . 97 | 1.00 |
| 63 | 0.50 | 0.51 | 0.29 | . 25 | . 23 | . 78 | 21/4 | 1.00 | 1.00 | 1.00 | 1.00 | . 95 | 1.00 |
| 75 | 0.60 | 0.63 | 0.38 | . 30 | . 27 | . 85 | 23/8 | 1.00 | 1.00 | 1.00 | . 99 | . 94 | 1.00 |
| 88 | 0.70 | 0.71 | 0.44 | . 35 | . 31 | . 91 | $21 / 2$ | 1.00 | 1.00 | . 99 | . 98 | . 93 | 1.00 |
| 100 | 0.75 | 0.78 | 0.50 | . 41 | . 35 | . 94 | 25/8 | 1.00 | 1.00 | . 98 | . 97 | . 92 | 1.00 |
| 113 | 0.78 | 0.83 | 0.55 | . 46 | . 40 | . 97 | 23/4 | 1.00 | 1.00 | . 98 | . 96 | . 89 | 1.00 |
| 125 | 0.82 | 0.88 | 0.61 | . 54 | . 46 | . 98 | 27/8 | 1.00 | 1.00 | . 97 | . 94 | . 88 | 1.00 |
| 138 | 0.85 | 0.91 | 0.66 | . 60 | . 52 | . 99 | 3 | . 99 | 1.00 | . 95 | . 93 | . 86 | 1.00 |
| 150 | 0.88 | 0.94 | 0.71 | . 65 | . 57 | 1.00 | 31/4 | . 98 | 1.00 | . 93 | . 91 | . 83 | 1.00 |
| 163 | 0.90 | 0.96 | 0.75 | . 71 | . 62 | 1.00 | $31 / 2$ | . 98 | 1.00 | . 91 | . 88 | . 81 | 1.00 |
| 175 | 0.92 | 0.98 | 0.78 | . 74 | . 67 | 1.00 | 33/4 | . 97 | 1.00 | . 88 | . 85 | . 78 | 1.00 |
| 188 | 0.94 | 0.99 | 0.82 | . 78 | . 71 | 1.00 | 4 | . 95 | . 99 | . 86 | . 82 | . 75 | 1.00 |
| 200 | 0.95 | 0.99 | 0.86 | . 82 | . 75 | 1.00 | 41/4 | . 94 | . 99 | . 83 | . 78 | . 71 | 1.00 |
| 213 | 0.97 | 1.00 | 0.88 | . 85 | . 78 | 1.00 | $41 / 2$ | . 93 | . 98 | . 78 | . 74 | . 67 | 1.00 |
| 225 | 0.98 | 1.00 | 0.91 | . 88 | . 81 | 1.00 | 43/4 | . 90 | . 96 | . 75 | . 71 | . 63 | 1.00 |
| 238 | 0.98 | 1.00 | 0.93 | . 91 | . 83 | 1.00 | 5 | . 88 | . 94 | . 70 | . 65 | . 57 | 1.00 |
| 250 | 0.99 | 1.00 | 0.95 | . 93 | . 86 | 1.00 | $51 / 2$ | . 85 | . 91 | . 65 | . 60 | . 52 | . 99 |
| 263 | 0.99 | 1.00 | 0.96 | . 94 | . 87 | 1.00 | 6 | . 83 | . 88 | . 60 | . 54 | . 46 | . 98 |
| 275 | 1.00 | 1.00 | 0.98 | . 96 | . 89 | 1.00 | $61 / 2$ | . 78 | . 83 | . 55 | . 47 | . 40 | . 97 |
| 288 | 1.00 | 1.00 | 0.98 | . 97 | . 91 | 1.00 | 7 | . 75 | . 78 | . 50 | . 41 | . 35 | . 94 |
| 300 | 1.00 | 1.00 | 0.99 | . 98 | . 93 | 1.00 | 8 | . 70 | . 71 | . 44 | . 36 | . 31 | . 91 |
| 313 | 1.00 | 1.00 | 0.99 | . 99 | . 94 | 1.00 | 9 | . 60 | . 63 | . 38 | . 30 | . 27 | . 85 |
| 325 | 1.00 | 1.00 | 1.00 | 1.00 | . 95 | 1.00 | 10 | . 50 | . 52 | . 29 | . 25 | . 23 | . 78 |
| 338 | 1.00 | 1.00 | 1.00 | 1.00 | . 96 | 1.00 | 11 | . 40 | . 40 | . 20 | . 20 | . 20 | . 65 |
| 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 |  |  |  |  |  |  |  |

[^8]Table IV. Factors used to determine effect of moisture and temperature on highway capacity.

| Surface type | Vehicle type <br> (highway tonnage rating) | Type and condition of Subsoill |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Sand and/or gravel |  |  |  |  | Clay |  |  |  |  | Silt ${ }^{\text {2 }}$ |  |  |  |  |
|  |  | Dry | Moist | Wet | Frozen | $\begin{array}{\|l\|l} \text { Freeze } \\ \text { \& thaw } \end{array}$ | Dry | Moist | Wet | Frozen | $\begin{aligned} & \text { Freeze } \\ & \text { \& thaw } \end{aligned}$ | Dry | Moist | Wet | Frozen | $\begin{aligned} & \text { Freeze } \\ & \text { \& thaw } \end{aligned}$ |
| Cement concrete, bituminous concrete. | 3T trk (avg for 2-axle). | 1.00 | 1.00 | 0.95 | 1.00 | 0.95 | 1.00 | 1.00 | 0.80 | 1.00 | 0.75 |  |  |  |  |  |
|  | 5T trk | 1.00 | 1.00 | 0.95 | 1.00 | 0.95 | 1.00 | 1.00 | 0.80 | 1.00 | 0.75 |  |  |  |  |  |
|  | 10T trk or stlr. | 0.90 | 0.90 | 0.90 | 1.00 | 0.90 | 0.90 | 0.90 | 0.80 | 1.00 | 0.75 |  |  |  |  |  |
|  | 18T stlr. | 0.90 | 0.90 | 0.90 | 1.00 | 0.90 | 0.90 | 0.90 | 0.70 | 1.00 | 0.65 |  |  |  |  |  |
|  | 50T stlr. | 0.90 | 0.90 | 0.85 | 1.00 | 0.80 | 0.90 | 0.90 | 0.70 | 1.00 | 0.65 |  |  |  |  |  |
|  | Admin veh. | 1.00 | 1.00 | $\underline{1.00}$ | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 1.00 | 0.90 |  |  |  |  |  |
| Intermediate bituminous. | 3T trk (avg for 2-axle) | 0.90 | 0.90 | 0.80 | 1.00 | 0.80 | 0.90 | 0.90 | 0.55 | 1.00 | 0.50 |  |  |  |  |  |
|  | 5T trk-.------------ | 0.90 | 0.90 | 0.80 | 1.00 | 0.80 | 0.90 | 0.90 | 0.55 | 1.00 | 0.50 |  |  |  |  |  |
|  | 10T trk or stlr | 0.80 | 0.80 | 0.70 | 1.00 | 0.70 | 0.80 | 0.80 | 0.45 | 1.00 | 0.40 |  |  |  |  |  |
|  | 18 T stlr. | 0.80 | 0.80 | 0.70 | 1.00 | 0.70 | 0.80 | 0.80 | 0.45 | 1.00 | 0.40 |  |  |  |  |  |
|  | 50T stlr. | 0.80 | 0.80 | 0.60 | 1.00 | 0.60 | 0.80 | 0.80 | 0.45 | 1.00 | 0.40 |  |  |  |  |  |
|  | Admin veh | 1.00 | 1.00 | 0.90 | 1.00 | 1.90 | 1.00 | 1.00 | 0.65 | 1.00 | 0.65 |  |  |  |  |  |
| Bituminous surface treatment. | 3T trk (avg for 2-axle)_ | 0.60 | 0.70 | 0.30 | 1.00 | 0.30 | 0.60 | 0.70 | 0.20 | 1.00 | 0.10 | 0.40 | 0.40 | 0 | 1.00 |  |
|  | 5T trk- | 0.40 | 0.50 | 0.30 | 1.00 | 0.30 | 0.40 | 0.50 | 0.20 | 1.00 | 0.12 | 0.25 | 0.25 | 0 | 1.00 | 0 |
|  | 10 T trk or stlr | 0.30 | 0.35 | 0.20 | 1.00 | 0.20 | 0.30 | 0.35 | 0.10 | 1.00 | 0.025 | 0.15 | 0.15 | 0 | 1.00 | 0 |
|  | 18T stlr. | 0.25 | 0.30 | 0.15 | 1.00 | 0.15 | 0.25 | 0.30 | 0.07 | 1.00 | 0.025 | 0.10 | 0.10 | 0 | 1.00 | 0 |
|  | 50T stlr. | 0.25 | 0.30 | 0.15 | 1.00 | 0.15 | 0.25 | 0.30 | 0.07 | 1.00 | 0.025 | 0.10 | 0.10 | 0 | 1.00 | 0 |
|  | Admin veh_ | 0.80 | 0.80 | 0.60 | 1.00 | 0.60 | 0.80 | 0.80 | 0.45 | 1.00 | 0.25 | 0.50 | 0.50 | 0 | 1.00 | 0 |
| Waterbound macadam, gravel, crushed stone. | 3T trk (avg for 2-axle). | 0.25 | 0.35 | 0.15 | 0.35 | 0.10 | 0.25 | 0.45 | 0.10 | 1.00 | 0.025 | 0.15 | 0.15 | 0 | 1.00 | 0 |
|  | 5T trk. - | 0.25 | 0.35 | 0.15 | 0.35 | 0.10 | 0.25 | 0.45 | 0.12 | 1.00 | 0.07 | 0.15 | 0.15 | 0 | 1.00 | 0 |
|  | 10T trk or stlr | 0.20 | 0.30 | 0.10 | 0.30 | 0.05 | 0.20 | 0.30 | 0.025 | 1.00 | 0 | 0.10 | 0.10 | 0 | 1.00 | 0 |
|  | 18T stlr. | 0.10 | 0.25 | 0.05 | 0.25 | 0.05 | 0.10 | 0.25 | 0.025 | 1.00 | 0 | 0.05 | 0.05 | 0 | 1.00 | 0 |
|  | 50T stlr. | 0.10 | 0.25 | 0.05 | 0.25 | 0.05 | 0.10 | 0.25 | 0.025 | 1.00 |  | 0.05 | 0.05 | 0 | 1.00 | 0 |
|  | Admin veh | 0.40 | 0.50 | 0.30 | 0.50 | 0.15 | 0.40 | 0.55 | 0.25 | 1.00 | 0.15 | 0.30 | 0.30 | 0 | 1.00 | 0 |
| Improved earth.-.------ | $3 T$ trk (avg for 2-axle). |  |  | 0.10 | 0.35 | 0.15 |  | 0.65 | 0 | 1.00 | 0 | 0.05 | 0.05 | 0 | 1.00 | 0 |
|  | 5T trk. | 0.17 | 0.35 | 0.12 | 0.35 | 0.17 | 0.30 | 0.65 | 0 | 1.00 | 0 | 0.05 | 0.05 | 0 | 1.00 | 0 |
|  | 10T trk or stlr | 0.10 | 0.30 | 0.05 | 0.30 | 0.10 | 0.17 | 0.40 | 0 | 1.00 | 0 | 0 | 0 | 0 | 1.00 | 0 |
|  | 18 T stlr. | 0.05 | 0.30 | 0.025 | 0.25 | 0.05 | 0.17 | 0.40 | 0 | 1.00 | 0 | 0 | 0 | 0 | 1.00 | 0 |
|  | 50 T stlr. | $0.05$ | 0.25 | $0.025$ | 0.25 | 0.05 | 0.17 | 0.40 | 0 | 1.00 | 0 | 0 | 0 | 0 | 1.00 | 0 |
|  | Admin veh | 0.25 | 0.50 | 0.20 | 0.50 | 0.25 | 0.55 | 1.00 | 0 | 1.00 | 0 | 0.15 | 0.15 | 0 | 1.00 | 0 |
| Unimproved earth.----- | 3T trk (avg for 2-axle). | 0.15 | 0.25 | 0.07 | 0.25 | 0.07 | 0.30 | 0.55 | 0 | 2.00 | 0 | 0.05 | 0.05 | 0 | 2.00 | 0 |
|  | 5T trk.------------ | 0.17 | 0.25 | 0.07 | 0.25 | 0.07 | 0.30 | 0.55 | 0 | 2.00 | 0 | 0.05 | 0.05 | 0 | 2.00 | 0 |
|  | 10 T trk or stlr | 0.10 | 0.20 | 0.025 | 0.20 | 0.025 | 0.17 | 0.30 | 0 | 2.00 | 0 | 0 | 0 | 0 | 2.00 | 0 |
|  | 18T stlr | 0.05 | 0.20 | 0 | 0.20 | 0 | 0.17 | 0.30 | 0 | 2.00 | 0 | 0 | 0 | 0 | 2.00 | 0 |
|  | 50T stlr | 0.05 | 0.20 | 0 | 0.20 | 0 | 0.17 | 0.30 | 0 | 2.00 | 0 | 0 | 0 | 0 | 2.00 | 0 |
|  | Admin veh........ | 0.25 | 0.40 | 0.12 | 0.40 | 0.10 | 0.55 | 0.80 | 0 | 2.00 | 0 | 0.15 | 0.15 | 0 | 2.00 | 0 |

[^9]${ }^{2}$ 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.

Table V. Base thickness factors (temperate zones).

| Surface type | Base thickness (inches)* |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Cement concrete, bituminous concrete. | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |
| Block type surface | 0.13 | 0.26 | 0.38 | 0.49 | 0.62 | 0.75 | 0.88 | 1.0 |  |  |
| Intermediate bituminous, bituminous surface treated | 0.2 | 0.35 | 0.5 | 0.65 | 0.83 | 1.0 |  |  |  |  |
| Waterbound macadam, gravel, crushed stone (total thickness) | 0.3 | 0.52 | 0.79 | 1.0 |  |  |  |  |  |  |

- Interpolation should be used to obtain factor if fractions of an inch are encountered.

| Surface type | Vehicle type <br> (highway tonnage ratings) | Type and Condition of Suhsoil |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Sand and/or gravel |  |  |  | Clay |  |  |  | Silta |  |  |  |
|  |  | Dry | Moist | Wet | $\begin{aligned} & \text { Freeze } \\ & \text { o thaw } \end{aligned}$ | Dry | Moist | Wet | $\begin{aligned} & \text { Freeze } \\ & \text { \& thaw } \end{aligned}$ | Dry | Moist | Wet | $\begin{aligned} & \text { Freeze } \\ & \text { \& thaw } \end{aligned}$ |
| Cement concrete, bituminous concrete. | $3 T$ trk (avg for $2-$ axle) <br> 5 T trk $\qquad$ <br> 10T trk or semi $\qquad$ <br> 18T stlr $\qquad$ <br> 50T stlr. $\qquad$ <br> Admin veh. $\qquad$ | $\begin{aligned} & 30 \\ & 30 \\ & 30 \\ & 30 \\ & 30 \\ & 90 \end{aligned}$ | $\begin{aligned} & 30 \\ & 30 \\ & 30 \\ & 30 \\ & 30 \\ & 90 \end{aligned}$ | $\begin{aligned} & 20 \\ & 20 \\ & 20 \\ & 20 \\ & 20 \\ & 50 \end{aligned}$ | $\begin{aligned} & 20 \\ & 20 \\ & 20 \\ & 20 \\ & 20 \\ & 50 \end{aligned}$ | $\begin{aligned} & 30 \\ & 30 \\ & 30 \\ & 30 \\ & 30 \\ & 90 \end{aligned}$ | $\begin{aligned} & 30 \\ & 30 \\ & 30 \\ & 30 \\ & 30 \\ & 90 \end{aligned}$ | $\begin{aligned} & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 50 \end{aligned}$ | $\begin{aligned} & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 50 \end{aligned}$ |  |  |  |  |
| Intermediate bituminous .------ | $3 T$ trk (avg for $2-$ axle) <br> 5 T trk $\qquad$ <br> 10 T trk or semi <br> 18 T stlr $\qquad$ <br> 50 T stlr. $\qquad$ <br> Admin veh. $\qquad$ | $\begin{aligned} & 15 \\ & 15 \\ & 15 \\ & 15 \\ & 15 \\ & 50 \end{aligned}$ | $\begin{aligned} & 15 \\ & 15 \\ & 15 \\ & 15 \\ & 15 \\ & 50 \end{aligned}$ | $\begin{array}{r} 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 20 \end{array}$ | $\begin{array}{r} 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 20 \end{array}$ | $\begin{aligned} & 15 \\ & 15 \\ & 15 \\ & 15 \\ & 15 \\ & 50 \end{aligned}$ | $\begin{aligned} & 15 \\ & 15 \\ & 15 \\ & 15 \\ & 15 \\ & 50 \end{aligned}$ | $\begin{array}{r} 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 10 \end{array}$ | $\begin{array}{r} 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 10 \end{array}$ |  |  |  |  |
| Bituminous surface treatment. -- | 3T trk (avg for 2axle) <br> 5 T trk $\qquad$ <br> 10T trk or semi. <br> 18T stlr. $\qquad$ <br> 50T stlr $\qquad$ <br> Admin veh. | $\begin{aligned} & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 20 \end{aligned}$ | $\begin{aligned} & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 20 \end{aligned}$ | $\begin{array}{r} 3 \\ 3 \\ 3 \\ 3 \\ 3 \\ 10 \end{array}$ | $\begin{array}{r} 3 \\ 3 \\ 3 \\ 3 \\ 3 \\ 10 \end{array}$ | $\begin{aligned} & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 20 \end{aligned}$ | $\begin{aligned} & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 10 \\ & 20 \end{aligned}$ | $\begin{aligned} & 1 \\ & 1 \\ & 0.75 \\ & 0.75 \\ & 0.75 \\ & 10 \end{aligned}$ | $\begin{aligned} & 1 \\ & 1 \\ & 0.75 \\ & 0.75 \\ & 0.75 \\ & 10 \end{aligned}$ | $\begin{aligned} & 2 \\ & 2 \\ & 2 \\ & 2 \\ & 2 \\ & 5 \end{aligned}$ | $\begin{aligned} & 2 \\ & 2 \\ & 2 \\ & 2 \\ & 2 \\ & 2 \\ & 5 \end{aligned}$ | $\begin{aligned} & 0.50 \\ & 0.50 \\ & 0.25 \\ & 0.25 \\ & 0.25 \\ & 2 \end{aligned}$ | $\begin{aligned} & 0.50 \\ & 0.50 \\ & 0.25 \\ & 0.25 \\ & 0.25 \\ & 2 \end{aligned}$ |
| Waterbound macadam, gravel, crushed stone. | $3 T$ trk (avg for 2axle. 5 T trk 10T trk or semi 18T stlr. 50T stlr Admin veh | 5 5 5 5 -10 | 5 5 5 5 -10 -10 | 1 <br> 1 <br> 0.5 <br> 0.5 <br> -----1 <br> 2 | 1 <br> 1 <br> 0.5 <br> 0.5 <br> ----1 <br> 2 | $\begin{array}{r} 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 10 \end{array}$ | $\begin{array}{r} 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 10 \end{array}$ | $\begin{aligned} & 0.62 \\ & 0.62 \\ & 0.37 \\ & 0.37 \\ & 0.37 \\ & 1.5 \end{aligned}$ | $\begin{aligned} & 0.62 \\ & 0.62 \\ & 0.37 \\ & 0.37 \\ & 0.37 \\ & 1.5 \end{aligned}$ | $\begin{aligned} & 0.50 \\ & 0.50 \\ & 0.50 \\ & 0.50 \\ & 0.50 \\ & 1 \end{aligned}$ | $\begin{aligned} & 0.50 \\ & 0.50 \\ & 0.50 \\ & 0.50 \\ & 0.50 \\ & 1 \end{aligned}$ | $\begin{aligned} & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \end{aligned}$ | $\begin{aligned} & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \end{aligned}$ |
| Improved earth--------------- | ```3T trk (avg for 2- axle) 5 T trk ------. 10T trk or semi. 18T stlr. 50T stlr Admin veh.``` | $\begin{gathered} 5 \\ 5 \\ 5 \\ 5 \\ ---10 \\ 10 \end{gathered}$ | $\begin{gathered} 5 \\ 5 \\ 5 \\ 5 \\ --. \\ 10 \end{gathered}$ | $\begin{aligned} & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & \ll 0 .-1 \end{aligned}$ | $\begin{aligned} & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <-1 .-6 \\ & <0.25 \end{aligned}$ | $\begin{array}{r} 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 10 \end{array}$ | $\begin{array}{r} 5 \\ 5 \\ 5 \\ 5 \\ 5 \\ 10 \end{array}$ | $\begin{aligned} & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & 10 \end{aligned}$ | $\begin{aligned} & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & 10 \end{aligned}$ | $\begin{array}{r} 0.25 \\ 0.25 \\ <0.25 \\ <0.25 \\ 0.25 \\ 0.25 \end{array}$ | $\begin{array}{r} 0.25 \\ 0.25 \\ <0.25 \\ <0.25 \\ 0.25 \\ 0.25 \end{array}$ | $\begin{aligned} & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \end{aligned}$ | $\begin{aligned} & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \\ & <0.25 \end{aligned}$ |

$\stackrel{\rightharpoonup}{\mathbf{O}}$
See footnotes at end of table.

| Surface type | Vehicle type (highway tonnage ratings) | Type and Condition of Subsoill |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Sand and/or gravel |  |  |  | Clay |  |  |  | Silt ${ }^{\text {a }}$ |  |  |  |
|  |  | Dry | Moist | Wet | Freeze \& thaw | Dry | Moist | Wet | $\begin{aligned} & \text { Freeze } \\ & \text { \& thaw } \end{aligned}$ | Dry | Moist | Wet | Freeze \& thaw |
| Unimproved earth. | 3T trk (avg for 2axle) | 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 |
|  | 10 T trk or semi | 5 | 5 | <0.25 | <0.25 | 5 | 5 | $<0.25$ | <0.25 | $<0.25$ | $<0.25$ | $<0.25$ | <0.25 |
|  | 18T stlr. | 5 | 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 |
|  | Admin veh | 10 | 10 | <0.25 | <0.25 | 10 | 10 | <0.25 | <0.25 | $<0.25$ | $<0.25$ | $<0.25$ | $<0.25$ |

[^10]e. Making the Estimate with Limited Information. The following table 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 the chart below, 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.

| Type of road | Daily tonnage forward (ST) |  |  | Reductions applicable to various conditions |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Optimum dispatch route only | $\begin{gathered} \text { Supply } \\ \text { (COAPAMZ } \\ \text { (COMMZ } \end{gathered}$ | Supply (ratfic (combat zone) $)$ | Narrow roadway | Rolling terrain | $\begin{gathered} \text { Hilly } \\ \text { with } \\ \text { wirves } \end{gathered}$ | Moun- | $\begin{aligned} & \text { Seasonal } \\ & \text { bead } \\ & \text { weather } \end{aligned}$ |
| 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 AND SUPPLY

### 3.39 Maintenance

a. Organization.

| Category | Definition | $\begin{aligned} & \text { Eche- } \\ & \text { lon } \end{aligned}$ | Scope | $\underset{\text { by }}{\substack{\text { Performed }}}$ | $\underset{\text { of }}{\text { Responsibility }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Organizational. | Work authorized for, performed by, and the responsibility of the using unit. | 1st | Care taken of and work done on equipment to keep it in a standard condition of serviceability. Consists of inspecting, cleaning, servicing, and tightening. | Operator or crew. | Company commander. |
|  |  | 2d | Consists of servicing, inspecting, adjusting, and making minor repair and minor replacement. | Unit mechanics. | Company commander. |
| Field.---.-.-- | Work performed by mobile or semimobile technical service units in direct support of using units. | 3d | Repair and/or replacement of major parts, components, and assemblies, done by units in direct support. | (1) | (1) |
|  |  | 4th | Repair and/or replacement of major parts, components, and assemblies; done by units for a geographical area. | Supporting army units. | Army commander. |
| Depot. | Work performed by permanent installations using extensive equipment. | 5th | Major overhaul or complete rebuild. | Depot units. | Chief of Army Material Command. |

${ }^{1}$ For divisions, third echelon is performed by organic support units. Responsible officer is the division commander.

## b. Preventive.

(1) Scope. Preventive maintenance is the systematic care, inspection, and servicing of equipment to maintain it in serviceable condition and to detect and correct incipient failures before expensive and time-consuming repairs or replacements are required. Preventive maintenance services are performed by vehicle operators and organizational maintenance personnel. Proper operation and use of equipment are just as important to preventive maintenance as are prescribed inspections and services.
(2) Intervals. To insure that all important parts of equipment are checked systematically, three types of recorded preventive maintenance services are prescribed. For further details, see TM 38-750.
(a) The daily service performed by the equipment operators or crew each day the equipment is operated.
(b) Periodic services prescribed by pertinent maintenance publications. These services are normally performed by organizational personnel.
(c) Lubrication is performed in accordance with the equipment lubrication order or other maintenance publications.

### 3.40 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 floatation (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 |  | Numplies | $\underset{\substack{\text { pecommended } \\(\text { psis })}}{\text { Refe }}$ | Recommended maximum load (b) |
| :---: | :---: | :---: | :---: | :---: |
| Passenger cars | Trucks, buses, and trailers |  |  |  |
| 5.50-16 | - | 4 | 30 | 810 |
| 5.90-15 |  | 4 | 24 | 745 |
| 6.00-16 |  | 4 | 28 | 915 |
|  | 6.00-16 | 6 | 45 | 1,140 |



| Tire size |  | Number of plies | Recommended pressure (psi) | Recommended maximum load (lb) |
| :---: | :---: | :---: | :---: | :---: |
| Passenger cars | Trucks. buses, and trailers |  |  |  |
|  | 14.00-24 | 20 | 90 | 9,150 |
|  | 16.00-25 | 20 | 60 | 9,475 |
|  | 18.00-24 | 16 | 40 | 13,590 |

- Tubeless tires.


### 3.41 Vehicle and Motor Park Checklist

a. General.
(1) Is the general appearance of the motor park satisfactory?
(2) Are gasoline dispensing areas properly maintained?
(3) Are dirty wiping rags and waste or similar flammable materials properly disposed of?
(4) Are sufficient fire extinguishers provided? Have they been checked for serviceability?
(5) Are fire extinguishers accessibly located?
(6) Are lubricant containers covered, and lubricants kept clean?
(7) Are lubricant dispensers clean and properly maintained?
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 and fuels?
(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?

Score (percent)

## -

$\qquad$
(10) Are authorized tools on hand, or on order, and in 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 and cutting equipment properly maintained?
(16) Is training of maintenance personnel adequate?
(17) Does the unit maintain a preventive maintenance roster?
(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 maintive action promptly?
(9) Does the unit attempt to perform higher echelon maintenance to the detriment of that required in its own echelon?
(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 correc-
$\qquad$

$\qquad$
$\qquad$
$\qquad$
$\qquad$

$\qquad$
$\qquad$



$\qquad$



tenance service is completed? $\qquad$
(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 of equipment? Are the appropriate entries made in each column of the record?.
(27) Do all drivers have the required U.S. Government operator's identification card? Are these cards properly made out?
(28) Does the equipment log book cover each vehicle?.--
(29) Are all the authorized publications on requisition or on hand and available for ready reference?
(30) Are required maintenance services up to date?
(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 actually 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 in use for repair parts?
(37) Does quantity of repair parts on hand exceed 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 item registration or serial number?
(41) Are stock number changes posted to date in supply records and catalogs?
(42) Have parts required for equipment out of commission 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 parts and supplies?
(46) Are supply personnel adequately trained in use of supply publications procedures?
(47) Are unserviceable recoverable parts and assemblies
promptly returned to supporting ordnance 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?
(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 material (OEM) tools present and in good condition? - --
(20) Does driver seem adequately trained?
(21) Is driver properly licensed?
(22) Is driver interested in his job?
(23) Is there a copy of the current technical manual and lubrication order in each vehicle?

### 3.42 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 travelled 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 present 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.)

| Speed |  |  | Average distance required for stopping |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | kmph | $\mathrm{ft} / \mathrm{sec}$ | Perception |  | Reaction |  | Braking |  | Total ${ }^{1}$ |  |  |
| mph |  |  | Feet | Meters | Feet | Meters | Feet | Meters | Feet | Yards | Meters |
| 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 |

[^11]| Speed |  |  | Average distance required for stopping |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | kmph | $\mathrm{ft} / \mathrm{sec}$ | Perception |  | Reaction |  | Braking |  | Total ${ }^{1}$ |  |  |
| mph |  |  | Feet | Meters | Feet | Meters | Feet | Meters | Feet | Yards | Meters |

Passenger vehicles ${ }^{2-}$ Continued

|  |  |  |  |  |  |  |  |  |  |  |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $40^{*}$ | 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 | 12.8 | 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 combinations of vehicles (truck tractor, semitrailer, and trailer) with gross weigh, 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 |

[^12]
## Section V. MISCELLANEOUS

### 3.43 Anchoring Methods

(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 stand the following pulls:
Picket Pounds

1-1 holdfast combination. ..........-.............................. 400



For wet earth, the holding power should be multiplied by the following factors:
Clay and gravel mixture .0 .9

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 surface, divide the total stress by the values given in the table 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, 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.


PICKET HOLDFAST


3-2-I COMBINATION PICKET HOLDFAST


Figure s.25. Picket holdfast and deadman.

### 3.44 Improvised, Unmounted A-Frame

(fig. 3.26)
An improvised A-frame is a field expedient that provides both a lift and a tow. It is useful for lifting a vehicle 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 a 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 for 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, the vehicle must be moved slightly forward and the ditch filled or bridged to allow the rear wheels to cross.

### 3.45 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 vehi-


Figute 3.26. A-frame.
cle, 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 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 shear pin 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 shear pins 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 be caused serious injury.
(4) Personnel handling winch cables should


RIG WITHOUT SPREADER BAR.


RIG WITH GHAIN PASSED UNDER ThE BUMPER BAR.


RIG WITH SPREADER BAR.
Figure 3.27. Use of winch and snatch block.


Figure 3.28. Using a winch to right an overturned vehicle.
always wear work gloves, preferably with leather palns, to protect themselves from cuts and scratches caused by broken strands in the cable.

### 3.46 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 in diameter. The saplings or rods are placed about 3 inches apart and wired together with 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.
c. Other types of expedient road surfaces for use in soft areas (swamp or snow) are shown in FM 31-70 and TM 5-250.

### 3.47 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.


Figure 3.29. Chespaling mats.


Figure 3.s0. Forkiift mounted on $6 \times 6$ truck.
3.48 Weights, Volume, and Conversion Factors for Packaged and Bulk Petroleum Products

| Product | Packaging | Weight (lb) | Cubic ft |  | Conversion factors |  | Gallons per |  |  | $\begin{array}{\|c} \text { Bblı } \\ \text { per } \\ \text { LT } \end{array}$ | Packages per |  |  | Capacity of vehicles for carrying filled containers ${ }^{2}$ |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Actual | Planning factor | Gal.tolb | $\begin{gathered} \text { Lb } \\ \text { to } \\ \text { gal. } \end{gathered}$ | ST | LT | MT |  | ST | LT | MT | Trailer |  | Truck |  |  | Semitrailer |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | $\begin{aligned} & 1- \\ & \text { ton } \end{aligned}$ | $\begin{aligned} & 11 / 2- \\ & \text { ton } \end{aligned}$ | $\begin{aligned} & 11 / 2- \\ & \text { ton } \end{aligned}$ | $21 / 2-$ | $\begin{array}{\|c\|c\|} \hline \text { Cargo } \\ 5 \text {-ton } \end{array}$ | $\begin{aligned} & 10- \\ & \text { ton } \end{aligned}$ | $\begin{aligned} & \text { 12- } \\ & \text { ton } \end{aligned}$ | $\begin{aligned} & 25- \\ & \text { ton } \end{aligned}$ |
| Aviation gasoline | Bulk |  |  |  | 5.90 | . 169 | 339 | 380 |  | 9.04 |  |  |  |  |  |  |  |  |  |  |  |
|  | 55-gal. drum ${ }^{3}$ | 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-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 ${ }^{6}$ | 40.5 | . 81 | 1 | 8.0 | . 125 | 250 | 280 | 200 |  | 49.4 | 55.3 | 40.0 | 49 | 74 | 74 | 124 | 248 | 495 | 594 | 1,239 |
| 91A gasoline | Bulk |  |  |  | 6.11 | . 164 | 327 | 367 |  | 8.73 |  |  |  |  |  |  |  |  |  |  |  |
|  | 55-gal. drum ${ }^{3}$ | 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 ${ }^{5}$ | 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 ${ }^{6}$ | 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 ${ }^{5}$ | 351 | 9.2 | 11 | 6.62 | . 151 | 302 | 338 | 181 |  | 5.70 | 6.38 | 3.42 | 5 | 8 | 8 | 14 | 28 | 57 | 68 | 142 |
|  | 5-gal. can ${ }^{6}$ | 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 | 5.19 | 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 | 116 |
|  | 5-gal. can ${ }^{6}$ | 46 | . 81 | 1 | 9.20 | .109 | 317 | 244 | 200 |  | 43.5 | 48.7 | 40.0 | 43 | 65 | 65 | 109 | 217 | 436 | 522 | 1,090 |


| Lubricating oils | Bulk |  |  |  | 7.60 | . 132 | 263 | 295 |  | 7.02 |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 55-gal. drum ${ }^{3}$ | 472 | 9.03 | ' 11 | 8.58 | . 117 | 233 | 261 | 191 |  | 4.24 | 4.75 | 3.48 | 4 | 6 | 6 | 10 | 21 | 42 | 51 | 106 |
|  | 55-gal. drum ${ }^{4}$ | 488 | 8.8 | 11 | 8.87 | . 113 | 226 | 253 | 196 |  | 4.10 | 4.59 | 3.57 | 4 | 6 | 6 | 10 | 20 | 41 | 49 | 102 |
|  | 55-gal. drum ${ }^{5}$ | 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 ${ }^{6}$ | 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 |
|  | $\begin{aligned} & \text { Case of } 1 \text {-qt cans ( } 12 / \\ & \text { case) } \end{aligned}$ | 35 | . 88 | 1 |  |  |  |  |  |  | 58.0 | 64.9 | 40 | 57 | 85 | 85 | 143 | 286 | 572 | 687 | 1,430 |
|  | Case of 1-qt cans (24/ case) | 60 | 1.6 | 2 |  |  |  |  |  |  | 33.4 | 37.3 | 20 | 33 | 50 | 50 | 83 | 166 | 333 | 400 | 835 |
|  | Case of 5-qt cans (6/ case) | 77 | 1.9 | 2 |  |  |  |  |  |  | 26.0 | 29.1 | 20 | 26 | 39 | 39 | 65 | 130 | 260 | 312 | 660 |
| Greases | 25-lb pail | 29 | . 95 | 1 |  |  |  |  |  |  | 69.0 | 77.2 | 40.0 | 69 | 103 | 103 | 173 | 345 | 692 | 827 | 1,720 |
|  | $5-\mathrm{lb}$ can (6/case) | 44 |  |  |  |  |  |  |  |  | 45.4 | 50.9 | 20.0 | 45 | 68 | 68 | 114 | 227 | 455 | 545 | 1,140 |

${ }^{1}$ For ocean shipping, storage, snd pipeline computstions, bulk petroleum proaucts usuaily sre measured in. ، wituls u' 42 gallons each instead of 55 gallons.
 reached first.
${ }^{8}$ 18-gage standard, weighs 54 pounds empty, holds 54 gallons of light products and 55 gallons of heavy products. Federsl Specification PPP-D-729, Amendment 1.
416 -gage standard, weighs 70 pounds empty, holds 54 gallons of light products and 55 gallons of heavy products. Federal Specification PPP-D-729, Amendment 1.
b 18 -gage limited atandard, weighs 52 pounds empty, holds 53 gallons of light products and 54 gallons of heavy products. Federal Specification PPP-D-729.
 mately 11 pounds.

### 3.49 Volume of Barracks Bags

Barracks bags packed to capacity average 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 bags do not average over 50 pounds each. Should this weight be exceeded, appropriate adjustments must be made.

| Vehrcle | Body cargo space (cu ft) | $\begin{gathered} \text { No. barracks } \\ \text { bags } \end{gathered}$ |
| :---: | :---: | :---: |
| Truck: |  |  |
| $1 / 2$-ton, pickup, $4 \times 2$, Chev | 37 | 8 |
| 3/4-ton, cargo, M37. | 160 | 30 |
| $11 / 2$-ton, cargo, $4 \times 4$, Chev. | 258 | 60 |
| $21 / 2$-ton, $6 \times 6$, LWB, M36 - | 630 | 100 |
| $21 / 2$-ton, $6 \times 6, \mathrm{M135}$. | 408 | 87 |
| $21 / 2$-ton, $6 \times 6$, COE, 15 ft | 475 | 100 |
| $21 / 2$-ton, $6 \times 6$ M35 | 456 | 99 |
| $21 / 2$-ton, $6 \times 6, \mathrm{COE}, 17 \mathrm{ft}$. | 540 | 100 |
| 5-ton, $6 \times 6$, cargo, M54...-- | 515 | 112 |


| Vehicle | $\begin{gathered} \text { Body caroo space } \\ (\mathrm{cu} / \mathrm{fl}) \end{gathered}$ | No. barra |
| :---: | :---: | :---: |
| Trailer: |  |  |
| 1/4-ton, 2-wheel, M100. | 28 | 6 |
| 3/4-ton, cargo, M101. | 175 | 30 |
| 1-ton, cargo, 2-wheel. | 113 | 20 |
| $11 / 2$-ton, cargo, M104. | 283 | 59 |
| Semitrailer: |  |  |
| 5-ton, S\&P, 2-wheel | 515 | 112 |
| 6-ton, van, 2 -wheel, MGSW4 | 1.096 | 240 |
| 10-ton, S\&P, 2-wheei - | 730 | 161 |
| 12-ton, M 127 | 830 | 184 |

### 3.50 Vehicle Size and Weight Limits by States

The chart below may be used as a planning guide. Size and weight limits are changed periodically in the various states 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.

| State | Size restrictions |  |  |  |  |  |  | Gross weight limits (pounds) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Width } \\ \text { (inches) } \end{gathered}$ | Height(inehes) | Length (feet) |  |  | Number (stlr $=$ ( $1 / 2 \mathrm{tlr}$ ) |  | Per inch of tire width | In thousands |  |
|  |  |  | Single unit | $\underset{\substack{\text { Tractor } \\ \text { stlr }}}{ }$ | Other nations |  |  |  | Per axle | Pertandem axle, 4 feet apart |
| Alabama $\mathrm{he}^{\text {c }}$ | 96 | d 150 | e 35 | 50 | ( 1 ) | 1/2 | 40 | (8) | 18 | 36 |
| Alaska | 96 | 156 | 35 | 60 | 60 | 2 | 40 | 500 | 18 | 32 |
| Arizona ${ }^{\text {b }}$ | 102 | 162 | 40 | 65 | 65 | $11 / 2$ | 40 | (8) | 18 | 32 |
| Arkansas ${ }^{\text {b }}$ | 96 | 162 | - 35 | 50 | 50 | (i) | 40 | ( ${ }^{\text {( })}$ | 18 | 32 |
| California ${ }^{\text {b }}$ | j 96 | 162 | x e 35 | 60 | 60 | (1) | (8) | 81; m 600 | 18 | 32 |
| Colorado ${ }^{\text {- }}$ | - 96 | 150 | ke 35 | 60 | 60 | 2 | 40 | (i) | - 18; ${ }^{\text {P } 16}$ | 36 |
| Connecticut ${ }^{\text {a }}$ | 102 | 150 | 45 | 45 | (1) | 1/2 | (8) | g 1; m 800 | 22.4 | 36 |
| Delaware ${ }^{\text {b }}$ | 96 | ${ }^{\text {d } 150}$ | - 35 | 50 | 60 | 11/2 | 48 | 700 | 20 | 36 |
| District of Columbia ${ }^{\text {b }}$ b | 96 | 150 | 35 | 50 | 50 | 1 or $1 / 2$ | 40 | (8) | 22 | 38 |
| Florida ${ }^{\text {h }}$ | 96 | ${ }^{\text {d }} 150$ | * 40 | 50 | 50 | 1 or $1 / 2$ | 40 | 550 | 20 | 40 |
| Georgia - | 96 | 162 | - 939.5 | 48 | 48 | 1 or $1 / 2$ | 40 | (i) | $\bigcirc 920.3$ pq16 | ¢ 40.6 |
| Hawaii | 108 | 156 | 40 | 55 | 65 |  | 42 |  | 24 | 40 |
| Idaho ${ }^{\text {b }}$ | n 96 | 168 | - 35 | 60 | 65 | 11/2 | (8) | - 800 | 18 | 32 |
| Illinois ${ }^{\text {e }}$ | 96 | 162 | 42 | 50 | 50 | $11 / 2$ | 40 | 800 | 18 | 32 |
| Indiana | 96 | 162 | - 36 | 50 | 50 | 11/2 | 40 | 800 | 18 | 32 |
| Iowa a ${ }^{\text {a }}$ | 96 | 150 | $\mathrm{k} \cdot 35$ | 45 | (1) | 1/2 | 40 | (i) | 18 | 32 |
| Kansas " | - 96 | 150 | k e 35 | 50 | 50 | 1 or $1 / 2$ | 40 | ( ${ }^{\text {i }}$ | - 18; ${ }^{\text {P }} 16$ | 32 |
| Kentucky | 96 | 150 | 35 | 45 | (1) | 1/2 | 42 | 600 | 18 | 36 |
| Louisiana | 96 | d 150 | $\mathrm{k}=35$ | 50 | 60 | 1 or $1 / 2$ | 40 | 450 | - 18; p 16 | 32 |
| Maine ${ }^{\text {b }}$ | 96 | 150 | 45 | 45 | 45 | 1 or $1 / 2$ | 48 | 600 | - 22 | 32 |
| Maryland ${ }^{\text {e }}$ | 96 | ${ }^{\text {d }} 150$ | 55 | 55 | 55 | (1) | (8) | (8) | 22.4 | 40 |
| Massachusetts | - 96 | (i) | ${ }^{4} 35$ | 45 | (8) | 1 or $1 / 2$ | (8) | 800 | 22.4 | 36 |
| Michigan.- | 96 | ${ }^{d} 150$ | - 35 | 55 | 55 | $11 / 2$ | 42 | 700 | ${ }^{1} 18 ;{ }^{\text {n }} 16$ | $\times 26$ |
| Minnesota ${ }^{\text {b }}$ | - 96 | ${ }^{\text {d }} 150$ | 40 | 45 | 45 | 1 or $1 / 2$ | ${ }^{\text {i }} 40$ | (i) | ${ }^{1} 18$; ${ }^{\text {m }} 10.8$ | 28 |
| Mississippi b y | 96 | ${ }^{\text {d }} 150$ | ke 35 | 45 | 45 | 1 or $1 / 2$ | 40 |  | - 18; ${ }^{\text {P } 16}$ | $\times 28.6$ |
| Missouri ${ }^{\text {b }}$ | 96 | 150 | ke 35 | 45 | 45 | (i) | 40 | 600 | -18; ${ }^{\text {P } 16}$ | 32 |
| Montana ${ }^{\text {h }}$ | n 96 | 162 | ${ }^{\text {e }} 35$ | 60 | 60 | 1 or $1 / 2$ | 40 | ( ${ }^{\text {a }}$ ) | 18 | 32 |
| Nebraska ${ }^{\text {b }}$ | 96 | 150 | ¢ e 35 | 50 | 50 | 1 or $1 / 2$ | 40 | (i) | 18 | 32 |
| Nevada ${ }^{\text {b }}$-- | 96 | (i) | (i) | (i) | (i) | ${ }^{(1)}$ | 42 | 600 | 18 | 32 |
| New Hampshire ${ }^{\text {b }}$ - - -- | 96 | 162 | ${ }^{\text {¢ }} 35$ | 45 | 45 | (i) | (8) | 600 | 22.4 | - 36 |
| New Jersey -- - .-. .-. - | 96 | 162 | 35 | 45 | 50 | 1 or 1/2 | 40 | 800 | as 22.4 | 32 |


| State | Size restrictions |  |  |  |  |  |  | Gross weight limits (pounds) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Width } \\ \text { (inehee) } \end{gathered}$ | $\underset{\substack{\text { Height } \\ \text { (inches) }}}{\substack{\text { and } \\ \text {. }}}$ | (Length (feet) |  |  | Number (stlr $=$ 1/2 tlr) | $\begin{gathered} \text { Min } \\ \text { tandern } \\ \text { axle } \\ \text { spacing } \end{gathered}$ | Per inch of tire width | In thousands |  |
|  |  |  | $\begin{aligned} & \text { Single } \\ & \text { unit } \end{aligned}$ | $\underset{\text { stlr }}{\substack{\text { Traetor }}}$ | Other combinations |  |  |  | Per axle | Per tandem axle, 4 feet apart |
| New Mexico ${ }^{\text {b }}{ }^{\text {b }}$ | ロ 96 | 162 | 40 | 65 | 64 | 11/2 | 40 | 600 | 21.6 | 34.3 |
| New York ${ }^{\circ}$. | 96 | 156 | k 035 | 50 | 50 | 1 or $1 / 2$ | 46 | ${ }^{1} 800 ; \mathrm{m} 640$ | 22.4 | 36 |
| North Carolina ab | ${ }^{\text {n }} 96$ | ${ }^{\text {d } 150}$ | k © 35 | 48 | 48 | 1 or $1 / 2$ | 48 | 600 | ¢ ¢ 19; p q 17 | - 38 |
| North Dakota ${ }^{\text {a }}$ - | 96 | 150 | k 40 | 50 | 50 | 1 or $1 / 2$ | 40 | 550 | 18 | 30 |
| Ohio ${ }^{\text {- }}$ | 96 | d 150 | k 035 | 50 | 60 | (i) | (s) | 650 | 19 | $\times 24$ |
| Oklahoma ${ }^{\text {h }}$ | 96 | 162 | ${ }^{\text {- }} 35$ | 50 | 50 | 1 or $1 / 2$ | 40 | 650 | 18 | 32 |
| Oregon b b | 96 | 150 | 35 | 50 | 50 | . 1 or $1 / 2$ | 40 | 550 | 18 | 32 |
| Pennsylvania | 96 | ${ }^{\text {d } 150}$ | k ao 35 | 50 | 50 | 1 or $1 / 2$ | 36 | 800 | 22.4 | 36 |
| Rhode Island | 102 | 150 | 40 | 50 | 50 | 1 or $1 / 2$ | 40 | 800 | 22.4 | (8) |
| South Carolina ${ }^{\text {h }}$ | 96 | 150 | k 40 | 50 | 50 | 1 or $1 / 2$ | 40 | (1) | - 20; ${ }^{\text {P } 16}$ | 32 |
| South Dakota ${ }^{\text {h }}$ | 96 | 156 | k ¢ 35 | 50 | 50 | 1 or $1 / 2$ | 40 | 600 | - 18; ${ }^{\text {p }} 16$ | 32 |
| Tennessee ${ }^{\text {a }}$ b | 96 | 150 | - 35 | 45 | 45 | 1 or $1 / 2$ | 40 | (s) | 18 | 32 |
| Texas ${ }^{\text {b }}$. | - 96 | 162 | - 35 | 45 | 50 | 1 or $1 / 2$ | 40 | ${ }^{\circ} 650 ;{ }^{\text {p }} 600$ | - 18; ${ }^{\text {p }} 16$ | 32 |
| Utah ${ }^{\text {b }}$ | 96 | 168 | 45 | 60 | 60 | 2 | 40 | (8) | ${ }^{1} 18$; ${ }^{\text {m }} 13.5$ | 33 |
| Vermont. | 96 | 150 | 50 | 50 | 50 | 1 or $1 / 2$ | 40 | 600 | (i) | (i) |
| Virginia ${ }^{\text {b }}$ | 96 | ${ }^{\text {d } 150}$ | - 35 | 50 | 50 | 1 or $1 / 2$ | 40 | 650 | 18 | 32 |
| Washington ${ }^{\text {h }}$ | 96 | 150 | ad 35 | 60 | 60 | $11 / 2$ | 42 | 500 | 18 | 32 |
| West Virginia ${ }^{\text {b }}$ | 96 | d 150 | k e 35 | 45 | 45 | 1 or $1 / 2$ | 40 | (i) | 18 | 32 |
| Wisconsin ${ }^{\text {b }}$ c. | ; 96 | ${ }^{\text {d } 150}$ | e 35 | 50 | 50 | 1 or $1 / 2$ | 40 | 800 | ${ }^{\text {sc }} 18$; ar 12 | ¢ 32 |
| Wyoming ${ }^{\text {b }}$ - | +96 | 162 | 40 | 60 | 60 | 2 | 40 | ${ }^{(8)}$ | 18 | 32 |

[^13]
## CHAPTER 4

## RAIL

## Section I. ORGANIZATION

### 4.1 Organization of the Transportation Railway Service

(fig. 4.1)

Headquarters and headquarters company, transportation railway group.

Unit
General headquarters, transportation railway service.

Headquarters and headquarters company, transportation railway command.

Transportation railway operating battalion.

Headquarters and headquarters company, transportation railway operating battalion.

Company A (railway engineering), transportation railway operating battalion.

Company B (railway equipment), transportation railway operating battalion.

Operates and maintains a military railway division in a theater of operations. Can operate 40 steam engines or 20 diesel-electric engines per day in road and yard service over 90 to 150 miles of railroad and can inspect and maintain right-of-way for this mileage. Inspects condition of and performs organizational and field maintenance repairs 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 in the battalion.
Supervises and coordinates the operations of a railway operating battalion. Provides 1 operating battalion with the necessary supply, administration, and train dispatching services. Distributes rolling stock and locomotives as directed, and operates railway stations and towers.
Maintains and repairs approximately 90 to 150 miles of right-of-way, tracks, railway signals, electrical communications, structures, bridges, and buildings located within a railway division.
Inspects, services, and makes running repairs on approximately 40 locomotives and 800 railway cars. Makes running inspections on 2,000 railway

## Assignment

Normally 1 to a theater having 2 or more headquarters companies, transportation railway command.
To a theater of operations. It is the highest echelon in the theater if there is no general headquarters, transportation railway service.
To a headquarters and headquarters company, transportation railway command. If there is no transportation railway command in a theater, the group may operate separately under operational control of the theater transportation officer.
Normally 2 to 6 to a railway group.

1 per railway operating battalion.

Organic to railway operating battalion (normally 1 per battalion).

Organic to railway operating battalion (normally 1 per battalion).

Company $\mathbf{C}$ (train operating), transportation railway operating battalion.

Company D (electric power transmission), transportation railway operating battalion.

Transportation railway shop battalion.

Headquarters and headquarters company, transportation railway shop battalion.

Company A (erecting and machine shop), transportation railway shop battalion.

Company B (boiler and smith shop), transportation railway shop battalion.

Company C (car repair), transportation railway shop battalion.

Company D (diesel-electric locomotive repair), transportation railway shop battalion.
Transportation depot company.

55-229

55-217

55-235

55-236

55-237

55-238

55-239

55-247

55-260

Team EA, ambulance train maintenance crew.*
cars per day. Repairs tools and mechanical equipment of all companies within the battalion.
Operates locomotives and trains. Provides train crews to operate 40 locomotives per day over 90 to 150 miles of railroad.
Maintains and repairs electric power transmission facilities for train operation on an electrified division of a military railway ( 200 miles of electrified railway). Can maintain a catenary or third-rail system with substations, but cannot actually generate the required power.
Provides depot maintenance on locomotives, cars, and equipment. Capable of supporting 2 to 4 operating battalions, up to 100 steam locomotives, 200 diesel-electric locomotives, and 2,500 railroad cars.
Commands and furnishes technical supervision and plant maintenance for the railway shop battalion, plus administration, mess, and supply of companies orgenic to the railway shop battalion.
Performs depot maintenance involving erecting and machine shop work for a military railway using steam locomotives and/or diesel-electric locomotives, in support of 100 steam locomotives, 200 diesel-electric locomotives, and 2,500 railway cars.
Performs boiler and blacksmith repairs to locomotives and rolling stock, in support of 100 steam locomotives, 200 diesel-electric locomotives, and 2,500 railway cars.
Performs heavy repairs on freight and passenger cars for 2 to 4 railway operating battalions, in support of 2,500 cars.
Performs inspections and depot maintenance and support of 200 diesel-electric locomotive units.

Receives, stores, and issues all transportation items of supply, up to 100 tons per day.

Performs running repairs on railway cars of 1 ambulance train.

Organic to railway operating battalion (normally 1 per battalion).

To railway operating battalion.

Normally 1 or 2 to a railway group.

1 per railway shop battalion.

Organic to railway shop battalion (normally 1 per battalion).

Organic to railway shop battalion (normally 1 per battalion).

Organic to railway shop battalion (normally 1 per battalion).

Organic to railway shop battalion (normally 1 per battalion).

To a logistical command or to a general depot as the transportation section. Normally 1 depot company per 35,000 troops in a theater of operations. May be assigned to a railway command.
To headquarters and headquarters company, transportation railway command; or to senior transportation railway unit in a theater of operations.

See footnote on page 126.

| Unit | TOE | Mission and/or capability |
| :---: | :---: | :---: |
| Team EH, ambulance train | $55-500$ | Performs field maintenance repairs on |
| maintenance section.* |  | ambulance trains, up to 4 trains. |
| Team EP, railway work- | $55-500$ | Performs daily field maintenance of 5 <br> shop, mobile.* |
|  |  | steam and 15 diesel-electric locomo- |
|  |  | tives and 100 railway cars in forward |
|  |  |  |
|  |  | areas where stationary facilities are |
| inadequate. |  |  |

## Assignment

Same as Team EA, above.
Normally to headquarters and headquarters company, transportation railway group.


- ASSIGNED AS REQUIREO.

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 wheel's from front to rear; the wheels in the locomotive tender are not counted in the classification. For example, a Whyte 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 loco-
motives 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 $\mathrm{C}-\mathrm{C}$, etc.

Idler (those which exert no tractive effect) wheels and leading and trailing wheels are designated with numbers. A single-unit locomotive with two six-wheel trucks in which the center wheel is an idler would be designated as A1A-A1A. An electric locomotive with four-wheel leading and trailing trucks and six driving wheels would be designated $2-\mathrm{C} / \mathrm{C}-2$.

### 4.3 Characteristics of Railway Equipment

a. Locomotives.
(1) Steam.

| Type | $\begin{aligned} & \text { Gage } \\ & \text { (in.) } \end{aligned}$ | Weight, loaded (lb) |  |  | Tractive force (b) | $\begin{gathered} \text { Drawbar } \\ \text { pullar } \\ \text { (1b) } \end{gathered}$ |  | Fuel capacity | Water capacity |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Locomotive | Tender | $\stackrel{\text { On }}{\text { drivers }}$ |  |  |  |  |  |
| $\begin{gathered} \text { 82-ton, } \\ 2-8-0 \end{gathered}$ | $\left.\begin{array}{r} 561 / 2,60, \\ 63,66 \end{array} \right\rvert\,$ | 165,000 | 133,575 133,575 | 143,000 160,000 | $\begin{gathered} 34,000 \\ \text { ( } 85 \% \\ \text { boiler } \\ \text { pressure) } \\ 40,000 \end{gathered}$ | $\begin{aligned} & 42,000 \\ & \quad \text { (approx.) } \\ & 38,400 \end{aligned}$ | 231 193 | 11-ton coal or 2,000 gal. oil. | 7,500-gal. tender |
| $\begin{aligned} & 80-\text { ton } \\ & 0-6-0 \end{aligned}$ | $561 / 2$ | 160,000 | 133,575 | 160,000 | 40,000 | 38,400 | 193 | Same as above | Same as above |

(2) Diesel-electric.

| Type | $\begin{gathered} \text { Gage } \\ \text { (in.) } \end{gathered}$ | $\underset{\substack{\text { Wcight } \\ \text { locomotive } \\ \text { (1b) }}}{ }$ | Tractive force (b) |  | Horse- <br> power | Curvature, min radius (f) | $\begin{gathered} \text { Fuel } \\ \text { capacity } \\ \text { (gal.) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Starting at <br> 30-percent adhesion | Continuous |  |  |  |
| 131-ton, 0-6-6-0, domestic and foreign service. | 561/2 | 262,000 | 75,700 | $37,850^{(\mathrm{a})}$ | 1,000 | 231 |  |
| 127-ton, 0-6-6-0, domestic and foreign service. | 561/2 | 254,000 | 75,700 | $\begin{array}{r} (\mathrm{a}) \\ 37,850 \end{array}$ | 1,000 | 231 |  |
| 120-ton, 0-4-4-0, domestic service........ | 561/2 | 240,000 | 72,000 | $\begin{aligned} & 35,000 \text { at } \\ & 10 \mathrm{mph} \end{aligned}$ | 1,200 | 193 | 750 |
| 120-ton, single engine, 0-4-4-0, domestic service. | 561/2 | 240,000 | 72,000 | $\begin{aligned} & 34,000 \text { at } \\ & 8.3 \mathrm{mph} \end{aligned}$ | 1,000 | 75 | 700 |
| 120-ton, 0-4-4-0, domestic service........ | 561/2 | 240,000 | 72,000 | $\begin{array}{r} (0) \\ 36,000 \end{array}$ | 1,500 | 150 |  |
| 120-ton, 0-6-6-0, foreign service. . . . . . . . | $\begin{gathered} 561 / 2,60 \\ 63,66 \end{gathered}$ | 240,000 | 72,000 | $\begin{aligned} & 45,000 \text { at } \\ & 10 \mathrm{mph} \end{aligned}$ | 1,600 | 193 | ${ }^{\text {b }}$ 1,600 |
| 115-ton, 0-4-4-0, domestic service........ | 561/2 | 230,000 | 69,000 | $\begin{gathered} \text { (4) } \\ 34,500 \end{gathered}$ | 1,000 | 50 |  |
| 100-ton, 0-4-4-0, domestic service........ | $561 / 2$ | 200,000 | 59,700 | $\begin{gathered} \left({ }^{(a)}\right. \\ 29,850 \end{gathered}$ | 660 | 50 |  |
| 80-ton, 0-4-4-0, dual engine, domestic service. | $561 / 2$ | 161,000 | 48,000 | $\begin{aligned} & 21,000 \text { at } \\ & 5.2 \mathrm{mph} \end{aligned}$ | 470 | 75 | 300 or 400 |
| 76-ton, 0-6-6-0, foreign service. . . . . . . . | $\begin{gathered} 36,393 / 8 \\ 42 \end{gathered}$ | 152,000 | 45,000 | $\begin{gathered} \left({ }^{(a)}\right. \\ 22,500 \end{gathered}$ | 975 | 100 |  |
| 65-ton, 0-4-4-0, domestic service........ | 561/2 | 130,000 | 39,000 | $\begin{gathered} \left({ }^{(a)}\right. \\ 19,500 \end{gathered}$ | 400 | 75 |  |
| 60-ton, $0-4-4-0$, foreign and domestic service. | $\begin{gathered} 561 / 2,60, \\ 63,66 \end{gathered}$ | 122,000 | 36,000 | $\begin{aligned} & 15,680 \text { at } \\ & 7.28 \mathrm{mph} \end{aligned}$ | 450 | 75 | 500 |
| 58-ton, 0-4-4-0, foreign service. . . . . . . . |  | 116,000 | 36,000 | $\begin{gathered} (\stackrel{A}{( }) \\ 18,000 \end{gathered}$ | 400 | 75 |  |
| 48-ton, single engine, 0-4-4-0, foreign service. | $\begin{aligned} & 36,393 / 8 \\ & 42 \end{aligned}$ | 115,000 | 34,500 | $\begin{aligned} & 15,680 \text { at } \\ & 7.28 \mathrm{mph} \end{aligned}$ | 400 | 75 | 500 |


| Type | $\begin{aligned} & \text { Gage } \\ & \text { (in.) } \end{aligned}$ | $\begin{aligned} & \text { Weight } \\ & \text { locomotive } \\ & \text { (Ib) } \end{aligned}$ | Tractive force (b) |  | Horsepower | Curvature, min radius (ft) | $\begin{gathered} \text { Fuel } \\ \text { capacity } \\ \text { (gal.) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Starting at 30-percent ad hesion | Continuous |  |  |  |
| 45-ton, side-rod drive, 0-4-4-0, domestic service. | 561/2 | 90,000 | 27,000 | $\begin{array}{r} (\mathrm{a}) \\ 13,500 \end{array}$ | 300 | 50 |  |
| 45-ton, 0-4-4-0, domestic and foreign service. |  | 90,000 | 27,000 | $\begin{array}{r} (\mathrm{a}) \\ 13,500 \end{array}$ | 380 | 75 |  |
| 44-ton, 0-4-4-0, domestic service... | 561/2 | 88,000 | 26,400 | $\begin{array}{r} (\mathrm{a}) \\ 13,200 \end{array}$ | 380 | 75 |  |
| 25-ton, 0-4-0, domestic service | 561/2 | 50,000 | 15,000 | $\begin{gathered} (\mathrm{a}) \\ 6,200 \mathrm{at} \\ 6.2 \mathrm{mph} \end{gathered}$ | 150 | 50 | 75 |
| 25-ton, 0-4-0, foreign service. | 42 | 50,000 | 15,000 | $\begin{aligned} & (\mathrm{a}) \\ & 6,200 \mathrm{at} \\ & 6.2 \mathrm{mph} \end{aligned}$ | 150 | 40 | 75 |

- For diesel-electric power, the continuous TE is approximately half of the atarting TE.
b Reduced to 800 if equipped with Clarkson vapor heater.
(3) Gasoline-mechanical and diesel-mechanical.

| Type | $\begin{gathered} \text { Gage } \\ \text { (in.) } \end{gathered}$ | Weight (lb) | Drawbar pull ( ${ }^{\text {(h) }}$ | Horgepower (total engine | Curvature, min $\underset{(f t)}{\text { radius }}$ (ft) | $\underset{\text { (gal.) }}{\text { Fuel }}$ capacity |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 10-ton, single engine, 0-4-0, domestic service.- | 561/2 | 20,000 |  | 100 | 75 | 30 (diesel) |
| 5 -ton, single engine, 0-4-0, foreign and domestic service. | 36 | 11,000 | $\begin{gathered} 2.7 \mathrm{mph}-2,500 \\ 12 \mathrm{mph}-875 \\ \hline \end{gathered}$ | 34 | 20 | 15 (gasoline) |

## b. Boxcars.

| Type | Gage (in.) | Capacity |  | Inside |  |  | Door dimensions | Tare weight (ST) (ST) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | (lb) | (cu ft) | Length | Width | Height |  |  |
| 8W, narrow gage, foreign service. | $\begin{gathered} 36,393 / 8 \\ 42 \end{gathered}$ | 60,000 | 1,588 | $34^{\prime} 51 / 2^{\prime \prime}$ | 7'3/4" | $6^{\prime} 4^{\prime \prime}$ | $7^{\prime} 101 / 4^{\prime \prime}$ wide $6^{\prime} 1 / 16^{\prime \prime}$ high | 13.6 |
| 8W, domestic service....-. | $561 / 2$ | 100,000 | 3,975 | $40^{\prime} 6^{\prime \prime}$ | $9^{\prime} 2^{\prime \prime}$ | $10^{\prime} 6^{\prime \prime}$ | $6^{\prime}$ wide, clear opening <br> $8^{\prime}$ high, clear opening | 23 |
| 8W, broad gage, foreign service. | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | 80,000 | 2,520 | $40^{\prime} 6^{\prime \prime}$ | $8^{\prime} 6^{\prime \prime}$ | $6^{\prime} 55 /{ }^{\prime \prime}$ | $8^{\prime} 31 / 4^{\prime \prime}$ high <br> $6^{\prime} 83 / 4^{\prime \prime}$ wide | 18.5 |

## c. Open-Top Cars.

(1) Flatcars.

| Type | Gage (in.) | Nominal capacity (lh)* | Platform length* | Platform width* | Platform height above rail | Tare weight empty (ST) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 8W, narrow gage, foreign service. | 36, 393/8, 42 | 60,000 | $34^{\prime} 81 / 2^{\prime \prime}$ | 7' ${ }^{\prime \prime}$ | $3^{\prime} 7^{\prime \prime}$ | 10.9 |
| 12 W , domestic service | 561/2 | 200,000 | 54' | $10^{\prime} 61 / 2^{\prime \prime}$ | $4^{\prime} 11 / 4^{\prime \prime}$ | 35 |
| 8 W , domestic service. | 561/2 | 140,000 | $49^{\prime} 111 / 2^{\prime \prime}$ | $10^{\prime} 31 / 4^{\prime \prime}$ | $3^{\prime} 81 /{ }^{\prime \prime}$ | 27 |
| 12 W , broad gage, foreign service, 80-ton . . . . - | $\begin{gathered} 561 / 2,60,63 \\ 66 \end{gathered}$ | 160,000 | $46^{\prime} 4^{\prime \prime}$ | $9^{\prime} 8^{\prime \prime}$ | $4^{\prime} 27 / 8^{\prime \prime}$ | 35.3 |
| 12W, domestic service (passenger train service) | 561/2 | 200,000 | $54^{\prime}$ | $10^{\prime} 61 / 4^{\prime \prime}$ | $4^{\prime} 53 / 8^{\prime \prime}$ |  |
|  | 561/2 | 100,000 | $43^{\prime} 3^{\prime \prime}$ | $10^{\prime} 6^{\prime \prime}$ | $3^{\prime} 8^{\prime \prime}$ | 25.5 |
| 8W, broad gage, foreign service | $\begin{gathered} 561 / 2,60,63, \\ 66 \end{gathered}$ | 80,000 | $40^{\prime} 9^{\prime \prime}$ | $8^{\prime} 71 / 4^{\prime \prime}$ | $3^{\prime} 6^{15} / 16^{\prime \prime}$ | 14.5 |
| 8W, broad gage, depressed center, foreign service | $\begin{gathered} 561 / 2,60,63, \\ 66 \end{gathered}$ | 140,000 | $50^{\prime} 7^{\prime \prime}$ | $9^{\prime} 8^{\prime \prime}$ | --- | 41.5 |

[^14] first the number of vehicles by type that will fit on the flatcar bed. Then chcek their combined weights (including any cargo in the vehicles) againgt the weight capacity of the car. Either the platform dimenaions of the fatcar or its weight-carrying capacity is the controlling factor. Side sills of flatcars must be considered in determining ability to carry tracked vehicles, such as tanks, where the total loaded weight is resting on the outer edge of the car deck.
(2) Gondolas.

| Type | Gage (in.) | Capacity |  | Inside dimenslona |  |  | $\begin{gathered} \text { Tare } \\ \text { weight } \\ \text { empty } \\ \text { (ST) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | (b) | (cu ft) | Length | Width | Height |  |
| High side, 8W, narrow gage, foreign service. | 36, $393 / 8,42$ | 60,000 | 940 | 34'5 ${ }^{\prime \prime}$ | $6^{\prime} 101 / 2^{\prime \prime}$ | $4 \times$ | 13 |
| Low side, 8 W , narrow gage, foreign service. | 36, 393/8, 42 | 60,000 | 356 | $34^{\prime \prime} 6^{\prime \prime}$ | 6' $101 / 2^{\prime \prime}$ | $1^{\prime} 6^{\prime \prime}$ | 12.1 |
| High side, 8W, broad gage, foreign 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 | $40^{\prime} 41 / 2^{\prime \prime}$ | 8'31/4" | $1^{\prime} 6^{\prime \prime}$ | 16 |
| Low side, 8 W , drop ends, domestic service - | $561 / 2$ | 100,000 | 1,184 | $41^{\prime} 6^{\prime \prime}$ | $9^{\prime} 61 / 8^{\prime \prime}$ | $3^{\prime}$ | 23 |
| High side, std gage, domestic service.-. .- | 561/2 | 100,000 |  | 41'6" | $9^{\prime} 6^{\prime \prime}$ | $4^{\prime} 6^{\prime \prime}$ | 25 |

(3) Hopper car.

| Type | Gage (in.) | Nominal capacity (lb) | Inside dimenaions |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Length | Width | Height |
| 8W, domestic service. | 561/2 | 100,000 | 33' | $9^{\prime} 51 / 2^{\prime \prime}$ | $9^{\prime \prime} 7^{\prime \prime}$ |

## d. Tank Cars.

| Type | Gage (in.) | $\underset{\substack{\text { Length } \\ \text { overtank } \\ \text { heads }}}{\substack{\text { chate }}}$ | $\begin{gathered} \text { Nominnal } \\ \text { capacity } \\ (\text { gal.1.)! } \end{gathered}$ | Inside diameter (in.) |  | $\begin{gathered} \text { Tare } \\ \left.\begin{array}{c} \text { Teight } \\ \text { enempty } \\ \text { ent } \end{array}\right) \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | 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 | 593/8, approx |  |
| Caustic soda, ICC-103-W, 8W, domestic service. | 561/2 | 34', approx | 10,000 | 88, approx | 64 |  |
| Petroleum, 8 W , narrow gage, foreign service-- | 36, 383/8, 42 | 38, $41 / 8^{\prime \prime}$ | 6,000 | $621 / 2$ | 54 | 16 |
| Petroleum, 8W, broad gage, foreign service... | $\begin{gathered} 561 / 2,80,63 \text {, } \\ 66 \end{gathered}$ | $38^{\prime} 53 / 8^{\prime \prime}$ | 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' $81 /{ }^{\prime \prime}$ | 8,000 | 78, approx | 64 |  |
| Petroleum, std gage, domestic service | 561/2 |  | 10,000 |  |  | 23 |

' Specific gravity of a liquid should be checked before it ia loaded to avoid exceeding weight capacity of car.
${ }^{2}$ See paragraph 7.28 below for liquid volume in partially filled tank cars.

## e. Refrigerator Cars.

| Type | $\begin{aligned} & \text { Gage } \\ & \text { (in.) } \end{aligned}$ | Nominal <br> capacity <br> (lb) | Length inside end lining | Width inside side linlng | $\underset{\substack{\text { capaceity } \\(16)}}{\text { Ice }}$ | Dimensions of doors |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 8W, disassembled, foreign service . . . . . - | 561/2 | 80,000 | 38'91/2" | $6^{\prime} 11^{\prime \prime}$ | 11,000 | 4' wide 7' high |
| 8 W , disassembled, broad gage, foreign service. | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | 80,000 | $32^{\prime} 1 / 2^{\prime \prime}$ | 7' $8^{\prime \prime}$, approx | 11,000 | 4' wide 7' high |
| 8W, mechanical, foreign service.-.-.----- | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | 80,000 | $40^{\prime} 9^{\prime \prime}$, equipment compartment | $7^{\prime} 6^{\prime \prime}$, approx | None | 6' wide <br> 7' high |

f. Special Purpose Cars.

| Type | Gage (in.) | Weight (1b) |  | Over end sills |  | Height above rail | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Light | Loaded | Length | Width |  |  |
| Car, amb unit, 8W, domestic service. | 561/2 | 157,000 | 167,300 | $78^{\prime} 11^{\prime \prime}$ | $10^{\prime}$ | $13^{\prime \prime} 6^{\prime \prime}$ | Capacity: 27 patients, 6 corpsmen, 1 nurse, 1 doctor. |
| Car, kitchen, troop/amb train, 8W, domestic service. | 561/2 | 100,160 |  | *54' $21 / 2{ }^{\prime \prime}$ | $9^{\prime} 53 / 4^{\prime \prime}$ | $13^{\prime} 6^{\prime \prime}$ | Width, side door openings: 6 '. |
| Car, kitchen, dining and storage, amb train, 8W, foreign service. | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | $\begin{aligned} & 111,400 \\ & \quad \text { avg } \end{aligned}$ |  | $63^{\prime 1} 14^{\prime \prime}$ | 9' | 13' | Seat capacity: 24 |
| Car, ward, amb train.....- | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | $\begin{gathered} 111,400 \\ \text { avg } \end{gathered}$ |  | $63^{\prime} 1 / 4^{\prime \prime}$ | $9^{\prime}$ | $13^{\prime}$ | Berth capacity: 30 |
| Car, personnel, amb train --- $^{\text {a }}$ | $\begin{gathered} 561 / 2,60 \\ 63,66 \end{gathered}$ | $\begin{aligned} & 111,400 \\ & \text { avg } \end{aligned}$ |  | $63^{\prime 1} 14^{\prime \prime}$ | $9^{\prime}$ | $13^{\prime}$ | Berth capacity: 15 EM's, 4 doctors, 2 nurses. |

* Includes couplers.
g. Cranes.

| Type | $\begin{aligned} & \text { Gage } \\ & \text { (in.) } \end{aligned}$ | Weight (b) | Boom length ( ft ) | $\underset{\substack{\text { Boomn height } \\ \text { (down) }}}{ }$ |
| :---: | :---: | :---: | :---: | :---: |
| Wrecking, steam, 75-ton, broad gage, foreign service | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | 191,000 | 25, 2-piece, curved | $12^{\prime} 33 / 4^{\prime \prime}$ |
| Locomotive, diesel-mechanical, 25-ton, broad gage, domestic and foreign service. | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | 148,000 | 50, 2-piece, straight | $13^{\prime} 6^{\prime \prime}$ max. |
| Locomotive, diesel-mechanical, 40-ton, broad gage, foreign service. | $\begin{array}{r} 561 / 2,60 \\ 63,66 \end{array}$ | 210,000 | 50, 2-piece, straight | 13' 6" max. |
| Locomotive, diesel-mechanical, 25-ton, narrow gage, foreign service. | $\begin{gathered} 36,393 / 8 \\ 42 \end{gathered}$ | 161,000 | 40, 2-piece, straight | $10^{\prime} 10^{\prime \prime}$ |

### 4.4 Dimensions, Weighf, 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 | Capacity |  |  |  | Weight (tons) (tons) | Inside dimensions (ft) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Tons | Men $\mathbf{~}^{8}$ sq ft per man snd equipment) | $\begin{gathered} \text { Animals } \\ \text { (horsees, } \\ \text { mules, } \\ \text { oxen are avg. } \\ \text { width. } \\ 22 \text { inches } \end{gathered}$ | $\underset{\text { feet }}{\text { Cubic }}$ |  | Length | Width | Height |
| Automobile. | $40$ | $\begin{aligned} & 45 \\ & 58 \end{aligned}$ | $\begin{aligned} & 22 \\ & 27 \end{aligned}$ | 3,100 4,702 | 20 25 | 40.5 50.6 | 8.5 9.2 | $\begin{gathered} 9 \\ 10.1 \end{gathered}$ |
| Baggage |  |  |  |  | 45 | 60 | 9.1 | 8 |
| Box. | 30 | 38 | 20 | 2,750 | 18 | 36 | 8.5 | 9 |
|  | 40 | 43 | 22 | 3,100 | 20 | 40.5 | 8.5 | 9 |
|  | 50 | 43 | 22 | 3,100 | 24 | 40.5 | 8.5 | 9 |
| Caboose. |  |  |  |  | 20 | 27.5 | 8.2 | 7 |
| Diner. |  |  |  |  | 90 | 78.5 | 8.5 | 8.5 |
| Flat | 40 | - | - |  | 18 | 40 | 9 |  |
|  | 50 |  |  |  | 20 | 45 | 9 |  |
|  | 70 |  |  |  | 25 | 50 | 9 |  |
| Gondola | 50 |  |  | 1,570 | 22 | 40 | 9.9 | 4 |
|  | 70 |  |  | 1,920 | 25 | 48 | 10 | 4 |
| Refrigerator | :30 |  |  | 2,570 | 28 | 40.5 | 8.2 | 7.2 |


| Type | Capacity |  |  |  | $\begin{aligned} & \text { Weight } \\ & \text { empty } \\ & \text { (tona) } \end{aligned}$ | Inside dimensions (ft) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Tona | Men ${ }^{8} 8 \mathrm{aq}$ ft per man and equipment | Animala (borgea, mules, oxen-avg. 22 inchea) | $\underset{\text { feet }}{\text { Cubic }}$ |  | Length | Width | Height |
| Stock | ${ }^{4} 40$ | ------------------ | 2020 | 2,5702,625 | 30 | 40.5 | 8.2 | 7.58.5 |
|  | 30 |  |  |  | 20 | 36 | 8.5 |  |
|  | 40 |  |  | 3,003 | 22 | 40.6 | 8.6 | 8.6 |
|  | -40 |  |  |  | 20 | 33 | ${ }^{\bullet} 6.6$ |  |
|  | d50 |  |  |  | 24 | 33 | ${ }^{\circ} 7.2$ |  |

- Ice capacity, 4 tons.
b Ice capacity, 5 tona.
- 8,000 gal.
d $10,000 \mathrm{gal}$.
- Diameter.


### 4.5 Capacity of Standard U.S. Passenger Cars

|  | $\underset{\text { coach }}{\text { Day }}$ | Tourist sleeper | Standard slecper ${ }^{2}$ |
| :---: | :---: | :---: | :---: |
| Length in feet | 65-75 | 65-75 | 65-80 |
| Number of sections. | None | 13-16 | 12-16 |
| Maximum seating: |  |  |  |
| 2 men to each double seat. | 60-70 | 52-64 | 53-64 |
| 3 men to each 2 double seats | 45-52 | 39-48 | 40-48 |
| Sleeping capacity: |  |  |  |
| 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.
${ }^{2}$ Standard sleeper- 12 sectlows and 1 drawing room or 16 sections and no drawing room.

## Section III. OPERATIONS

### 4.6 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.

## Q. 7 Oufline of Sicnding Opercing Proc®dur for Rail movement

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 authority index 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.

## Q.8 OuTlime of Siancimg 1Operaimg Pro๔edvre for Tramsporiaiom 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 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. Responsi-
bility 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.

### 4.9 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: |  |  |  |
| Blankets, baled. | . 27 | 32 | 40 |
| Bread | -19 | 24 | 30 |
| Canned goods in boxes | -30 | 36 | 45 |
| Clothing, baled | . 27 | 32 | 40 |
|  |  | 20 | 25 |


| Meat | . 15 | 24 | 35 |
| :---: | :---: | :---: | :---: |
| Motor vehicle parts | . 24 | 28 | 40 |
| Oats | 18 | 24 | 30 |
| Sandbags. | . 21 | 24 | 30 |
| Tentage | 15 | 20 | 30 |
| Ties, railroad | 19 | 26 | 32 |

### 4.10 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 condition 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 | $22^{\prime \prime}$ |
| b. Side. |  |  |
| Buildings. | 2.59 | 8'6" |
| Canopies: |  |  |
| Up to $15^{\prime} 6^{\prime \prime}$. | 2.59 | 8'6" |
| Higher than $15^{\prime} 6^{\prime \prime}$. | 1.68 | $5^{\prime} 6^{\prime \prime}$ |
| Platforms: |  |  |
| $3^{\prime} 9^{\prime \prime}$ | 1.88 | $6{ }^{\prime \prime}$ |
| $4{ }^{\prime}$. | 1.52 | $5^{\prime} 0^{\prime \prime}$ |
| Refrigerator platforms: ${ }^{\prime \prime}$ |  |  |
| $3^{\prime} \mathbf{2}^{\prime \prime}$---------.- | 1.88 | $6^{\prime \prime} 2^{\prime \prime}$ |
| $4^{\prime} 7^{\prime \prime}$ | 2.59 | $8^{\prime 6}{ }^{\prime \prime}$ |
| c. Enginehouse Entrance. |  |  |
| Overhead.-.--...- | 5.18 | $17^{\prime \prime} 0^{\prime \prime}$ |
| Side. | 1.98 | $6^{\prime} 6^{\prime \prime}$ |

d. Bridge and Tunnel. Standard single-track bridge and tunnel clearances are shown in figure 4.2.

### 4.11 Railway Gages (in Inches) by Area

| Gages | 23\%6 | 24 | 291/2 | 30 | 35 | 36 | 37 | 37\% | 371/6 | 3936 | 40 | 41/4 | 411/2 | 41968 | 42 | $561 / 2$ | 56\%/8 | 571/8 | 60 | 63 | 66 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| a. Africa. |  |  |  |  |  |  |  |  |  |  | - |  |  |  |  |  |  |  |  |  |  |
| Algeria |  |  |  |  |  |  |  |  |  | x |  |  |  | $\mathbf{x}$ |  | x |  | x |  |  |  |
| Cameroun |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |
| Central African Republic |  |  |  |  |  |  |  |  |  |  |  |  |  |  | $\mathbf{x}$ |  |  |  |  |  |  |
| Chad |  |  |  |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |  |


| Gages | 235\% | 24 | 29 1/2 | 30 | 35 | 36 | 37 | 3768 | 371/4 | 393/3 | 40 | $41 / 4$ | $411 / 2$ | 41\%自 | 42 | $561 / 2$ | 56\% | 5736 | 60 | 63 | 66 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Congo, Republic of (Brazzaville) |  | K |  |  |  |  |  |  |  | $\mathbf{x}$ |  |  |  |  | x |  |  |  |  |  |  |
| Congo, Republic of (Leopoldville) |  | x |  |  |  |  |  |  |  | X |  |  |  |  | K |  |  |  |  |  |  |
| Dahomey |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |
| Egypt |  |  | X | X |  |  |  |  |  | X |  |  |  |  |  | X |  |  |  |  |  |
| Eritrea |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ethiopia |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Gabon |  |  |  |  |  |  |  |  |  | X |  |  |  |  | X |  |  |  |  |  |  |
| Ghana |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |
| Guinea |  |  |  | $\mathbf{x}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ivory Coast |  |  |  | X |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |
| Kenya |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Liberia |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Libya |  |  |  |  |  |  | X |  | X |  |  |  |  |  |  |  |  |  |  |  |  |
| Malagasy |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Mali |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |
| Mauritania |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  | X |  |  |  |  |  |
| Morocco |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |
| Niger |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  | X |  |  |  |  |  |
| Nigeria |  |  |  | X |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |
| Nyasaland |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |
| Portuguese East <br> Africa <br> (Mozambique) |  |  |  | x |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |
| Portuguese West <br> Africa (Angola) |  | x |  |  |  |  |  |  |  | X |  |  |  |  | X |  |  |  |  |  |  |
| Republic of South Africa |  | x |  |  |  |  |  |  |  |  |  |  |  |  | $\mathbf{x}$ |  |  |  |  |  |  |
| Reunion |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Rhodesia |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |
| Senegal |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  | . |  |  |
| Sierra Leone |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Somalia |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |


| Gages | 238/8 | 24 | $291 / 2$ | 30 | 35 | 36 | 37 | 378/8 | 377\% | 393/8 | 40 | 411/4 | $411 / 2$ | 419\%s | 42 | $561 / 2$ | 567\% | $571 / 8$ | 60 | 63 | 66 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sudan |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |
| Swaziland |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |
| Tanganyika |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |
| Togo |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |
| Tunesia |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  | X |  |  |  |  |  |
| Uganda |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Upper Volta |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |  |  |  |  |  |
| b. Asia. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Afganistan |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  | X |  |  | X |  |  |
| Borneo |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |
| Burma |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |
| Cambodia |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Ceylon |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |
| China |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |
| Formosa |  | X |  | X |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |
| India | . | X |  | X |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  | X |
| Indonesia |  |  |  | X |  |  |  |  |  |  |  |  | - |  | X | X |  |  |  |  |  |
| Iran |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  | X |  |  |
| Iraq |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  | X |  |  |  |  |  |
| Israel |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |
| Japan |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |  |  |  |  |  |
| Jordan |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |
| Korea |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |
| Laos |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Lebanon |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  | X |  |  |  |  |  |
| Malaya |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |
| Nepal |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  | X |
| Pakistan |  |  |  |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |  | X |
| Saudi Arabia |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  | X |  |  |  |  |  |
| Syria |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  | X |  |  |  |  |  |
| Thailand |  |  |  |  | 1 |  |  | 1 |  | X |  |  |  |  |  |  |  |  |  |  |  |


| Gages | 235/8 | 24 | 291/2 | 30 | 35 | 36 | 37 | 375/3 | 377 ${ }^{\text {de }}$ | 391/6 | 40 | 41/4 | 413/2 | 41916 | 42 | $561 / 2$ | 561/3 | 571/8 | 60 | 63 | 66 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Tibet |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |
| Turkey |  |  | x |  |  |  |  |  |  | x |  |  | x |  |  | x |  |  | x |  |  |
| USSR |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  | x |  |  |
| Vietnam |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |
| c. Europe. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Albania |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| Austria |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| Belgium |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| Bulgaria | x |  |  | x |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Czechoslovakia |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Denmark |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Estonia |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |
| Finland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |
| France |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| Germany |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| Greece |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| Hungary |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Ireland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |
| Italy |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  | x | x |  |  |  |  |
| Latvia | x |  | x |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  | x |  |  |
| Lithuania | x |  | x |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  | x |  |  |
| Luxembourg |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| Netherlands |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |
| Norway |  |  |  |  |  |  |  |  |  |  |  |  |  |  | $\mathbf{x}$ | x |  |  |  |  |  |
| Poland |  |  | x |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  | x |  |  |
| Portugal |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  | x |
| Rumania |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Spain |  |  |  |  |  | x |  |  |  | x |  |  |  |  |  |  |  |  |  |  | x |
| Sweden |  |  |  |  | x |  |  |  |  |  |  |  |  |  | x | x |  |  |  |  |  |
| Switzerland |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| Turkey |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |


| Gapes | 23\% | 24 | $291 / 2$ | 30 | 85 | 36 | 37 | 87\% | 377/10 | 893/6 | 40 | 41/4 | 413/2 | 41410 | 42 | $561 / 2$ | 667/8 | 571/3 | 60 | 63 | 66 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| USSR |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  | x |  |  |
| United Kingdom |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  | x |  |
| Yugoslavia |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| d. Central America and West Indies |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Costa Rica |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |
| Cuba |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Dominican Republic |  |  |  | x |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |
| El Salvador |  |  |  |  |  | $\mathbf{x}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Guatemala |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Haiti |  |  |  | x |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |
| Honduras |  |  |  |  |  | x |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |
| Jamaica |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Nicaragua |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |
| Panama - |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |
| Puerto Rico |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |
| Trinidad |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| e. North America. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Canada |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Newfoundland |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |
| Mexico |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| United States (CONUS) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Alaska |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Hawaii (see Pacific Ocean) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. South America. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Argentina |  |  | x |  |  |  |  |  |  | x |  |  |  |  |  | x |  |  |  |  | x |
| Bolivia |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  | . |  |  |  |  |  |
| Brazil |  | $\mathbf{x}$ |  | x |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  | x |  |
| British Guiana |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |


| Gages | 235/8 | 24 | 293/2 | 30 | 35 | 36 | 37 | 3756 | 377/6 | 391/8 | 40 | 413/4 | $411 / 2$ | 41\% | 42 | $561 / 2$ | 667/6 | 571/6 | 60 | 63 | 66 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Chile |  | x |  | $\mathbf{x}$ |  |  |  |  |  | x |  |  |  |  | x | x |  |  |  |  | x |
| Colombia |  |  |  |  |  | x |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |
| Dutch Guiana |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |
| Equador |  |  |  | x |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |
| Paraguay |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Peru |  |  |  |  |  | x |  |  |  | x |  |  |  |  |  | x |  |  |  |  |  |
| Uruguay |  |  |  |  |  |  | - |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| Venezuela |  | x |  | x |  | x |  |  |  | x |  |  |  |  | x | x |  |  |  |  |  |
| g. Pacific Ocean. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Australia |  |  |  | x |  |  |  |  |  |  |  |  |  |  | x | x |  |  |  | x |  |
| Hawaii |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |
| New Caledonia |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |  |  |  |  |  |
| New Zealand |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  | , |  |
| Philippines |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |
| Tasmania |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x |  |  |  |  |  |  |

### 4.12 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 (par. 4.11); therefore, all the limiting clearances shown in the composites will not 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 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.

### 4.13 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. 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 (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 I-Beam Bridge (fig. 4.5). The table below refers to bridges already constructed with two, four, six or more steel stringers or girders of


Figure 4.2. Standard single-track bridge and tunnel clearances.
equal dimensions. To estimate the capacity of a railway bridge with this type 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.

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 $3 \times \mathrm{W}$. 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 (inches) |  | Span length (feet) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Width | Depth | 10 | 12 | 14 | 16 | 18 | 20 | 22 |
| 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-39 | 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 |  |  |
| 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 |

### 4.14 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 AAR (Association of American Railroads). 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 dated 1 February 1960 and revised in January 1962, 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 4.10. 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 4.11. The various wooden blocks, cut to specific patterns and numbered, are illustrated in figure 4.12.
a. Six-Wheel Truck (fig. 4.7). ${ }^{1}$

| Item | No. of pieces | Description <br> A <br> Brake-wheel clearance (fig. 4.11). |
| :---: | :---: | :---: |
| C | Blocks, pattern 16 (1, fig. 4.12). <br> Locate 45 portion of block <br> against front and rear of front <br> wheels, in front of outside inter- <br> mediate wheels, and in back of <br> outside rear wheels. Secure heel <br> of block to floor with three 40- <br> penny nails and toenail that por- <br> tion under tire to floor with two <br> $40-p e n n y ~ n a i l s ~ b e f o r e ~ i t e m s ~ D ~$ |  |
| and E are applied. Substitute, |  |  |
| if desired, at each location, |  |  |
| blocks, pattern 17 (2, fig. 4.12), |  |  |
| or blocks, pattern 18 (3, fig. |  |  |
| $4.12)$. |  |  |


| Item | No. of pieces | Description |
| :---: | :---: | :---: |
|  |  | spring shackles, underneath and around item $G$ and twist taut after item $G$ has been nailed in place. $1^{\prime \prime}$ bolts ( 2 for each axle), made from $1^{\prime \prime}$ steel rods threaded at each end, may be substituted. Each bolt is secured on the axle with a steel plate having two holes, a lock washer, and a $1^{\prime \prime}$ 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 Cor. then through a $2^{\prime \prime} \times 4^{\prime \prime} \times$ $18^{\prime \prime}$ piece of hardwood, and is |


| Item | No. of pieces | Description |
| :---: | :---: | :---: |
|  |  | secured with a flat washer, and $1^{\prime \prime}$ square nut. |
| G | 1 each item F. | 2 by 4 by 18 inches. Secure to floor, lengthwise of car, with four 30 -penny nails. Not required when steel straps are used, pattern 19 (4, fig. 4.12). |
| H | 4 each unit. | Four strands of No. 8 gage, black annealed wire. Attach to each corner of machine and to stake pockets. Not required for unit loaded in gondola cars. |

See notes at end of $d$ below.


Figure 4.3. A composite clearance diagram: $561 / 2-, 60-, 69$-, and 66 -inch gages.
b. Landing Vehicle, Wheeled, $21 / 2$-ton, $6 \times 6$ (fig. 4.8). ${ }^{1}$

| Item | No. of pleces | Description |
| :---: | :---: | :---: |
| A |  | Brake-wheel clearance (fig. 4.11). |
| B | 8 | Blocks, pattern 24 (5, fig. 4.12). Locate in front and rear of front wheels, in front of intermediate wheels, and back of rear wheels, and secure to floor with five 30-penny nails in each. |
| C | 8 | 2 by 4 by 20 inches. Secure upper end to item $B$ and lower end to floor with two 30-penny nails at each location. |
| D | 8 | 2 by 4 by 12 inches. Locate against bottom of item $C$ and secure each to floor with three 30penny nails. |
| E | 6 | Suitable material, such as waterproof paper, burlap, etc. Locate bottom portion under items $F$, top portion to extend 2 inches above items $\mathbf{F}$. |
| F | 6 | Each consisting of 2 pieces of 2 by 4 by 36 inches. Secure lower piece to floor with four 30 -penny nails and top piece to one below in like manner. |
| G | 2 each axle. | 1-inch, No. 14 Birmingham wire gage, hot-rolled steel, with anchor plates, pattern 19 (4, fig. 4.12). Locate over axle, springs, or spring shackles, and secure each plate to floor with eight 20-penny, cement-coated nails. Substitute, if desired, at each location, four strands of No. 8 gage black annealed wire. Pass around item H and twist taut after item $H$ has been nailed in place. |
| H | 1 each item G. | 2 by 4 by 18 inches. Secure to floor, lengthwise of car, with four 30-penny nails. Not required when steel straps are used, pattern 19 (4, fig. 4.12). |
| J | 2 | 1-inch, No. 14 Birmingham wire gage, hot-rolled steel, with anchor plates, pattern 19 (4, fig. 4.12). Pass through towing clevises and secure each plate to floor with eight 20-penny ce-ment-coated nails. Substitute, |

See notes at end of $d$ below.

| Item | No. of pieces | Description |
| :--- | :--- | :--- |
| K | if desired, at each location, four <br> strands of No. 8 gage black an- <br> nealed wire. Pass through tow- <br> ing clevises, underneath, and <br> around item K, and twist taut <br> after item K has been nailed in <br> place. Not required when steel <br> straps are used, pattern 19 (4, <br> fig. 4.12). |  |
| L each item J. | 2 by 4 by 18 inches. Secure to <br> floor, lengthwise of car, with <br> four 30-penny nails. Not re- <br> quired when steel straps are <br> used, pattern 19 (4, fig. 4.12). |  |
| 1 | Four strands of No. 8 gage, black <br> annealed wire. Loop around <br> towing hook and through oppo- <br> site stake pockets. Not required <br> for units loaded in gondola cars. |  |

c. Mounted Gun or Howitzer (fig. 4.9). ${ }^{12}$

| Item | No. of pieces | Description |
| :---: | :---: | :---: |
| A |  | Brake-wheel clearance (fig. 4.11). |
| B | 4 | Blocks, pattern 16 (1, fig. 4.12). Locate $45^{\circ}$ portion of block at front and rear wheels. Secure heel of block to floor with three 40-penny nails and toenail that portion under tire to floor with two 40-penny nails before items C are applied. |
| C | 2 | Each consisting of 2 pieces of 2 by 4 by 36 inches. Secure lower piece to floor with three 40 penny nails and top piece to one below in like manner. |
| D | 2 | Support, pattern 62 (8, fig. 4.12), 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 -penny 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 | 6 by 8 by 24 inches, cut to fit contour of spade. Locate in front |


| Item | No. of pleces | Description |
| :---: | :---: | :---: |
| double spade. | and rear of spade. Toenail to <br> foor with five 40-penny nails. |  |
| H each item F. | Each consisting of 2 pieces of 2 by <br> 4 by 12 inches. Secure lower <br> piece to floor, against item F <br> with three 40-penny nails and <br> top piece to one below in like <br> manner. |  |
| 2 | 2 by 4 by 12 inches. Locate against <br> each side of spade and secure to <br> floor with three 40-penny nails. |  |


| Item | No. of pieces | Description |
| :---: | :---: | :---: |
| J | 1 pair. | Stakes or green saplings. Locate <br> 1/3 distance from end of gun <br> trail to center of wheels. |
| 1 | Six strands, No. 8 gage, black an- <br> nealed wire. Loop around and <br> over top of rear end of gun trail <br> and secure to opposite stake <br> pockets. Substitute, if desired, <br> 2-inch by .05-inch high-tension <br> bands or 1/2-inch steel cables. |  |

See notes at end of $d$ below.


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

Natez: 4' for 36-and 393-inch track gage 4'-5" far 42-inch track gage

Figure 4.4. A composite clearance diagram: $36-, 393 / 8$-, and 42-inch gages.
d. Tanks and Similar Units, From 60,000 to 100,000 Pounds (fig. 4.10). ${ }^{12}$

| Item | No. of pieces | Deacriptlon |
| :---: | :---: | :---: |
| A |  | Brake-wheel clearance (fig. 4.11). |
| B | 2 | Blocks, pattern 31 (7, fig. 4.12). Locate one against each rear crawler tread. |
| C | 2 | Blocks, pattern 30 (6, fig. 4.12). 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 -penny nails. |
| E | $\begin{aligned} & 2 \text { each items B } \\ & \text { and C. } \end{aligned}$ | Each consisting of 2 pieces of 2 by 4 by 12 inches. Locate against ends of items B and C. Secure lower piece to floor with four 20-penny nails and top piece to one below in like manner. |
| F | 2 each unit. | Each consisting of 2 pieces of 2 by 4 by 14 inches. Locate on floor against inside of each crawler tread, and secure lower piece to floor with twelve 30-penny nails and top piece to one below in like manner. |
| G | 3 each unit. | Each consisting of 2 pieces of 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-penny nails and top piece to one below in like manner. |
| H | 6 | Each consisting of 2 pieces of 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. |
| J | 6 | Each consisting of 2 pieces of 4 by 4 inches, length to suit. Locate against bogie wheels on top of item $\mathbf{H}$. |
| K | 6 | Each consisting of 2 pieces of 4 by 4 inches, long enough to fill space between items H. Toenail each to items $H$ with two 20-penny nails. |
| L | 12 | Each consisting of two strands No. |


| Item | No. of pleces | Descriptlon |
| :---: | :---: | :---: |
|  |  | 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 .035 -inch high-tension band. Use staples or nails bent over to retain bands or wires in position. |
| M | 4 | $11 / 4$-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. |

I Set handbrake and wire, or block, lever. When tiedown rods are found slightly loose in tranait, they need not be tightened.
${ }^{2}$ Place turret gun in straight forward position, and wire turret-lock handwheel and elevating-mechaniam handwheel to prevent rotating. When unit ia not equipped with built-in gun brace, apply two $8 / 6$-Inch high-tension bands, becuring gun barrel to unlt at each side. Rock a tracked vehicle forward and backward under ita own power to take the slack out of the tracks and thus secure the vehicle to the blocka.


Figure 4.5. Measuring a steel stringer.


Figure 4.6. Measuring a wooden stringer.

### 4.15 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 4.7. Loading a six-wheel truck on an open-top car.
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 tool kits, the lowering of booms, and the depressing of gun barrels.
$c$. 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, TM's, FM's, etc., should not be used without


Figure 4.8. Loading a 21/2-ton wheeled landing vehicle on an open-top car.
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.

### 4.16 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. 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.
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 do 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


Figure 4.9. Loading a 37 mm to 105 mm mounted gun or howitzer on an open-top car.
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-eighths 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:
(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.
(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 4.13. The distances shown in the figure represent lengths of


Figure 4.10 Loading a tank or similar unit, 60,000 to 100,000 pounds, on an open-top car.
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 4.13 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 clover-leaf packages. Less-than-carload shipments may be loaded and braced in the same manner as the partial shipment shown in figure 4.14. All space between sides of car and rows of bundles must be filled. All bundles 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.

### 4.17 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 are usually 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.


Figure 4.11. Brake-wheel clearance.
c. Examples. Typical car placards used on commercial and military railroads in the United States are shown in figure 4.15, and four-language placards for use by the Army in Europe are shown in figure 4.16.

### 4.18 Cargo Security

a. At Origin.
(1) The shipper is responsible for the security of carload freight until the car is coupled to an engine 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 insure 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.
(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. 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

(3)


Fioure 4.12. Chocks with dimensions and pattern numbers of the Association of American Railroads.


$A=$ NOT MORE THAN $15 \%$ LOAD LIMIT BETWEEN TRUCK CENTERS AND ENDS OF GAR
Figure 4.13. Load limits for explosives.
placards to the cars. After a car is loaded, sealed, and documented, it should be moved as quickly as possible.
(6) Railway personnel must inspect all opentop cars before movement to insure they are loaded properly and meet clearance requirements.
b. In Transit.
(1) 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.

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 military police or other units assigned or attached to Transportation railway service for


Figure 4.14. Loading and blocking ammunition in cloverleaf packages.
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 be 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


Figure 4.15. Railway car placards, United States.
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 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, par-
ticularly 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.

### 4.19 Troop Movements

a. Space Requirements. For planning purposes,


GIFTSTOFFE MATIÈRE TOXIQUE SOSTANZA TOSSICA TOXIC MATERIALS


## EXPLOSIVE STOFFE

SUBSTANCE EXPLOSIVE SOSTANZA ESPLOSIVA EXPLOSIVES


Figure 4.16. Railway car placards, U. S. Army Europe.
the following capacity data may be used when loading troops on U.S. equipment:
(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.
(h) Enlisted men move in tourist pullmans, usually two per section. NCO's 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 tactical 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 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 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 bag-
gage 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.


### 4.20 Troop-Train Ccmmanders

a. Assignment.
(1) A troop-train commander 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.
(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 in 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 Transportation Corps.
(c) Ascertains details of loading baggage, vehicles (if any), and personnel from
transportation movements officer, station master, 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 sides 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's provided by the local commander.

### 4.21 Estimating Railway Capacity

a. General. Even though the amount and quality of technical information available for analysis varies, a standardized method of approach insures use of the same principles of evaluation. In general, rail capacity depends upon net division tonnage, terminal facilities, and service and repair facilities. The proper use of the procedures described below should produce data needed to estimate railway capacity.
b. Net Division Tonnage. Net division tonnage is the tonnage (short tons), or payload, that can be moved over a railway division each day. This tonnage is the sum of all net trainloads for a 24hour period. In order to determine this sum, the analyst must make certain basic assumptions and determine each net trainload and the train density for the division.
(1) Basic assumptions. A study of a capacity problem must be accompanied by a statement of the assumptions upon which the suggested solution is based. The assumptions listed below may be considered basic in solving rail capacity problems; however, conditions may necessitate the making of other assumptions. Generally, the following may be assumed.
(a) An adequate number of freight cars and locomotives are available.
(b) An adequate number of qualified personnel are available.
(c) All trains are freight trains or are operated at freight-train speed.
(d) Enemy action does not interrupt operations.
(e) Operations continue more than 72 hours.
(2) Net trainload (NTL).
(a) General. Net trainload is the payload carried by each train. The total weight of the cars under load is the gross weight; the weight of the cars empty is tare or light weight. The difference between these two is the net load (payload) of a train. In calculating the net trainload, the analyst must consider the tractive effort (TE), gross trailing load (GTL), the length of passing sidings, and the
effect of weather. These factors are discussed below.
(b) Tractive effort. Tractive effort is the horizontal force which a locomotive can exert, provided its wheels do not slip. There are two classes of tractive effort: starting TE is the effort required to start the locomotive; continuous TE is the effort required to keep it moving. Generally, a locomotive's starting TE is equal to or greater than its continuous TE. The starting TE on the level should be compared with the continuous TE required to keep the same train moving on the ruling grade, for the larger required TE controls the size of the train. Therefore, the analyst must bear in mind the ruling grade of the line. However, because of the many variables involved, the following discussion does not include the effect of the ruling grade; only level track is considered, and the starting TE is the controlling factor in determining the locomotive's pulling power. If a locomotive's TE is not furnished by a reliable source, such as the manufacturer, it can be computed by using known characteristics. Steps in computing TE are described below according to type of locomotive. (For a rule-of-thumb method, see FM 55-21.)

1. Steam locomotive. The effective energy at the wheel rim is reduced by friction of the piston, piston rod, crosshead, and various bearings. Steam pressure in the cylinder is always less that in the boiler, even at low speed and full cutoff. These reductions may be allowed for figuring the steam pressure (effective at the drivers) at 85 percent of the boiler pressure. The rated, or starting, TE may be determined by using the formula given below. This formula may be used with no appreciable inaccuracy up to speeds of 15 miles per hour. One of the limiting factors of tractive effort is the frictional force, or adhesion, between drivers and rail. This is a function of the weight on drivers and of the coefficient of
friction between the wheel and the rail. An average value of 0.25 is generally used for the latter; the corresponding reciprocal of the coefficient of friction is known as the factor of adhesion. A formula for determining starting TE of a steam locomotive is-

$$
\mathrm{TE}=\frac{0.85 \times \mathrm{P} \times \mathrm{d}^{2} \times \mathrm{S}}{\mathrm{D}}
$$

where

$$
\begin{aligned}
\mathrm{TE} & =\text { tractive effort in pounds } \\
\mathrm{P} & =\text { boiler pressure in pounds } \\
& \text { per square inch } \\
\mathrm{d} & =\text { diameter of cylinders in } \\
& \text { inches } \\
\mathrm{S} & =\text { length of piston stroke in } \\
& \text { inches } \\
\mathrm{D} & =\text { diameter of drivers in inches }
\end{aligned}
$$

A close approximation of the starting tractive effort may be obtained by using the simple formula-

$$
\mathrm{TE}=0.2 .5 \times \mathrm{W}
$$

where
$\mathrm{W}=$ weight of the locomotive on the drivers (adhesive weight)
The adhesive weight of a locomotive can be approximated by using the following table.

| Wheel arrangement <br> of locomotive | Percont of <br> weight on <br> drivers | Wheel arrangement <br> of locomotive | Percent of <br> veright on <br> driners |
| :---: | :---: | :---: | :---: |
| $0-4-0$ | 100 | $2-8-2$ | 73 |
| $2-4-0$ | 80 | $2-8-4$ | 61 |
| $2-4-2$ | 57 | $4-8-0$ | 80 |
| $4-4-0$ | 67 | $4-8-2$ | 67 |
| $0-6-0$ | 100 | $4-8-4$ | 57 |
| $0-6-2$ | 75 | $0-10-0$ | 100 |
| $2-6-0$ | 86 | $0-10-2$ | 83 |
| $2-6-2$ | 87 | $0-10-4$ | 71 |
| $4-6-0$ | 75 | $2-10-0$ | 91 |
| $4-6-2$ | 60 | $2-10-2$ | 77 |
| $0-8-0$ | 100 | $2-10-4$ | 67 |
| $0-8-2$ | 80 | $4-10-0$ | 83 |
| $0-8-4$ | 67 | $4-10-2$ | 72 |
| $2-8-0$ | 89 | $4-10-4$ | 62 |

2. Diesel-electric locomotive. Tractive effort curves are computed from data on generator-traction motors and auxiliaries with an overall limitation imposed by the horsepower rating of the diesel engine. These curves
are furnished by locomotive manufacturers. Whenever possible, diesel-electric locomotive TE should be obtained from these curves. If such curves are not available, starting TE can be approximated by dividing the adhesive weight of the locomotive by 3. The continuous TE can be approximated by dividing the adhesive weight by 6 .
3. Electric locomotive. The TE for an electric locomotive is governed by the amount of power supplied to the motor and by the capability of the motor. Manufacturers of electric locomotives prepare TE curves that should be used when available. These curves are usually based on substation voltage. Because of transmission losses, it is recommended that the values taken from these curves be reduced by 10 percent. Tractive effort may also be obtained by equating work done at the rim of the driving wheels to the work produced by the motor torque in one revolution of the driving wheels. The following formula gives hourly TE; this can be considered the starting TE.

$$
\mathrm{TE}=\frac{\mathrm{T} \times 24 \times \mathrm{G} \times \mathrm{E} \times \mathrm{N}}{\mathrm{D} \times \mathrm{g}}
$$

where

$$
\begin{aligned}
\mathrm{TE}= & \text { tractive effort in pounds } \\
\mathrm{T} \times 24= & \text { torque of a single motor. } \\
& \quad \text { (Torque is taken at a } 1 \text {-foot } \\
& \quad \text { radius from the armature } \\
& \text { shaft center.) } \\
\mathrm{G}= & \text { number of teeth in the driving } \\
& \text { gear } \\
\mathrm{E}= & \text { combined electrical and } \\
& \text { mechanical efficiency } \\
& \text { (averages } 80 \text { to } 85 \text { percent) } \\
\mathrm{N}= & \text { number of motors } \\
\mathrm{D}= & \text { driving wheel diameter in } \\
& \text { inches } \\
\mathrm{g}= & \text { number of teeth in the pinion } \\
& \text { gear }
\end{aligned}
$$

Continuous TE for speeds between 5 and 10 miles per hour can be approximated by dividing the adhesive weight by 3 .
(c) Gross trailing load (GTL). This is the maximum weight a locomotive can pull. The GTL is affected by locomotive TE, train resistance, grade resistance, and weight of locomotive and tender. The GTL may be calculated by using the following formula:

$$
\mathrm{GTL}=\frac{\mathrm{TE}}{\mathrm{TR}+\mathrm{GR}}=\mathrm{W}
$$

where

$$
\begin{aligned}
& \text { GTL }= \text { gross training load in short } \\
& \text { tons }
\end{aligned}
$$

$\mathrm{TE}=$ locomotive tractive effort in pounds
$\mathrm{TR}=$ train resistance. (This factor depends on the weight per car and the speed of the train. A resistance of 4 pounds per ton is considered an acceptable average when the speed of a train is from 5 to 15 miles per hour and the weight per car is 30 to 50 tons.)
GR = grade resistance. (This is found by multiplying 20 pounds per ton of train by the grade in percent.)
$\mathrm{W}=$ weight of locomotive and tender in short tons.
(d) Length of sidings. The net trainload is sometimes limited by the length of the passing sidings on the line. The minimum length of passing sidings should be compared with the length of train needed to carry the planned net tonnage. To do this, estimate the average freight car length and load per car.
(e) Effects of weather. Snow, ice, and freezing temperature affect locomotives and operations, thereby reducing net tonnage. For winter operations, planned net tonnage should be reduced. (A reduction may not have to be made if the net trainload has already been reduced because of the siding lengths.) See paragraph 4.22 below to determine the percent of reduction.
(3) Train density. Train density is the number of trains that can be operated each way over a line in a 24 -hour period. It
varies greatly on different divisionsdepending upon the type of line, number and location of passing tracks, train movement control facilities and procedures, and availability of train crews, motive power, and rolling stock.
(a) Single-track line. The number of trains that can be operated in one direction on a single-track line in 24 hours depends on the speed of the trains, the maximum distance between passing sidings, and the delay time spent in sidings to allow other trains to pass. Additional time must be allowed for operating delays. The relationship of these various factors is shown by the following formula:

$$
\mathrm{N}=\frac{720 \times \mathrm{EF}}{\mathrm{RT}+\mathrm{DT}}
$$

where
$\mathrm{N}=$ train density in number of trains each way per day.
$R T=$ running time in minutes over longest distance between passing sidings on line. (Speed of train is usually considered as 10 mph -an average for war conditions. The speed might be 20 mph on an electrified line in good condition.) $\mathrm{DT}=$ delay time in minutes. (This is for meeting with train from opposite direction and may vary from 0 to 15 min utes, depending on train control, switch control, etc.)
$\mathrm{EF}=$ efficiency factor. (This may vary from 0.5 to 0.85 , depending upon type of signaling and dispatch used.) EF's for different types are: telephone and ticket, and rudimentary, 0.5 ; manual block, 0.6 ; automatic, 0.75 ; and centralized traffic control, 0.85.
(b) Double-track line. Estimates of maximum train density on double-track lines often vary greatly because these estimates, unlike those for single-track lines, are based largely on individual judgment. Assuming the use of an
absolute blocking signal system on a double-track line, theoretically the type and interval of signals and the speed of the train are the only limiting factors. On a line that used permissive blocking, train density is limited only by the braking distance between successive trains. Visibility and speed determine the braking distance. The possible train density of a double-track line is usually greater than the number of trains that can be assembled in the yards. The efficiency factor is the same as for a single-track line ( $(a)$ above). The capacity of the yards and line may exceed the number of locomotives that can be serviced in existing facilities. Therefore, it is necessary to calculate the capabilities of yard and terminal servicing facilities for each double-track line under consideration and to select the lowest capability as the limiting factor.
c. Terminal Facilities.
(1) Classification yard.
(a) The tonnage that can be classified and handled in a yard depends upon the total number of cars that can be held and operated in it. To estimate the tonnage capacity of a yard-

1. Determine the total trackage of the yard in feet.
2. Multiply the total trackage figure by 0.60 .
3. Convert this new trackage figure to numbers of cars by dividing it by the average length in feet of the freight cars used on the line.
4. Determine the operational capability of the yard by multiplying its holding capacity in number of cars by its turnover factor. (The turnover factor, which means the number of times the holding capacity can be replaced daily, may vary from 2.0 for a hump yard with automatic facilities to as low as 0.8 for a flat yard with rudimentary operations.)
(b) This estimated yard capability should be checked against the line capability to make sure the yard will support the line operations.
(2) Relay yard. A relay yard is used to receive, service, and forward through trains; each train is kept intact. Car classification in these yards is not necessary. An appraisal must be made in each operation to determine which yards should be designated as relay yards. Operations in relay yards require an average time delay of 3 hours per train. This gives a train turnover factor of about 8 for a 24 -hour period.
d. Service and Repair Facilities. The various distinctions made in classes of repair-not only worldwide but even on one railway-make it difficult to estimate the maximum capabilities of railway servicing facilities. It is necessary, however, when studying the capabilities of a railway to estimate its service and repair facilities. This problem cannot be reduced to a formula; estimates of servicing capabilities must be based largely upon good judgment and experience. For example, a 2 to 4 turnover factor in 24 hours is usual for enginehouses; servicing a locomotive requires from 6 to 12 hours. Nevertheless, the capability to provide locomotives for line operations is not determined solely by the number of hours required to service a road engine because allowance must be made for the servicing of branch line and yard locomotives also. Care must be exercised not to overestimate servicing and repair facilities when estimating maximum train density.

### 4.22 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 |

b. Average Rolling Resistance Values.

| Condition of track | Pounda 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. Requirement for Rolling Stock.
(1) Broad planning. The tables in (2)(b) below shows the distribution and disposition of rolling stock for the operation of a military railway. The term " 1 day's dispatch" means the number of cars dispatched in a day from the base of operations. For broad planning purposes, the number of cars dispatched from a division terminal, railhead, etc., may be considered the same as the number dispatched from the base of operations. Therefore, 1 day's dispatch is considered the same for all divisions of the railway in operation. In broad planning, it is also assumed that all divisions between the base of operations and the railhead will be operated at the same train density and will handle the same number of cars per train. The number of cars required is computed as follows:
(a) Determine the value of 1 day's dispatch by multiplying the number of cars required per train by the train density of the first division. The number of cars required per train is obtained by dividing the net trainload by the net payload of the cars to be used.
(b) When the number of divisions and the number of cars in 1 day's dispatch are known, the table in (2)(b) below may be used to determine the number of cars required for the operation. To this total, add 10 percent to allow for routine maintenance, bad order cars, operational peaks, etc.
(2) Detailed planning.
(a) The formula below may be used for computing car requirements for each division by substituting proper values for each factor-

No. of cars required $=\mathrm{TD} \times 2 \times \mathrm{CPT} \times 1.15 \times$ $\frac{(\mathrm{RT} \times \mathrm{TF})}{24}$
where

$$
\begin{aligned}
\mathrm{TD} & =\text { train density } \\
2 & =\text { constant for two-way per train } \\
\mathrm{CPT} & =\text { number of cars per train } \\
1.15= & \text { factor for maintenance and } \\
& \text { car pool } \\
\mathrm{RT}= & \text { running time (length of divi- } \\
& \quad \text { sion divided by average } \\
& \text { speed) } \\
\mathrm{TF}= & \text { time factor (switching, loading } \\
& \quad \text { and/or unloading time) } \\
24= & \text { number of hours per day }
\end{aligned}
$$

(b) Values of TF may be determined by analysis of the rail line operation under consideration using the following factors. Where loading and unloading is accomplished on the same division, increase TF by a percentage of the first and second factors given below equal to the proportion of the net division tonnage set out or filled out.

24-Division terminals having major loading points classification yards, and/or interchange facilities.

12-Division terminals having major unloading points or classification yards.
4-Intermediate terminals having no significant loading, unloading, or classification operations. (Primarily traincrew and locomotive change points or points where the gross trailing load is increased or decreased due to gradient or adjacent divisions. Local loading or unloading of cars does not exceed 10 cars per day.)

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

e. Road Engines. The number of road engines required for operation over a given railway division may be determined by the following formula:

Road engines required $=\mathrm{TD} \times \frac{(\mathrm{RT} \times \mathrm{TT})}{24}$
$\times 2 \times 1.20$
where
$\mathrm{TD}=$ train density
RT = running time (length of division divided by average speed)
$\mathrm{TT}=$ 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 $\frac{\mathrm{RT} \times \mathrm{TT}}{24}$ is the percent of time during a 24-hour period in which a road engine is in use and is called the engine 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.

| Type of terminal | Switch engines |
| :--- | :--- |
| Port, railhead, loading, un- <br> loading. <br> Division. | 1per 67 cars dispatched and <br> received per day. <br> per 100 cars passing per <br> day. |

g. Fuel Requirements.

| Type of locomotive | Type of operation | Estimated average rate of fuel consumption |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Per train mile |  |  | Per hour |  |  |
|  |  | $\begin{gathered} \text { Coal } \\ \text { (lb) } \end{gathered}$ | $\begin{gathered} \text { Oit } \\ \text { (ib) } \end{gathered}$ | $\underset{(\mathrm{gal.})}{\mathrm{oin}_{\text {il }}}$ | $\underset{(\mathrm{lb})}{\text { Coal }}$ | (ib) | $\underset{\text { (gail) }}{\text { Oil }}$ |
| Steam (coal-burning): <br> 2-8-0, 82-ton, standard gage. <br> 2-8-0, 90-ton, standard gage. <br> 2-8-2, 60-ton, narrow gage .- |  |  |  |  |  |  |  |
|  | Road. | 90 |  |  | 700 |  |  |
|  |  | 115 |  |  | 950 |  |  |
|  | Road | 100 |  |  | 750 |  |  |
| Steam (oil-burning): <br> 2-8-0, 82-ton, standard gage. <br> 2-8-2, 60-ton, narrow gage .- |  |  |  |  |  |  |  |
|  | Road. |  | 55 |  |  | 450 |  |
|  | 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 |

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 factora |  | Average apeed |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Condition of track | Percent ofgrade | Single track |  | Double track |  |
|  |  | mph | kmph | mph | 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 | 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

### 4.23 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 Corps of Engineers is responsible for new rail construction and large-scale rehabilitation. Transportation 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 stand-ard-gage ( $561 / 2$-inch), single-track railroad.

|  | Short tons | $\begin{aligned} & \text { Measure } \\ & \text { ment cons } \end{aligned}$ | Man-hours |
| :---: | :---: | :---: | :---: |
| Grading, includes clearing average wooded terrain. |  |  | 5,000 |
| Ballast delivered (bank run material), 5-mile $(8.05-\mathrm{km})$ average haul |  |  | 2,500 |
| Track laying and surfacing, allows 400 man-hours per mile ( 1.61 km ) for placing ties, delivered at site |  |  | 3,400 |
| Bridging: 70 linear feet (21.34 <br> m) per mile. $\qquad$ | 128 | 111 | 3,200 |
| Culverts (7 per mile): 280 linea feet ( 85.34 m ) | 8 | 7 | 1,400 |
| Ties: 2,900. | 218 | 300 |  |



### 4.24 Maintenance 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 field maintenance of railway block signals, of interlocking plants, and of centralized traffic control devices. It is also responsible for the installation, maintenance, and operation of organizational communications within railway groups, battalions, and lower echelon units.
$c$. The transportation railway system is normally divided into a number of divisions for maintenance and operation. Each division is assigned a railway operating battalion; each battalion in-
cludes 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.

### 4.25 Maintenance Categories

a. General. Army maintenance is divided into three categories and five echelons: organizational (first and second echelon), field (third and fourth echelon), and depot (fifth echelon).

## b. Locomotives.

(1) First echelon maintenance consists primarily of preventive maintenance and includes inspection of visible moving parts, lubrication, and making minor adjustments. The rail equipment com-
pany of the operating battalion performs first echelon maintenance before and after operations. During operations, first echelon maintenance is the responsibility of the train operating company of the operating battalion.
(2) Second echelon maintenance consists of preventive maintenance which includes repair or removal of parts whose condition might interfere with the efficient operation of the equipment. The railway equipment company of the operating battalion is responsible for second echelon maintenance and the accomplishment of required records and reports.
(3) Third echelon maintenance repairs are performed by the mobile railway workshop in the forward area and by the railway equipment company of the operating battalion 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 equipment company and the mobile railway workshop, only those repairs will be made that are necessary to move the locomotive to a fixed installation for repair.
(4) Fourth and fifth echelon maintenance is normally performed by the transportation railway shop battalion. In a theater of operations, it may be both feasible and necessary for some heavy maintenance to be performed by the transportation railway operating battalion.
(5) On diesel-electric locomotives, maintenance by the railway operating battalion includes making periodic inspections (using DD Form 1336), running repairs, and current reports of inspections and repairs. The transportation railway operating battalion does not attempt to replace major parts, such as diesel engines and main generators, unless directed by proper authority. Components, such as air compressors and auxiliary generators, may be replaced.
c. Rolling Stock.
(1) Normally the railway operating battalion's train maintenance sections and crews perform the firsi three echelons of repair; this includes running repairs and inspection of rolling stock. The railway
shop battalion is responsible tor fourth and fifth echelon maintenance. Fourth and fifth echelon repairs usually require over 40 man-hours of labor per car.
(2) First echelon maintenance is performed by car inspectors at the train originating point and at inspection points en route to insure safe movement of the car and its lading.
(3) Second echelon 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 necessary for the safe operation of freight equipment and the safe and comfortable operation of passenger cars. Second echelon repair does not require taking cars out of service.
(4) Third echelon 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.
(5) Repair-track installations (rip tracks) are normally set up at main terminals. They are also usually necessary at other points on the division, such as junction 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.

## Q.26 Inspecioion an@ Maimfename of Sisam L®G®m๐アives

a. Basic Principles.
(1) Suitable inspection pits and facilities must be provided for inspection, repair, and adjustment of parts.
(2) The engineer is responsible for the equipment he operates; this responsibility is primarily first echelon.
(3) The fireman is responsible for maintaining the proper water level and steam pressure. He receives instructions from the engineer, 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.
(5) Each locomotive must be inspected monthly, and DA Form 55-227 completed.
(6) In addition to the daily and monthly inspections, each locomotive must be inspected quarterly, semiannually, and annually (DA Form 55-228).
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.

### 4.27 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.

### 4.28 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 meters) 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-

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

Equating the two expressions above,

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

where

$$
\begin{aligned}
& \mathbf{R}=\text { radius of curvature in feet } \\
& \mathbf{D}=\text { degree of curvature in degrees }
\end{aligned}
$$

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 | D | R |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 5730 | 8 | 716 | 15 | 382 | 22 | 261 |
| 2 | 2865 | 9 | 637 | 16 | 358 | 23 | 249 |
| 3 | 1910 | 10 | 573 | 17 | 337 | 24 | 239 |
| 4 | 1433 | 11 | 521 | 18 | 318 | 25 | 229 |
| 5 | 1146 | 12 | 478 | 19 | 300 | 26 | 220 |
| 6 | 955 | 13 | 441 | 20 | 286 | 27 | 212 |
| 7 | 819 | 14 | 409 | 21 | 273 | 28 | 205 |

### 4.29 Curve Resistance

Curve resistance is the resistance offered to motion along a curved track in excess of that offered by a straight track. Curve resistance is developed in terms of pounds per ton of train. A constant factor of 0.8 pound per ton of train for each degree of curve is used in all capacity determination formulas. 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 Corps of Engineer personnel. A field expedient for determining the curvature of a track is the string method (par. 4.30).

## Q.30 Derermiming Curvaiure by Sirimg Nofhod

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 an absolutely exact one because of the uncertainty of how much the string used 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 ( $5 / 8^{\prime \prime}$ down from the top) of the high rail (A to B, fig. 4.17).
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 4.17, if M is 5 inches, the degree of curvature is $5^{\circ}$. (As a curve gets sharper, the distance $M$ increases. A $10^{\circ}$ curve is sharper than a $5^{\circ}$ curve when the chord-distance remains constant.)

## Q.37 Grad Resisiance

Grade resistance is the resistance to the progress of a train on an incline, caused by the force of gravity which tends to pull the train back downhill. Expressed in pounds per ton of train, grade resistance is obtained by multiplying the grade percentage by 20 . Grade percentage is obtained by dividing the vertical rise in feet by the horizontal distance travelled in feet and then multiplying the dividend by 100 .

### 4.32 RoDimg Resisicmee

Rolling resistance is brought about by friction between the rails and wheels, undulation of track under a moving train, internal friction of rolling stock, and the resistance of still air. The amount of resistance depends to a large extent upon track condition and varies between 5 and 10 pounds per ton of train.

### 4.33 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 shop 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 operating 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.


Figure 4.17. Determination of degree of curvature, using the string method.

Revisions are necessary based on operating conditions.

### 4.34 Transportafion Depot Company

The basic organization for supply in the Transportation Corps is the transportation depot company. Its mission is to provide for the receipt, storage, and issue of all Transportation Corps items of supply and equipment.

### 4.35 Requisition Procedure

a. The normal procedure for requisitioning 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 requisition, 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 requisition is processed and forwarded to the assistant general manager, supply (G4). The assistant general manager, supply, may then direct the transfer of the requisitioned item or items from one railway group to another. If the items cannot be obtained from another railway group, he passes the requisition to the transportation depot company for issue. If no depot company is assigned to the transportation railway service, the requisition is forwarded to the proper supply agency.
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 operating battalion is not operating as a part of a railway group, the bat-
talion 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 requisition certain transportation items of routine supply directly from the transportation depot company 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 requisition routine items from the depots of the other technical services.
c. The railway group may authorize the operating battalion supply officer to deal directly with the railway shop battalion for parts and assemblies manufactured or repaired by the railway shop battalion.
d. To obtain supplies from outside sourcesindustry, railway stocks, and railway supply channels-the battalion supply officer prepares purchase orders or requisitions 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 operating 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 U.S. Government from fraudulent claims.
$e$. All captured enemy material and equipment must be recorded and accounted for.

## CHAPTER 5

## TERMINAL AND WATER TRANSPORT

## Section I. TERMINAL ORGANIZATION

## Und Headquarters and head- quarters company, terminal command $A$.

5:1 Terminal Units: Capabilities and Assignment

Headquarters and headquarters company, terminal command B.

Headquarters and headquarters company, terminal command C.

Headquarters and headquarters detachment, transportation terminal battalion.

Transportation terminal service company.

TOE 55-131

55-121

55-111 transportation boat battalion.

Transportation light
boat company.

Load 1 ship at rate of 500 ST general cargo daily,

> and

Sort cargo by technical service and load cargo on initial mode of transport from wharf and/or at waterline in beach operation,
and
Prepare transportation documents for all cargo loaded or unloaded,
and
Account for cargo handled.
When operating at reduced strength, can discharge 360 ST cargo or load 250 ST cargo daily (working one 5 -hatch ship) and clear unloading site of equivalent tonnages.
When reinforced with other modes of transport and other technical and administrative services, can conduct terminal operations at an isolated location involving discharge of 1 ship at the rate of 720 ST cargo per day.
To command, administer, and supervise operations of transportation units engaged in movement of personnel and cargo in Army water terminal operations and Army waterborne tactical operations and to augment naval craft in joint amphibious operations.

Transports 1,440 ST of general cargo daily in logistical over-the-shore operations with each of the 24 available landing craft making 4 round trips with an average load of 15 ST each.
With 32 landing craft a vailable, the maximum one-time lift capability for cargo having a high density is $1,088 \mathrm{ST}$ cargo or 3,840 com-bat-equipped troops for a 7 -hour trip.
Based on maintenance factor of 25 percent, provides 12 task LCM (8)'s daily for sustained 24 -hour, day-to-day operations. With 12 landing craft available, transports daily-
2,400 ST of outsize, heavy lifts, based on an average load of 50 ST per landing craft, each craft making 4 round trips.
720 ST of general cargo, based on an average load of 30 ST per craft, each craft making 2 round trips.
With 16 task landing craft available, the maximum one-time lift capability with high density cargo is 960 ST or 3,200 com-bat-equipped troops for short distances.
Transports an average of 16,000 troops with individual equipment, or $2,160 \mathrm{ST}$ vehicles, or 6,000 ST tanks.

## Agrignment

pervision of the appropriate staff transportaportation officer.

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

Normally assigned or attached to a boat battalion, a terminal battalion, a terminal command, a logistical command, or an engineer amphibious support command.

Normally assigned or attached to a boat battalion, a terminal command, a
Unit
Transportation amphib-
ious truck company.
Transportation light
amphibian company.

Transportation medium amphibian company.
ransportation amphib
ious truck company.

Transportation heavy amphibian company.

Transportation staging area company.

Transportation floating craft depot maintenance company.
Transportation amphibian general support company.

Floating craft crews, floating craft maintenance teams, terminal service teams.**

55-500 and 55-510

At full strength, operating two 10 -hour shifts, transports an average of 1,800 ST heavy vehicles and equipment or 7,200 combatequipped troops daily, assuming availability of 12 BARC's, each carrying 30 tons or 120 personnel per trip ang making 5 trips per day.
Provides mess andrbillēting for 7,500 troops in units daily.
Operates 5 dispersed staging areas, each capable of staging an infantry battle group or its equivalent.
Provides depot maintenance on a 24-hour basis for approximately 100 self-propelled craft and all associated nonpropelled craft.
To provide field maintenance support for amphibians.

Mission and/or capability
Transports an average of 1,440 ST general cargo.
Transports in a one-time maximum lift 1,800 ST cargo or 4,800 troops with individual equipment.
At full strength, operating two 10 -hour shifts, transports an average of 720 ST cargo daily assuming availability of 30 vehicles, each vehicle carrying 3 tons per trip and making 8 trips per day.

Transporting daily, in two 10 -hour shifts, an average of $1,080 \mathrm{ST}$ general cargo, with an average availability of 27 amphibians, each carrying 4.5 tons per trip and averaging 9 trips per day. Transporting in a one-time emergency lift 170 ST general cargo, based on 34 amphibians carrying 5 tons each.

At full strength, operating two 10 -hour shifts, transports an average of 1,080 ST cargo daily, assuming availability of 19 LARC15's, each carrying 10.2 tons per trip and making 5-6 trips per day.

Provides personnel and equipment for the following purposes-
To supplement TOE organizations where additional trained personnel are required in numbers less than TOE strength.
To perform transportation functions as part of a larger organization where the need for the activity is less than a similar TOE organization.
To form an organization where no TOE unit

## Assionment

logistical command, or an engineer amphibious support command.

Normally, to a terminal battalion, but may operate separately under the supervision of an appropriate staff transportation officer.
To a logistical command. May be attached to a terminal command or a terminal battalion or may operate separately under the supervision of the appropriate staff transportation officer.
Normally, to a logistical command. May be attached to a terminal command or terminal battalion or may operate separately under the supervision of an appropriate staff transportation officer.
Normally to a logistical command. May be attached to a terminal command. Platoons may be attached separately to terminal battalions.

Normally, to a terminal command or logistical or area command.

Normally, to a terminal command.

To a terminal command or terminal battalion or may operate separate under the supervision of an appropriate staff transportation officer.
Teams may be attached or assigned as required to higher echelon units or may be organized into service units. to perform functions as required by existing conditions.

[^15]is provided or where a number of small cells of diversely trained personnel are required for the proper functioning of an organization.

### 5.2 Assigned or Aftached Units

Terminal commands may have any combination of these units assigned or attached as required to perform their mission.
a. Transportation Units.
TOE. Uni

55-16 Headquarters and Headquarters Detachment, Transportation Truck Battalion.
55-17 Transportation Light Truck Company.
55-18 Transportation Medium Truck Company.
55-19 Transportation Car Company.
55-28 Transportation Heavy Truck Company.
55-116 Headquarters and Headquarters Detachment, Terminal Battalion.
55-117 Transportation Terminal Service Company.
55-126 Headquarters and Headquarters Company, Transportation Boat Battalion.
55-127 Transportation Light Boat Company.
55-128 Transportation Medium Boat Company.
55-129 Transportation Heavy Boat Company.
55-137 Transportation Amphibious Truck Company.
55-138 Transportation Light Amphibian Company.

| toe | Unit |
| :---: | :---: |
| 55-139 | Transportation Medium Amphibian Company. |
| 55-140 | Transportation Heavy Amphibian Company. |
| 55-147 | Transportation Staging Area Company. |
| 55-157 | Transportation Floating Craft Depot Maintenance Company. |
| 55-158 | Transportation Amphibian General.Support Company. |
| 55-500 Transportation Service Organization. |  |
| b. Other Units. |  |
| toe | Uni |
| 5-129 | Engineer Port Construction Company. |
| 5 | Engineer Service Organization. |
| 8-500 | Medical Service Organization. |
| 9-348 | Ordnance Motor Vehicle Assembly Company, Communications Zone. |
| 9-500 | Ordnance Service Organization. |
| 10-67 | Quartermaster Service Company. |
| 10-500 | Quartermaster Service Organization. |
| 11-500 | Signal Service Organization. |
| 12-605 | Army Postal Unit, General Assignment. |
| 14-500 | Finance Service Organization. |
| 19-55 | Military Police Battalion. |
| 19-57 | Military Police Company. |

55-140 Transportation Heavy Amphibian Company.
55-147 Transportation Staging Area Company.
55-157 Transportation Floating Craft Depot Maintenance Company.
55-158 . Transportation Amphibian General.Support Com-: pany.
5-500 Transportation Service Organization.
b. Other Units.

Unil
5-129 Engineer Port Construction Company.
5-500 Engineer Service Organization.
8-500 Medical Service Organization.
9-348 Ordnance Motor Vehicle Assembly Company, Communications Zone.
9-500 Ordnance Service Organization.
10-67 Quartermaster Service Company.
Quartermaster Service Organization.
12-605 Army Postal Unit, General Assignment.
14-500 Finance Service Organization.
19-55 Military Police Battalion.
19-57 Military Police Company.

## Section II. VESSEL CHARACTERISTICS AND DATA

### 5.3 Transportation Unit Floating Craft

| Type of vessei | Designation | Length | Beam | Light placement | Maxi-mumdraft(aft) | Fuel ity (gal.) | Fuelcon-sump-tion(gal. perhour) | Speed, Ioaded (knots) | $\begin{gathered} \text { Cruising } \\ \text { ranged } \\ \text { (naded } \\ \text { (nautical } \\ \text { miles) } \end{gathered}$ | Crew | Capacity |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  |  | Cargo | Pagsen- gera |
| Supply, diesel, steel, $176^{\prime}$, design 381. | FS ${ }^{1}$ | $176^{\prime} 6^{\prime \prime}$ | $32^{\prime}$ | 465 | $12^{\prime}$ | 21,000 | 69 | 12.5 | 3,800 | 24 | $\begin{aligned} & 340 \mathrm{LT} \\ & 21,462 \end{aligned}$ | 9 berth 75 deck |
| Dry cargo, SP, diesel, steel, 210', design 7013. | FS ${ }^{2}$ | $222^{\prime} 91 / 2^{\prime \prime}$ | $38^{\prime}$ | 1,068 | $14^{\prime} 6^{\prime \prime}$ | 54,100 | 96 | 12 | 6,750 | 32 | $\begin{aligned} & 1,260 \\ & \mathrm{LT} \\ & 56,400 \\ & \mathrm{cu} \mathrm{ft} \end{aligned}$ |  |
| Liquid cargo, SP, diesel, steel, $210^{\prime}$, design 7014 (fig. 5.1). | Y | $222^{\prime} 91 / 2^{\prime \prime}$ | $38^{\prime}$ | 797 | $17^{\prime}$ | 58,670 | 96 | 12.7 | 7,700 | 29 | $\left\lvert\, \begin{aligned} & 462,000 \\ & \text { gal. } \end{aligned}\right.$ |  |
| Refrg cargo, SP, diesel, steel, 210', design 7015. | FSR ${ }^{2}$ | $222^{\prime} 91 / 2^{\prime \prime}$ | $38^{\prime}$ | 1,246 | 15' | 62,000 | 96 | 12 | 7,700 | 29 | $\begin{aligned} & 1,000 \\ & \mathrm{LT} \\ & 40,920 \\ & \mathrm{cu} \mathrm{ft} \end{aligned}$ |  |

[^16]
## I 5.4 Boats

| Type of boat | Designation | Length | Beam | Ught displace (LT) | Maximum $\underset{\text { (aft) }}{\text { draft }}$ | $\underset{\substack{\text { Fupal } \\ \text { (gacity }}}{\text { cosen }}$ | Fuel con-sump(gal. per | Speed (knots) |  | Crew | Capacity |  | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  |  | Cargo | PasBenger |  |
| Utility, diesel, plastic, 26', design 6009. | $\mathrm{J}^{1}$ | $26^{\prime \prime}{ }^{\prime \prime}$ | $8^{\prime} 1^{\prime \prime}$ | 3.04 | $4{ }^{\prime}$ | 80 | 4 | 10 | 200 | 2 | 1 LT | 12 to 15 | Can be transported in cradle on |
| Picket, diesel, wood, $36^{\prime} 6^{\prime \prime}$, design 234-B. | ${ }^{\mathbf{J} 1}$ |  | $10^{\prime \prime} 7^{\prime \prime}$ | 6 9.8 |  | 300 | 10 | 15 | 450 | 4 |  |  | freight vessels. <br> Can be crated and stowed on deck or in hold of freight vessel. Bow reinforced for beaching. |
| Picket, diesel, steel, 46', design 4003 (fig. 5.2). | J | $46^{\prime} 41 /{ }^{\prime \prime}$ | $12^{\prime} 3^{\prime \prime}$ | 9.8 | $3^{\prime \prime} 6^{\prime \prime}$ | 370 | 18 | 16 | 328 | 3 |  | --- | Replaces design 234-B. |
| Picket, diesel, wood, 65', design 4002 (fig. 5.3). | Q | $64^{\prime} 11^{\prime \prime}$ | 15'11* | 31 | $6^{\prime}$ | 900 | 25 | 14 | 500 |  | 4 LT | 5 | Replaces design 416. |
| Passenger and cargo vessel, steel, 65', design 2001 (fig. 5.4). | T | $65^{\prime \prime} 6^{\prime \prime}$ | $17^{\prime \prime} 8^{\prime \prime}$ | 66 | 7 | 1,150 | 19 | 10.5 | 635 | 4 | $\begin{gathered} 24 \mathrm{LT} \\ 1,800 \\ \mathrm{cu} \mathrm{ft} \end{gathered}$ | 24 | Normally deckloaded on large cargo ship. Under good conditions, can proceed overseas under own power. |

[^17]
### 5.5 Tugs

| Type of tug | Desigpation | Length | Beam | Light placement (LT) | Maximum (aft) <br> ( | Fuel capac${ }_{\text {ity }}$ (gal.) | $\left.\begin{gathered} \text { Fuel } \\ \text { con- } \\ \text { comp } \\ \text { siton } \\ \text { (gal. per } \\ \text { hour) } \end{gathered} \right\rvert\,$ | $\begin{gathered} \text { Speed } \\ \text { W/ } \\ \text { tow } \\ \text { (knots) } \end{gathered}$ | Cruising (nagge (nati- cal miles) | Crew | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Harbor, diesel, 200-hp, steel, 45', design 320. | ST | $45^{\prime} 21 / 4^{\prime \prime}$ | 12'51/4" | 25.2 | $6{ }^{\prime}$ | 900 | 12 | 10 | 750 | 5 |  |
| Harbor, diesel, $600-\mathrm{hp}$, steel, 65 ', design 3004 . | ST | $70^{\prime}$ | 19'6" | 100 | $8^{\prime \prime} 3^{\prime \prime}$ | 5,850 | 41 | 12 | 1,700 | 5 | Capable of short ocean passages under own power. Normally transported overseas on larger vessel. |
| Harbor, diesel, 1,200 hp steel, $100^{\prime}$ design 3006. | LT | 107' | 26' $6^{\prime \prime}$ | 295 | $12^{\prime} 2^{\prime \prime}$ | 20,768 | 83 | 12 | 3,000 | 16 | Can move oversea un der own power. |
| Oceangoing, diesel-electric, $1,530-\mathrm{hp}$, steel, 143', design 377-A. | LT ${ }^{1}$ | 143' 5" | $33^{\prime}$ | 566 | $14^{\prime}$ | 58,131 | 130 | 11.5 | 5,100 | 46 | Can move overseas un der own power. |

### 5.6 Floating Cranes

| Type of crane | Desig- <br> nation | Length | Beam | $\begin{aligned} & \text { Light } \\ & \text { dilise } \\ & \text { place- } \\ & \text { ment } \\ & \text { (LTT) } \end{aligned}$ | $\begin{aligned} & \text { Maxi- } \\ & \text { muma } \\ & \text { draft } \\ & \text { (aft) } \end{aligned}$ | $\begin{aligned} & \text { Fuel } \\ & \text { capacity } \\ & (\text { gal. }) \end{aligned}$ | $\begin{gathered} \text { Fuel } \\ \text { con- } \\ \text { sump- } \\ \text { tion } \\ \text { (gal. per } \\ \text { hour) } \end{gathered}$ | Crew | Cargo handing equipment |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Barge, diesel-electric, revolving, steel, 60 LT, design 413-D (fig. 5.5). | BD | 142' | $58^{\prime}$ | 1,000 | $5^{\prime} 6^{\prime \prime}$ | 1,350 | 16 |  | Main hoist capacity: 60 LT Main hoist radius: 73' Aux. hoist capacity: 15 LT |
| Barge, diesel-electric, revolving, steel, 89 LT, design 264-B (fig. 5.6). | BD | $140^{\prime}$ | $70^{\prime}$ | 1,407 | $6^{\prime}$ | 15,000 | 25 | 14 | Main hoist capacity: 89 LT Main hoist radius: $\mathbf{8 0}^{\prime}$ Aux. hoist capacity: 15 LT Aux. hoist radius: 122' 6" $^{\prime \prime}$ Aux. reach below waterline: $25^{\prime}$. |



Figure 5.1. Vessel, liquid cargo, diesel, steel, 11,500 barrels, 210 feet, design 7014.

### 5.7 Self-Propelled Barges

| Type of barge | Designation | Length | Beam | Light displacement (LT) | $\begin{aligned} & \text { Maxi- } \\ & \text { maum } \\ & \text { draft } \\ & \text { (af(t) } \end{aligned}$ | $\begin{gathered} \text { Fuuel } \\ \text { capacity } \\ \text { (gal.) } \end{gathered}$ | Fuel consumption (gal. per hour) | Loaded speed s. (knota) | Cruising range range (nautical miles) | Crew | $\underset{\substack{\text { Cargo } \\ \text { capacity } \\(L T)}}{ }$ | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Liquid-cargo, self-propelled, diesel, steel, $6,500 \mathrm{bbl}, 182^{\prime}$, design 294-A. | BSP1 | $182^{\prime} 6^{\prime \prime}$ | $30^{\prime}$ | 476 | 11'6" | 10,946 | 43 | 8 | 2,000 | 17 | $\begin{aligned} & \text { Dry: 49, } \\ & \text { Liq: } 770 \\ & \text { (273,000 } \\ & \text { gal.) } \end{aligned}$ |  |
| Inland waterways, self-propelled, diesel, steel, 55', design 3011. | BPSI ${ }^{1}$ | $56^{\prime \prime} 2^{\prime \prime}$ | $15^{\prime}$ | 42 | $5^{\prime} 6^{\prime \prime}$ | 1,750 | 22 | 8 | 675 | 3 | 20 | Can push 3 hopper barges (55 ) loaded to $5^{\prime} 6^{\prime \prime}$ at 8 knots. Can be disassembled for rail shipment. |

I Obsoleacent, nonstandard.


Figure 5.2. Boat, picket, steel, 46 feet $41 / 2$ inches.

### 5.8 Nonpropelled Barges

| Type of barge | Desig- nation | Length | Beam | $\begin{gathered} \text { Light } \\ \text { displace } \\ \text { ment } \\ \text { (LT) } \end{gathered}$ | Maxi- mum draft (aft) | Crew | Capacity cap | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Deck cargo, nonpropelled, steel, 570 tons, $110^{\prime}$, design 7005 (fig. 5.7). | BC | 110' | $32^{\prime}$ | 120 | $8^{\prime}$ | NA | 570 LT | Conversion kit 7006 makes it into a covered barge. Can towed overseas. |
| Deck cargo, nonpropelled, steel, 585 tons, $120^{\prime}$, design 231-A (fig. 5.8). | BC | $120^{\prime}$ | $33^{\prime}$ | 175 | $8^{\prime}$ | NA | 585 LT | Can be towed overseas. Good hull design for relatively high-speed towing. |
| Deck or liquid cargo, nonpropelled, steel, 578 tons or 4,160 bbl, 120', design 231-B (fig. 5.9). | BG | $120^{\prime}$ | $33^{\prime}$ | 175 | $8^{\prime \prime} 8^{\prime \prime}$ | NA | $\begin{aligned} & 585 \text { LT } \\ & 174,720 \\ & \text { gal. } \end{aligned}$ | Can be towed overseas at full load, provided maximum draft does not exceed $\mathbf{8}^{\prime}$. |
| Repair shop, floating, marine equipment, nonpropelled, steel, 210', design 7011. | FMS | $210^{\prime} 5^{\prime \prime}$ | $40^{\prime}$ | 1,160 | $8^{\prime}$ | 22 | NA | Repair shops include electrical, carpentry, engine repair, battery, fuel injector, blacksmith, and machine. Can be towed overseas. |
| Deck cargo, nonpropelled, steel, 81', design 7001, sectionalized, nesting (fig. 5,10). | BK | $81^{\prime}$ | $22^{\prime}$ | 57.5 | $5{ }^{\prime}$ | NA | 105 LT | Can be assembled in sheltered water with few handtools and unskilled labor, but requires lift of 9 - to 13.5 -LT capability to place pontons and tilt for bottom connections. Two sections can be shipped nested on larger vessels. Conversion kit 7007 makes into liquidcarrying barge. Can carry two 35-ton tanks on deck. Lacks stability. |
| Pier, self-elevating, nonpropelled, steel: <br> 250', design 7024-...-.-. | BPL | $250{ }^{\prime}$ | $60^{\prime}$ | 1,482.4 | $4^{\prime \prime} 5^{\prime \prime}$ | NA | NA | Used to construct piers and sea island terminals. Fitted with 1 compressor for air jacks, 12 ea $100^{\prime}$ caissons. |
| 427', design 7025 | BPL | 427' | $90^{\prime}$ | 4,618.3 | 5 | NA | NA | Same use as 7024. Fitted with 3 compressors for air jacks, 38 ea $100^{\prime}$ caissons. |



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

## 5.9 landing Ships

| Type | Length | Beam | Light displace (LT) | Draft loaded |  | Speed loaded (knots) | Operatling range $\underset{\text { mileas }}{ }$ | Capacity |  | Cargo space |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Fwd | Aft |  |  | Cargo (LT) | Troops |  |
| Landing ship, dock (LSD) (1 through 27). | 458' | 72 | 4,428 | $\begin{aligned} & \text { 18', dry; 27', } \\ & \text { flooded } \end{aligned}$ | $\begin{aligned} & 18^{\prime}, \text { dry; } 27^{\prime}, \\ & \text { flooded } \end{aligned}$ | 15 | 13,000 | 1,233, combat | 266 | $338^{\prime} \times 44^{\prime}$ plus $56^{\prime} \times 24^{\prime}$ |
| Landing ship, dock (LSD) (28).... | $510^{\prime}$ | 84' | 6,143 | $\begin{aligned} & 199^{\prime} \text { dry; } 30^{\prime}, \\ & \text { flooded } \end{aligned}$ | $\begin{aligned} & 19^{\prime} \text {, dry; } 30^{\prime}, \\ & \text { flooded } \end{aligned}$ | 15+ | 13,000 | 2,410, combat | 341 | $396^{\prime} \times 50^{\prime}$ |
| Landing ship, tank (LST) (1171 class). | 442' | $62^{\prime} 1^{\prime \prime}$ | 4,150 | 5. $8^{\prime \prime}$ | $13^{\prime} 11^{\prime \prime}$ | 14 | 6,048 | 500, landing condition | 634 | Tank deck $10,700 \mathrm{sq} \mathrm{ft}$ Main deck 7,613 sq ft |
| LST (1156 class).-.-....---...-- | 384' | 55' $7^{\prime \prime}$ | 2,309 | $4^{\prime \prime} 2^{\prime \prime}$ | $9^{\prime} 11^{\prime \prime}$ | 12 | 6,000 | 446, landing condition | . 395 | Tank deck $274^{\prime} 9^{\prime \prime} \times 32^{\prime} .1^{\prime \prime}$ <br> Main. deck $187^{\prime} \times 47^{\prime} 8^{\prime \prime}$ |
| LST (1153 class).---.----------- | 382' | $55^{\prime}$ | 2,009 | $3^{\prime} 4^{\prime \prime}$ | $11^{\prime \prime} 3^{\prime \prime}$ | 10.4 | 7,706 | 446, landing condition | 197 | Tank deck $280^{\prime} \times 30^{\prime} 5^{\prime \prime}$ <br> Main deck $160^{\prime} \times 46^{\prime}$ |
| LST (542 class). | 328' | $50^{\prime}$ | 1,589 | $4^{\prime} 4^{\prime \prime}$ | $9^{\prime} 3^{\prime \prime}$ | 8.5 | 19,200 | 446, landing condition | 141 | Tank deck $222^{\prime} 6^{\prime \prime} \times 24^{\prime}$ Main deck $100^{\prime} \times 45^{\prime}$ |
| Lighter, beach discharge (fig. 5.11). | $338{ }^{\prime}$ | $65^{\prime}$ | 1,549 | $\begin{gathered} 4^{\prime} \text {, landing; } \\ 7^{\prime} 8^{\prime \prime}, \\ \text { ocean } \end{gathered}$ | $\begin{gathered} 10^{\prime} \text {, landing; } \\ 13^{\prime} 8^{\prime \prime}, \\ \text { ocean } \end{gathered}$ | 11 | 4,800 | ${ }^{\text {b2, }} 300$ | -200 | 15,000 sq ft |

- Figures are for protype design.
- Designed primarily to be a vehicle carrier.
- Vehicle drivers (without berths).


### 5.10 Landing Craft

| Type | Length | Beam | Lightdigplacement (LT) | Draft | ded | Speed, (knots) | Operating range,nautical milea (loaded) | $\begin{gathered} \text { Fuel } \\ \text { con- } \\ \text { coup- } \\ \text { tion- } \\ \text { (gal, per } \\ \text { hours) } \end{gathered}$ | Crew | Capacity |  | Cargo space dimensions |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Fwd | Aft |  |  |  |  | $\underset{(\mathrm{LT})}{\mathrm{Cargo}^{2}}$ | Troops |  |
| Landing craft, utility (LCU) (501 class).- | 119' | $32^{\prime}$ | 150 | $3^{\prime} 4^{\prime \prime}$ | $4^{\prime}$ | 6.5 | 700 | 34 | 12 | 133.0 | 300 (min) | $\begin{aligned} & 47^{\prime} 6^{\prime \prime} \times 14^{\prime} \text { plus } 36^{\prime} \times 26^{\prime} \times 12^{\prime} . \\ & \text { plus } 18^{\prime} 21 / 4^{\prime \prime} \times 12^{\prime} 6^{\prime \prime} . \end{aligned}$ |
| Landing craft, utility (LCU) (1466 class) (fig. 5.12). | $115^{\prime}$ | $34^{\prime}$ | 180 | $3 \prime$ | $4^{\prime}$ | 6.5 | 700 | 34 | 12 | 160.0 | $\begin{gathered} 300 \\ (\min ) \end{gathered}$ | $\begin{aligned} & 52^{\prime} \times 29^{\prime} 6^{\prime \prime} \text { plus } 22^{\prime} 5^{\prime \prime} \times \\ & 14^{\prime} 4^{\prime \prime} . \end{aligned}$ |
| Landing craft, mechanized, Mark VI (LCM (6)) (fig. 5.13). | $56^{\prime}$ | $14^{\prime}$ | 28 | $3^{\prime}$ | $4^{\prime} 8^{\prime \prime}$ | 8.0 | 128 | 28 | 4 | 32.0 | 120 | $37^{\prime} 6^{\prime \prime} \times 9^{\prime} 6^{\prime \prime}$ |
| Landing craft, mechanized, Mark VIII (LCM (8)) (fig. 5.14). | 73'8" | 21' | 60 | $3^{\prime}$ | $5^{\prime} 6^{\prime \prime}$ | 10.2 | 284 | 41 | 6 | 53.5 | 200 | $42^{\prime} \times 14^{\prime} 6^{\prime \prime}$ |
| Landing craft, vehicle, personnel (LCVP). | $36^{\prime}$ | $10^{\prime} 5^{\prime \prime}$ | 8 | $2^{\prime} 2^{\prime \prime}$ | $3^{\prime}$ | 10.5 | 135 | 15 | 4 | 3.5 | 36 | $17^{\prime} 3^{\prime \prime} \times 7^{\prime \prime} 5^{\prime \prime}$ |


| Type | Length | Beam | Light digplace- ment (LT) <br> (LT) | Draft loaded |  | Speed, | Operating rangeloaded (mlles) | $\begin{array}{\|c} \text { Fuel con- } \\ \text { sumption } \\ \text { (gal. per } \\ \text { hour) } \end{array}$ | Crew ${ }^{1}$ | Capacity |  | Cargo apace dimenaions |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Fwd | Aft |  |  |  |  | Cargo (LT) | Troops |  |
| Landing vehicle, wheeled (DUKW) ${ }^{2}$. | $31^{\prime}$ | $8^{\prime} 27 / 8^{\prime \prime}$ | 6.4 | $3^{\prime \prime} 6^{\prime \prime}$ | $4^{\prime} 3^{\prime \prime}$ | 5 knots, water 50 mph , land | 30 , water 250, land | 8 | 3 | Normal 2.2 Maximum 4.5 | 25 | $12^{\prime} 5^{\prime \prime} \times 6^{\prime} 10^{\prime \prime}$ |
| Lighter, amphibious, 5-ton (LARC-5)2 (fig. 5.15). | $35^{\prime}$ | $10^{\prime}$ | 7.2 | $4^{\prime} 1^{\prime \prime}$ | $4^{\prime} 3^{\prime \prime}$ | 8.7 knots, water 25 mph , land | 60, water 160, land | 20 | 2 | Normal <br> 4.5 <br> Maximum <br> 5.0 | Emergency 20 | $16^{\prime} \times 8^{\prime} 8^{\prime \prime}$ |
| Lighter, amphibious, 60 -ton ${ }^{2}$ (BARC) (fig. 5.16). | 62'63/4" | $26^{\prime \prime} 7^{\prime \prime}$ | 87 | $8^{\prime \prime} 8^{\prime \prime}$ | $8^{\prime} 8^{\prime \prime}$ | 7 knots, water 14 mph , land | $\begin{aligned} & \text { 105, water } \\ & 210, \text { land } \end{aligned}$ | 40 | 8 | Normal <br> 53.6 <br> Emer- <br> gency <br> 89.3 | Normal <br> 125 <br> Emer- <br> gency <br> 200 | $38^{\prime} 3^{\prime \prime} \times 14^{\prime}$ |
| Landing vehicle, tracked, Mark V (LVTP) ${ }^{2}$. | $29^{\prime \prime} 8^{\prime \prime}$ | $11^{\prime} 81 / 2^{\prime \prime}$ | 31.2 | $5^{\prime} 3^{\prime \prime}$ | $5^{\prime} 3^{\prime \prime}$ | 6.7 knots, water 27.8 mph , land | 45, water 187, land | 47 | 3 | Water 6.0 Land 9.0 | 34 | $\begin{aligned} & 15^{\prime} 2^{\prime \prime} \times 7^{\prime} 9^{\prime \prime} \times \\ & 5^{\prime} 3^{\prime \prime} . \end{aligned}$ |

${ }^{1}$ For around-the-clock operations.
${ }^{2}$ Transportability (see 5.9, 5.16, 5.17 and 7.4)
DUKW may be deck or hold loaded on any general cargo vessel.
LARC-5 may be deck-loaded on general cargo vessel or in well of LSD.
BARC and LVTP may be deck- or hold-loaded on special heavy-lift ship or in well of LSD.

### 5.12 Navy Transport Vessels



### 5.13 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).


Figure 5.4. Boat, passenger and cargo, diesel, steel, 65 feet 6 inches, design 2001.
b. Prefix Designations.
(1) Other than emergency and Victory types.

| $\underset{\substack{\text { Single } \\ \text { letter }}}{\text { and }}$ | Clasa of vesgel | Length designation (load waterline in feet) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 1 | 2 | 3 | 4 | 5 | 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)....- | Under 400 | 400-450 | 450-500 | 500-550 | 550-600 | 600-650 |  |
| N | Coastwise cargo-.------------------ | Under 200 | 200-250 | 250-300 | 300-350 | 350-400 | 400-450 | 450-500 |
| R | Refrigerator------------------------ | Under 400 | 400-450 | 450-500 | 500-550 |  |  |  |
| S | Special | Under 200 | 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 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 cages.
(2) Emergency and Victory types.

| Doubleletter | Class of vesse |  | Length deaignation (load wsterline in feet) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | 1 | 2 | s |  | 4 |
| EC | Emergency cargo (Libert Emergency tanker |  | $\begin{aligned} & \text { Under } 400 \\ & 450 \\ & \text { Under } 400 \end{aligned}$ | 400-450 | $\begin{aligned} & 450-500 \\ & 450-500 \end{aligned}$ |  | $\begin{aligned} & 500-550 \\ & 500-550 \end{aligned}$ |
| vc | Victory cargo...- |  |  | 400-450 |  |  |  |
| (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. |  | Type ofmuchinery |  | ypeof of | Under 18 | Over 12 |
|  |  |  | Steam.-. |  | - | -ST | S2 |
|  |  |  | Motor |  |  | MT | M2 |
|  |  |  | Turboelectric |  |  | SET | SE2 |
|  |  |  |  | MET | ME2 |  |
|  |  |  | Gas turboelectric |  |  |  |  |
| C1-A | C2-Seas shipping | C3-E |  |  | Stea |  | wheel. | _SW | So |
| C1-B | C2-SU | C3-IN (P\&C) | Mot |  | 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.


Figure 5.5. Crane, barge, diesel-electric, revolving, steel, 60 long tons, design $413 D$.


Figure 5.6. Crane, barge, diesel-electric, revolving, steel, 89 long tons, design 264B.


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 281 A.


Figure 5.9. Barge, deck and liquid cargo, nonpropelled, steel, 578 tons or 4,160 barrels, 120 feet, design 281 B.


Figure 5.10. Barge, deck cargo, nonpropelled, sleel, 130 tons, 81 feet, sectionalized, nesting, design 7001.


Figure 5.11. Lighter, beach discharge, deck cargo, diesel, steel, 338 feet, design 5002.

### 5.14 Commercial Vessels

| Type | Description |  |
| :---: | :---: | :---: |
| B7 | Concrete hull, cargo barge, nonpropelled. | EC2 |
| C1-A | Designed for general cargo in world trade; steamturbine and motor-propelled (four modifications). |  |
| C1-B | Designed for general cargo in world trade; steamturbine and motor-propelled (four modifications). | L6 |
| C1-M | Designed for general cargo; motor-propelled. | N3 |
| C1-S | Concrete barge designed for cargo purposes; steam reciprocating engine propelled. | P1 |
| C2 | Designed for general cargo in world trade; steamturbine propelled (several modified types). Those prefixed by the symbol " $Z$ " were in operation during World War II. Modified types were used mostly as hospital ships. | P2 T1 |
| C3 | Combination passenger and cargo ship; steamturbine propelled (several modified types). | T2 |
| C3-S | Designed for cargo; steam-turbine propelled. | T |
| C4 | Designed for cargo; steam-turbine propelled (two modifications). | V4 VC2 |
| C4-S-1a | Mariner class. Recently developed by Maritime Administration in cooperation with the Department of Defense to provide modern high- |  |

speed commercial vessel that can readily be converted for wartime shipping.
Liberty type designed for general cargo; steam reciprocating engine propelled. Several modified types, prefixed by the symbol " $Z$," were designed as tank carriers and later modified as plane carriers.
Specially designed for coal or grain trade on the Great Lakes; steam reciprocating engine propelled.
Cargo carrier designed for coastal trade; steam reciprocating engine propelled.
Specially designed passenger-type vessel; steamturbine propelled.
Designed to carry troops. Two types: turbineelectric propelled, steam-turbine propelled.
Designed for tanker service in coastal and inland waters; diesel propelled (five modifications).
Designed to carry bulk oil in world trade; turboelectric propelled (two modifications).
Designed to carry bulk oil in world trade; steamturbine propelled (three modifications).
Large diesel-powered oceangoing tug.
Victory type designed to carry cargo in world trade. Three types, one with $6,000-\mathrm{hp}$ engine, two with $8,500-\mathrm{hp}$ engines. All three are steam-turbine propelled.

### 5.15 Commercial Cargo Ships

| Type | Length | Beam | $\begin{aligned} & \text { Logded } \\ & \text { draft } \end{aligned}$ | Dead-weight-ton(LT) | $\begin{gathered} \text { Gross } \\ \text { tons } \\ \text { nage } \end{gathered}$ | Capacity (cubic feet) |  |  | $\begin{aligned} & \text { Liquid } \\ & \text { cargo } \\ & \text { capacity } \end{aligned}$ | No. of hatches | $\underset{\substack{\text { Speed } \\(k n o t s)}}{ }$ | Cruising range cal miles) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Bale | Grain | Reefer |  |  |  |  |
| C1-B | $417^{\prime} 9^{\prime \prime}$ | $60^{\prime}$ | 28'878" | 8,777 | 6,711 | 451,624 | 505, 877 |  |  | 5 | 14 | 24,440 |
| C1-M-AV1 | $338^{\prime \prime} 8^{\prime \prime}$ | $50^{\prime}$ | 21'1" | 5,087 | 3,805 | 227, 730 | 249,835 | 9,830 |  | , | 11 | 25, 130 |
| C2-S-AJ | $4591^{\prime \prime}$ | $63^{\prime}$ | 27' $778{ }^{\prime \prime}$ | 10,828 | 8,258 | 542,824 | 582,845 |  |  | 5 | 15 | 16,200 |
| EC2 (Liberty) | $441^{\prime} 6^{\prime \prime}$ | $56^{\prime} 108 / 4^{\prime \prime}$ | 27' $878{ }^{\prime \prime}$ | 10,865 | 7,191 | 499, 573 | 562,608 |  |  | 5 | 11 | 17,000 |
| VC2 (Victory) | $455^{\prime} 3^{\prime \prime}$ | $62^{\prime}$ | $28^{\prime \prime} 6^{\prime \prime}$ | 10,805 | 7,612 | 456, 525 | 528,325 |  |  | 5 | 15 | 23,000 |
| C3-S-A2 | 492' | $69^{\prime} 6^{\prime \prime}$ | $28^{\prime \prime} 6^{\prime \prime}$ | 12,258 | 7,886 | 736,850 | 813,020 |  |  | 5 | 16.5 | 11,950 |
| C4-S-A4 | $522^{\prime} 101 / 2^{\prime \prime}$ | $71^{\prime \prime}{ }^{\prime \prime}$ | 32'978" | 14,941 | 10,685 | 672,243 | 808,154 |  |  | 7 | 17 | 15,870 |
| C4-S-B5 | $520^{\prime}$ | $71^{\prime \prime}{ }^{\prime \prime}$ | $32^{\prime} 97{ }^{\prime \prime}$ | 15,014 | 10,780 | 711,580 | 829,310 |  |  | 7 | 18 | 18,380 |
| C4-S-1a (Mariner)-- | $563^{\prime} 7$ 3/4" | $7{ }^{\prime}$ | 29' $10^{\prime \prime}$ | 13,420 | 9,216 | 736,723 | 837,305 | 30,254 |  | 7 | 20 | 21,660 |
| T2-SE-A2 | $523{ }^{\prime \prime}{ }^{\prime \prime}$ | $68^{\prime}$ | 29' $111 / 2^{\prime \prime}$ | 16,590 | 10,461 |  |  |  | $\begin{gathered} 140,721 \\ \mathrm{bbl} \end{gathered}$ |  | 16.5 | 18, 165 |

### 5.16 Hold, Hafch, and Baam Daia

| Vessel | No. of cargo holds | No. of booms | Boom capacity (LT) | Hatches w/hv lift booras | $\underset{\text { (LT) }}{\text { Hv-lift }}$ capacity |
| :---: | :---: | :---: | :---: | :---: | :---: |
| C1-B. | 5 | 15 | 5 | 2 | 30 |
| C1-M-AV1 | 4 | 14 | 11/2, 5 | 2, 3 | 30 |
| C2-S-AJ | 5 | 17 | 5 | 3 | 50 |
| EC2 (Liberty). | 5 | 12 | 5 | 2, 4 | ${ }^{2} 50-15$ |
| VC2 (Victory) | 5 | 16 | 5 | 3, 4 | 50, 30 |
| C3-S-A2 | 5 | 21 | 5,10 | 5 | 30 |
| C4-S-A4 | 7 | 25 | 5 | 6 | 50 |
| C4-S-B5. | 7 | 24 | 5 | 4, 5 | 50 |
| C4-S-1a (Mariner) | 7 | 26 | 5,10 | 4, 6 | 60 |
| FS Freighter ${ }^{\text {b }}$ | 2 | 5 | 5 | 2 | 15 |

[^18]

Figure 5.12. Landing craft, utility, diesel, steel, 115 feet, Navy design, LCU 1466 class.
5.17 Below-Deck Capacities

| Versel | $\begin{aligned} & \text { Hatch } \\ & \text { No. } \end{aligned}$ | Hatch dimensions | Cargo capacities (MT) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Upper 'tween | Lower 'tween | Hold | Deep tankg |
| C1-B_---- | 1 | $29^{\prime} 3^{\prime \prime} \times 20^{\prime}$ | 481 | 398 | 862 |  |
|  | 2 | $31^{\prime} 6^{\prime \prime} \times 20^{\prime}$ | 750 | 742 | 1,438 |  |
|  | 3 | $31^{\prime} 6^{\prime \prime} \times 20^{\prime}$ | 845 | 779 | 1,222 |  |
|  |  |  | -102 |  |  |  |
|  | 4 | $31^{\prime \prime} 6^{\prime \prime} \times 20^{\prime}$ | 780 | 1,229 |  | 480 |
|  | 5 | $31^{\prime} 6^{\prime \prime} \times 20^{\prime}$ | 574 | 608 |  |  |
|  |  |  | 3,532 | 3,756 | 3,522 | 480 |
| C1-M-AV1 | 1 | $20^{\prime} 11 / 2^{\prime \prime} \times 19^{\prime} 11^{\prime \prime}$ |  | 601 | 616 |  |
|  | 2 | $40^{\prime} 5^{\prime \prime} \times 19^{\prime} 11^{\prime \prime}$ |  | 982 | 1,378 |  |
|  | 3 | $40^{\prime} 5^{\prime \prime} \times 19^{\prime} 11^{\prime \prime}$ |  | 901 | 1,179 |  |
|  | 4 | $9^{\prime} \times 8^{\prime}$ |  | ${ }^{\text {b }} 169$ | 113 |  |
| Total |  |  |  | 2,653 | 3,286 |  |


| Vessel | $\begin{aligned} & \text { Hatch } \\ & \text { No. } \end{aligned}$ | Hatch dimensions | Cargo capacities (MT) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Upper 'tween | Lower 'tween | Hold | Doep tanks |
| C2-S-AJ. | 1 | $26^{\prime} 10^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ | 602 | 519 | 947 |  |
|  | 2 | $32^{\prime} 4^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ | 804 | 805 | 1,405 |  |
|  | 3 | $34^{\prime} 10^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ | 908 | 968 | 1,514 |  |
|  | 4 | $29^{\prime} 10^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ | 902 | 932 | 1,483 |  |
|  | 5 | $29^{\prime} 10^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ | 722 |  | 1,056 |  |
| Total |  |  | 3,938 | 3,224 | 6,405 |  |
| EC2 (Liberty) | 1 | $33^{\prime \prime} 7^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ |  | 983 1.065 | $\begin{array}{r} 902 \\ 2300 \end{array}$ | $416$ |
|  | 2 | $34^{\prime} 10^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ |  | 1,065 | $2,300$ |  |
|  | 3 | $19^{\prime} 10^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ |  | 597 | 1,495 |  |
|  | 4 | $34^{\prime} 10^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ |  | 742 | 1,315 |  |
|  | 5 | $34^{\prime} 10^{\prime \prime} \times 19^{\prime} 10^{\prime \prime}$ |  | 771 | 1,290 |  |
| Total |  |  | ------- | 4,158 | 7,302 | 1,029 |
| VC2 (Victory) | 1 | $24^{\prime} 11^{\prime \prime} \times 22^{\prime \prime} 3^{\prime \prime}$ | 551 | 595 | 698 |  |
|  | 2 | $23^{\prime} 11^{\prime \prime} \times 22^{\prime \prime} 3^{\prime \prime}$ | 675 | 545 | 698 |  |
|  | 3 | $35^{\prime} 11^{\prime \prime} \times 22^{\prime} 3^{\prime \prime}$ | 1,139 | 945 | 1,321 |  |
|  | 4 | $35^{\prime} 11^{\prime \prime} \times 22^{\prime \prime} 3^{\prime \prime}$ | 1,230 |  | 1,277 |  |
|  | 5 | $23^{\prime} 11^{\prime \prime} \times 22^{\prime \prime}{ }^{\prime \prime}$ | 1,091 |  | 648 |  |
| Total |  |  | 4,686 | 2,085 | 4,642 |  |
| C3-S-A2 | 1 | $35^{\prime} 91 / 2^{\prime \prime} \times 19^{\prime} 91 / 2^{\prime \prime}$ | 812 | 1,130 | 1,079 |  |
|  | 2 | $29^{\prime} 91 / 2^{\prime \prime} \times 23^{\prime} 91 / 2^{\prime \prime}$ | 830 | 1,381 | 1,396 |  |
|  | 3 | $37^{\prime} 31 / 2^{\prime \prime} \times 23^{\prime} 91 / 2^{\prime \prime}$ | 1,244 | 1,553 | 2,002 |  |
|  | 4 | $29^{\prime} 91 / 2^{\prime \prime} \times 23^{\prime} 91 / 2^{\prime \prime}$ | 1,164 | 1,255 | 1,419 |  |
|  | 5 | $39^{\prime} 91 / 2^{\prime \prime} \times 23^{\prime} 91 / 2^{\prime \prime}$ | 1,009 | 1,704 | 212 |  |
| Total. |  |  | 5,059 | 7,023 | 6,108 |  |
| C4-S-A4 |  | $17^{\prime} 9^{\prime \prime} \times 16^{\prime} 8^{\prime \prime}$ |  |  |  |  |
|  | 2 | $26^{\prime} 10^{\prime \prime} \times 17^{\prime} 9^{\prime \prime}$ | -1,139 | d1,258 | $772$ |  |
|  | 3 | $26^{\prime} 10^{\prime \prime} \times 17^{\prime \prime} 9^{\prime \prime}$ $26^{\prime \prime} 10^{\prime \prime} \times 17^{\prime \prime} 9^{\prime \prime}$ | 798 | 651 d1 533 | 994 | -1,084 |
|  | 4 | $26^{\prime} 10^{\prime \prime} \times 17^{\prime} 9^{\prime \prime}$ $26^{\prime \prime} 10^{\prime \prime} \times 17^{\prime \prime} 9^{\prime \prime}$ | 803 765 | d 1,533 d1,515 | 994 1,017 |  |
|  | 6 | $26^{\prime} 10^{\prime \prime} \times 17^{\prime} 9^{\prime \prime}$ | 795 | 782 | 1,636 |  |
|  | 7 | $17^{\prime} 9^{\prime \prime} \times 17^{\prime} 1^{\prime \prime}$ | 1583 | 4454 |  |  |
| Total |  |  | 5,379 | 6,533 | 4,560 | 1,084 |
| C4-S-B5. | 1 | $20^{\prime} 0^{\prime \prime} \times 18^{\prime} 0^{\prime \prime}$ | 608 | 293 |  |  |
|  | 2 | $27^{\prime} 6^{\prime \prime} \times 20^{\prime} 0^{\prime \prime}$ | 1,160 | 1,128 | 704 |  |
|  | 3 | $27^{\prime} 6^{\prime \prime} \times 20^{\prime} 0^{\prime \prime}$ | 702 | 641 | 603 | 837 |
|  | 4 | $30^{\prime} 0^{\prime \prime} \times 20^{\prime \prime} 0^{\prime \prime}$ | ${ }^{8} 1,626$ | 764 | 1,047 |  |
|  | 5 | $30^{\prime} 0^{\prime \prime} \times 20^{\prime \prime} 0^{\prime \prime}$ | ${ }^{\text {s }}$, 623 | 772 | 1,055 |  |
|  | 6 | $30^{\prime} 0^{\prime \prime} \times 20^{\prime \prime} 0^{\prime \prime}$ | ${ }^{1} 1,540$ | 794 | 998 |  |
|  | 7 | $20^{\prime} 3^{\prime \prime} \times 18^{\prime} 0^{\prime \prime}$ | 95 | 482 | 358 |  |
| Total. |  |  | 7,354 | 4,874 | 4,765 | 837 |
| C4-S-1a (Mariner) | 1 | $19^{\prime} 6^{\prime \prime} \times 17^{\prime \prime} 9^{\prime \prime}$ | - 402 | 453 | 305 |  |
|  | 2 | $29^{\prime} 10^{\prime \prime} \times 23^{\prime} 10^{\prime \prime}$ | 731 | 865 | 637 |  |
|  | 3 | $39^{\prime} 10^{\prime \prime} \times 29^{\prime} 10^{\prime \prime}$ | 1,050 | 1,454 | 1,284 |  |
|  | 4 | $39^{\prime} 10^{\prime \prime} \times 29^{\prime} 10^{\prime \prime}$ | 1,006 | 1,500 | 1,528 |  |
|  | 5 | $39^{\prime} 10^{\prime \prime} \times 29^{\prime} 10^{\prime \prime}$ | 1,044 | 410 | 401 | 953 |

See footnotes at end of table.

| Vessel | $\begin{aligned} & \text { Hatch } \\ & \text { No. } \end{aligned}$ | Hatch dimensions | Cargo capacities (MT) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Upper 'tween | Lower 'tween | Hold | Deep tanks |
| Total | 67 | $39^{\prime} 10^{\prime \prime} \times 29^{\prime} 10^{\prime \prime}$$29^{\prime} 10^{\prime \prime} \times 24^{\prime} 10^{\prime \prime}$ | $\begin{array}{r} 965 \\ 1,627 \end{array}$ |  | 1,646 856 | 298 |
|  |  |  | 6,825 | 4,682 | 6,657 | 1,251 |
| FS Freighter | $\begin{aligned} & 1 \\ & 2 \end{aligned}$ | $\begin{aligned} & 20^{\prime} 0^{\prime \prime} \times 16^{\prime} 0^{\prime \prime} \\ & 28^{\prime} 0^{\prime \prime} \times 16^{\prime} 0^{\prime \prime} \end{aligned}$ |  |  | $\begin{aligned} & 251 \\ & 285 \end{aligned}$ |  |
| Total |  |  |  |  | 536 |  |

- Special cargo locker on upper 'tween level between hatches Nos. 3 and 4.
b Includes 36 MT in trunked hatch.
- Includes upper deck and second deck.
$d$ Includes third deck and first platform.
- Liquid cargo space.
${ }^{\text {f }}$ Includes refrigerated cargo apace.
s Includes main 'tween deck.


Figure 5.13. Landing craft, mechanized, diesel, 56 feet, Mark VI, Navy design, LCM(6).

### 5.18 Vehicle-Loading Capacities

These figures reflect general loading conditions and by no means represent the maximum vehicle capacities of the vessels. With the exception of
crated vehicles, 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.


Figure 5.14. Landing craft, mechanized, diesel, steel, 69 feet, Mark VIII, Navy design, LCM(8).
a. C4-S-1a (Mariner).

| Hatch No. | Location | Trailer, cargo, 132-ton | Truck, utility, 1/4-ton | Truck, cargo |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | \% T T $4 \times 4$ | ${ }_{\text {21/ }}^{\text {TWB }}$ ¢ $\times 6$ | ${ }^{5} \mathrm{~T}_{\text {TW }}^{6} \times{ }^{\text {a }}{ }^{6}$ |
| 1 | On deck | 20 | 20 | 11 | 7 | 4 |
|  | 'Tween deck: | 16 | 20 | 12 | 6 | 4 |
|  | Upper-- | 10 | 14 | 12 9 | 4 | 0 |
|  | Hold. | 5 | 9 | 6 | 3 | 0 |
| 2 | On deck | 23 | 33 | 20 | 10 | 7 |
|  | 'Tween deck: |  |  |  |  |  |
|  | Upper | 23 | 37 | 22 | 11 | 7 |
|  | Lower. | 21 | 26 | 15 | 9 | 7 |
|  | Hold | 11 | 15 | 9 | 5 | 2 |
| 3 | On deck | 42 | 52 | 30 | 20 | 10 |
|  | 'Tween deck: |  |  |  |  |  |
|  | Upper - | 48 | 61 | 38 | 25 | 13 |
|  | Lower - | 44 | 52 | 32 | 21 | 13 |
|  | Hold | 32 | 36 | 22 | 14 | 9 |
| 4 | On deck | 36 | 52 | 26 | 18 | 10 |
|  | 'Tween deck: |  |  |  |  |  |
|  | Upper - | 46 | 69 | 38 | 20 |  |
|  | Lower- | 46 | 69 | 38 | 20 | 14 |
|  | Hold | 44 | 56 | 30 | 16 | 12 |


| Hatch No. | Location | Trailer, cargo, 1/2-ton | Truck, utility, 54-ton | Truck, cargo |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | 3/4 T $4 \times 4$ | ${ }^{21 / 2} \underset{\text { TWB }}{6} \times 6$ | ${ }^{5} \mathrm{~T}_{\mathrm{LWB}}^{6 \times}{ }^{6}$ |
| 5 | On deck_... 'Tween deck: | 36 | 54 | 28 | 20 | 12 |
|  | 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 |




Figure 5.15. Lighter, amphibious (LARC), 5 tons, design 8005.


Figure 5.16. Lighter, amphibious (BARC), self-propelled, diesel, steel, 60-tons, 61 feet, design 2303.
b. C1-B.

| Hatch No. | Location | Trailer cargo,$11 / 2$ ton | Truck, utility, 1/4-ton | Truck, cargo |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | 3/4 $4 \times 4$ | ${ }^{21 / 2}$ LWB $^{6} \times 6$ | ${ }^{5} \mathrm{~T}_{\text {LWB }}^{6} \times 6$ |
| 1 | On deck | 14 | 14 | 12 | 5 | 7 |
|  | Upper. | 18 | 21 | 12 | 6 | 4 |
|  | Lower | 18 | 21 | 12 | 6 | 5 |
|  | Lower hold. | 13 | 14 | 9 | 4 | 4 |
| 2 | On deck. | 21 | 25 | 18 | 12 | 7 |
|  | 'Tween deck: |  |  |  |  |  |
|  | Upper. | 37 | 46 | 25 | 13 | 12 |
|  | Lower. | 37 | 42 | 25 | 15 | 12 |
|  | Lower hold*. | 36 | 34 | 21 | 13 | 11 |

[^19]| Hatch No. | Location | Trailer, cargo, 11/2-ton | Truck, utility, 1/4-ton | Truck, cargo |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | \%T4×4 | ${ }_{\text {2 }}^{31 / 2}{ }_{\text {LWB }}^{6} \times 6$ | ${ }^{5} \mathrm{~T}_{\mathrm{LW}}^{6 \times \mathrm{x}}{ }^{6}$ |
| 3 | On deck 'Tween deck: | 21 | 23 | 14 | 10 | 5 |
|  | Upper | 42 | 44 | 30 | 17 | 12 |
|  | Lower | 42 | 41 | 28 | 13 | 12 |
|  | Lower hold*- | 42 | 41 | 28 | 13 | 9 |
| 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 | 6 |

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

| Hatch No. | Location | Trailer, cargo, 13 ton | Truek, ntility. 1/4-ton | Truck, cargo |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $3 / 4 \mathrm{~T} \times 4$ | $\underset{\text { LWB }}{21 / 2 T 6 \times 6}$ | $5 \underset{\text { LWB }}{6 \times 6}$ |
| 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.
d. VC2 (Victory).

| Hatch No. | Location | Trailer, cargo, <br> 1/2-ton | Truck, utility, 14-ton | Truck, cargo |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $3 / 4 \mathrm{~T} \times 4$ | $2 \underset{\text { LWB }}{1 / 2 T 6} \times 6$ | $5 \mathrm{LWB}^{6} \times{ }^{6}$ |
| 1 | On deek | 12 | 14 | 6 | 5 | 4 |
|  | 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: |  |  |  |  |  |


| Hatch No. | Location | Trailer, cargo, $11 / 2$ ton | Truck, utility, 5/4-ton | Truck, cargo |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | 3/4 T $4=4$ | ${ }^{21 / 2 T 66}{ }_{\text {LWB }}=6$ | $5 \mathrm{TWBB}^{\mathbf{T}}{ }^{6}$ |
| 4 | Upper- - | 48 | 48 | 29 | 17 | 12 |
|  | Lower | 46 | 46 | 30 | 18 | 12 |
|  | Hold. | 46 | 44 | 30 | 18 | 8 |
|  | 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 |

e. $C 1-M-A V 1$.*

| Hatch No. | Locstion | Trailer, cargo, 12x-ton | Truck, utility, 1/4-ton | Truck, eargo |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $3 \mathrm{~T} 4 \times 4$ | ${ }^{21 / 2}{ }_{\text {TW }}^{6} \times 6$ |  |
| 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 |

* No. 4 hatch ia not large enough for vehicle loading.


### 5.19 United States Navy Ship and Service Craft Designators

a. Combatant Vessels.
(1) Warships.

| BB. - | .battleship |
| :---: | :---: |
| BBG. | guided missile capital ship |
| CA. | . heavy cruiser |
| CAG | -guided missile heavy cruiser |
| CG | - large cruiser |
| CBC. | large tactical command ship |
| CG. - | -guided missile cruiser |
| CL | light cruiser |
| CLAA. | antiaircraft light cruiser |
| CLC. | tactical command ship |
| CLG | guided missile light cruiser |
| CVA. | attack aircraft carrier |
| CVE. | escort aircraft carrier |
| CVHE | escort helicopter aircraft carrier |
| CVL. | _small aircraft carrier |
| CVS. | .-antisubmarine support aircraft carrier |
| DD. | destroyer |
| DDC. | corvette |
| DDE. | .escort destroyer |
| DDG | .guided missile destroyer |
| DDR. | . radar picket destroyer |
| DL. . | -frigate |

DLG_- - . - guided missile frigate
SS ..---- - submarine
SSG------guided missile submarine
SSK . - . - - antisubmarine submarine
SSR_--.-.-.radar picket submarine
(2) Amphibious warfare vessels.

AGC.---- amphibious force flagship
AKA.......attack cargo ship
APA .-...-attack transport
APD . . . .-. high-speed transport
ASSP - - - -transport submarine
CVHA - - - assault helicopter aircraft carrier
DEC . . . . . control escort vessel
IFS. .-. . . inshore fire support ship
LPH -----amphibious assault ship
LSD - ----dock landing ship
LSFF _ . . . flotilla flagship landing ship
LSIL_.....infantry landing ship (large)
LSM. . .-. medium landing ship
LSMR_ . . medium landing ship (rocket)
LSSL . . . . support landing ship (large)
LST - - - - -tank landing ship
(3) Mine warfare vessels.

DM......minelayer, destroyer
DMS...-. -minesweeper, destroyer
MCS......mine warfare command and support

MHC_-.- minehunter, coastal
MMA_-. - minelayer, auxiliary
MMC_-.-_minelayer, coastal
MMF-. . . .minelayer, fleet
MSC.-.-- minesweeper, coastal
MSC(O) ... minesweeper, coastal (old)
MSF---- -minesweeper, fleet (stl hull)
MSO....... minesweeper, ocean (nonmag)
(4) Patrol vessels.

DE_ . . . . .escort vessel
DER_-----radar escort vessel
PC_-.-.-- submarine chaser (173')
PCE.-.-. escort ( $180^{\prime}$ )
PCER_-.-_rescue escort (180')
PCS.----- submarine chaser ( $136^{\prime}$ )
PF.--.-.-- patrol escort
PGM_ . . . motor gunboat
PR _--.-.-river gunboat
PY.-....-. yacht
SC.-.-.-. -submarine chaser ( $110^{\prime}$ )
b. Auxiliary Vessels.

AD---------destroyer tender
ADG-.-----degaussing vessel
AE -----.---ammunition ship
AF-----.-- - store ship
AG ---.-.-.-. miscellaneous
AGB------ icebreaker
AGP ------- - motor torpedo boat tender
AGS------- -surveying ship
AGSC - . . . - coastal surveying ship
AG(SS) . . . . auxiliary submarine
AH---....-. - hospital ship
AK_--------cargo ship
AKD . . . . . - cargo ship, dock
AKL_--.-.-. - light cargo ship
AKN . . - - - - net cargo ship
AKS.------- general stores issue ship
AKV . - - . . . cargo ship and aircraft ferry
AN---------net laying ship
AO-------- oiler
AOG_------- gasoline tanker
AOR_-.----replenishment fleet tanker
AO(SS) . . . . . submarine oiler
AP_...-....-transport
APB------- self-propelled barracks ship
APC.-------small coastal transport
AR-.------- -repair ship
ARB.-.----- - battle damage repair ship
ARC--------cable repairing or laying ship
ARG-----.-. - internal combustion engine repair ship
ARL_---.-.-. landing craft repair ship
ARS.-------salvage vessel
ARSD .-. . . . salvage lifting vessel
ARST - - - . - salvage craft tender
ARV - - - - - - aircraft repair ship
ARVA----- aircraft repair ship (aircraft)
ARVE -.-.-.aircraft repair ship (engine)
AS.-.----.-submarine tender
ASR_----.- . submarine rescue vessel
ATA.-.-.-. - auxiliary ocean tug
ATF----....-fleet ocean tug
ATR---------rescue ocean tug

AV -------- - seaplane tender
AVD - - - - - - advanced aviation base ship
AVM -------guided missile ship
AVP_..-.-. - small seaplane tender
AVS _-.....-aviation supply ship
AW--------- distilling ship
IX - - ----- - unclassified miscellaneous

## c. Service Crafi.

AFDB ----- large auxiliary floating drydock
AFDL_---. -small auxiliary floating drydock
AFDM.-----. medium auxiliary floating drydock
APL_------ barracks ship (nonpropelled)
ARD - . . . - - floating drydock auxiliary
LCU
MSA - -- -- - minesweeper auxiliary
MSB_-...-.- minesweeping boat
MSI --------minesweeper inshore
PT. .-...-...-. motor torpedo boat
PYC--------coastal yacht
SST -.-.-...-target and training submarine
X.----------submersible craft

XFU -------harbor utility craft
XMAP---.--.sweeper device
YAG -- -- . - miscellaneous auxiliary
YAGR----. ocean radar station ship
YC.------- - open lighter
YCF------. - car float
YCK_------ open cargo lighter
YCV -------- aircraft transportation lighter
YD_-----...- floating derrick
YDT -----.-. diving tender
YF-----.-. covered lighter (self-propelled)
YFB ----.-. - ferryboat or launch
YFD - - - -- - - yard floating drydock
YFN ------ covered lighter (nonpropelled)
YFNB----- - large covered lighter
YFND--- .- . covered lighter (used with drydock)
YFNG---.-. covered lighter (special purpose)
YFNX.----- lighter (special purpose)
YFP------.-floating power barge
YFR--.-....refrigerated covered lighter (selfpropelled)
YFRN.-.-. - -refrigerated covered lighter (nonpropelled)
YFRT-...-. covered lighter (range tender)
YFT-------- torpedo transportation lighter
YFU------ - harbor utility craft
YG------- garbage lighter (self-propelled)
YGN .-.-.-- garbage lighter (nonpropelled)
YHB - - . . . . . houseboat
YM .-...-.-. - dredge
YMP ---.-.- motor mine planter
YMS - -- -- - auxiliary motor minesweeper
YNG-------gate vessel
YO .-...-. . . fuel oil barge (self-propelled)
YOG - - - .-. - gasoline barge (self-propelled)
YOGN-.-..-.gasoline barge (nonpropelled)
YON ......... fuel oil barge (nonpropelled)
YOS ---.-. - oil storage barge
YP - -- -- - . - patrol vessel
YPD - . . . . . - floating pile driver
YPK_------- - ponton stowage barge

YR-------- - floating workshop
YRB - ------ submarine repair and berthing barge
YRBM ..... . submarine repair, berthing and messing barge
YRDH........ floating drydock workshop (hull)
YRDM . . . . . floating drydock workshop (machine)
YRL....-....-. covered lighter (repair)
YSD.-.-...... seaplane wrecking derrick
YSR...-.-.-- -sludge removal barge
YTB...-...-. - large harbor tug
YTL_.-..-.-. -small harbor tug
YTM ------. medium harbor tug
YTT-.......... - torpedo testing barge
YV .-.......-drone aircraft catapult control craft
YW .-.-.--- water barge (self-propelled)
YWN....-.-.-. Water barge (nonpropelled)

### 5.20 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.

BARC - . - lighter, amphibious (BARC), self-propelled, diesel, steel, 60-ton, 61-foot, design 2303
BC.---.-.barge, dry cargo, nonpropelled, 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)
BCP . . . . . barge, railroad carfloat
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 $-\ldots$ - - freight and supply vessel, medium (100 feet through 139 feet)

FSR_-....freight and supply vessel, refrigerated cargo
J.-.---.-boat, work and inspection, small (50 feet and under)
LARC.... - lighter, amphibious, resupply, cargo
LCM .-....landing craft, mechanized (Mark VI, Mark VIII)

LCR_-... landing craft, retriever
LCU_ .-. . . landing craft, utility
LCVP.-. . landing craft, vehicle, personnel
LT_...-. - tug, large ( 100 feet and over)
LTI.--- - - towboat, large, inland waterways ( 100 feet and over)
Q....-.-.boat, work and inspection, large (over 50 feet)
R.-.-.-. . - rowboat

ST---.-. -tug, small ( 99 feet and under)
STI--.-- towboat, small, inland waterways (99 feet and under)
T.-....... freight and supply vessel, small (under 100 feet)
Y .- . . . . . - vessel, liquid cargo, self-propelled

### 5.21 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 deter-


Figure 5.17. Deadweight scale for a Victory ship.
mine 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 $63 / 4$ 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, 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

### 5.22 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-the-clock 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 5.26.
$b$. 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.

### 5.23 Terminal Capacity

a. Terminal throughput 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 ships 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.
Collect these data: Compute these factors: To determine:

| Channel depths. |  |  |
| :---: | :---: | :---: |
| Obstructions. |  |  |
| Enemy air activity |  |  |
| Enemy surface activity | (1) Evaluate to determine water terminal |  |
| Enemy submarine activity | reception capacity. |  |
| Climate and seasons. |  |  |
| Weather and tide characteristics |  |  |
| Minefields or contaminated areas. |  |  |
| Capabilities in combating obstacles |  |  |
| Tactical dispersion requirements. |  |  |
| Wharf facilities. |  |  |
| Beach capabilities. |  |  |
| Discharge rates ashore. |  |  |
| Discharge rates in the stream. |  |  |
| Anchorage area. |  | Water terminal throughout |
| Extent of destruction or contamination. |  | capacity. |
| Climate and seasons -------------- | discharge (input) capacity. |  |
| Weather and tide characteristics. Cargo-handling equipment available |  |  |
| Floating craft and equipment available. |  |  |
| Transit sheds and areas - |  |  |
| A vailability of local labor. |  |  |
| Space reserved for local economy. |  |  |
| Enemy activity |  |  |
| Capability of rail facilities |  |  |
| Capacity of highway facilities. |  |  |
| Capacity of inland waterway facilities | (3) Evaluate to determine water terminal |  |
| Capacity of pipeline facilities. | clearance (output) capacity. |  |
| Capacity of air facilities. |  |  |
| Enemy activity. |  |  |

### 5.24 Defermination 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 throughput 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 caparity over a period of time.

### 5.25 Wharf Facilities and Anchorage Areas

a. General. Terminal discharge capacity is the 1-day capacity of a terminal to accommodate ships in the harbor, to discharge them, and to clear the terminal of cargo. Considerations must include the harbor berths and anchorage areas available, wharf capacity, lighterage discharge, and local conditions. For general planning purposes, two methods of ship discharge are: discharge directly onto the wharf from vessels berthed alongside and discharge by lighterage from vessels anchored in the stream. Deep-draft wharfage must be provided wherever alongside discharge is contemplated, while shallow-draft wharfage and anchorage areas must be given joint consideration when lighter discharge is contemplated.
b. Berths and Anchorages. The first fact that must be determined is whether vessels can be brought into the anchorage areas and alongside the wharves. Berths and anchorages are evaluated according to the size of vessels they can accommodate.
(1) Berth classifications.
(a) General berths.

| Class of general | Size vessel berthed |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Length |  | Average draft |  |
|  | Feet | Meters | Feet | Meters |
| A. | Over 500 | Over 152 | 30 | 9.2 |
| B | 500 to 460 | 152 to 140 | 26 | 7.9 |
| C | 460 to 350 | 140 to 107 | 19 | 5.8 |
| D. | 350 to 250 | 107 to 76 | 16 | 4.9 |
| E. | 250 to 200 | 76 to 61 | 12 | 3.6 |
|  | Under 200 | Under 61 | Under 12 | Under 3.6 |

(b) Tanker berths.

| Class of tanker berths | Size vessel berthed |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Length |  | Average draft |  |
|  | Feet | Meters | Feet | Meters |
| T-A | 600 and over 525 | 183 | 33 | 10 |
| T-B.-- |  | 160 | 30 | 9.2 |


| Class of tanker berth | Size vessel berthed |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Length |  | Average draft |  |
|  | Feet | Meters | Feet | Metera |
| T-C. | 450 | 137 | 25 | 7.6 |
| T-D. | 250 | 76 | 13 | 4 |
| T-E... | Under 250 | Under 76 | Under 13 | Under 4 |

1 Most modern ocean-going tankers will arrive with drafte of 30 feet and over. Commercial supertankers with of drafts 35-45 feet are becoming common.
(2) Anchorage berths.
(a) Anchorage berth diameter formulas. The following formulas are used to find the diameter for anchorage berths:

$$
\frac{2(7 \mathrm{D} \times 2 \mathrm{~L})}{3}=\text { diameter in yards }
$$

(0.61) $(7 \mathrm{D} \times 2 \mathrm{~L})=$ diameter in meters where
$\mathrm{D}=$ depth of water in feet
$\mathrm{L}=$ length of vessel in feet
(b) Standard classification system.

| Class | Diameter |  | Depth of water |  | Type of vessel |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Yards | Meters | Feet | Meters |  |
| I | Over 800 | Over 732 | Over 38 | Over 12 | Capital naval ship or large passenger ship. |
| II | 500 to 800 | 457 to 732 | 30 to 38 | 9 to 12 | Standard oceangoing vessel |
| III | Under 500 | Under 457 | Under 30. | Under 9 | Destroyer or small cargo 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 estimatefor example, open or covered terminals, naval wharves, ship-repair and fitting-out wharves, bulk-cargo wharves, and special-purposes 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, transit-shed 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-ofthumb 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 (par. 5.26 below) 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 (75meter) 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 deepdraft 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). This 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 lighters 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.

### 5.26 Discharge Rafes

a. Commercial-Type Loading. For planning purposes, the average ship is considered to be 450 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 stream indicate tonnage dis-
charged 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 stream500 short tons or 446 long tons per 20 hour day.
(3) Average lighter alongside wharf-180 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 bridles 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 stowage 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 lb for $5 / 8^{\prime \prime}$ wire and $8,800 \mathrm{lb}$ for $3 / 4^{\prime \prime}$ wire (improved plow steel) in good condition. Heavier weights must be lifted by doubled yard-and-stay rigs, swinging booms, fourboom rigs, or jumbo booms.
(5) Average weights of drafts:
(a) Palletized general cargo- 1 ST
(b) Palletized ammunition- $11 / 2$ ST
(c) CONEX-5 ST
(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 min utes per draft (CONEX, empty 21/2ton 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 RO/RO, LPH, and LPD 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.
(8) Detailed guidance on combat loading,

commodity loading, and selective loading is contained in FM 60-30. Profile loading diagrams for ainphibious force vessels, as well as standard maritime commission design vessels, are obtained from the amphibious force of the nearest U.S. Navy fleet.

### 5.27 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.

### 5.28 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 5.25 above lists the factors for determining ship berth space.

### 5.29 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 harbor chart shown in figure 5.19.
a. Wharf Facilities.

| WharfNo. | Length |  | Width |  | Minimum depth alongside |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 wharjage.

| Wharf No. | Victory <br> ship berths | Diseharge rate <br> $(S T$ per day $)$ |
| :---: | :---: | :---: |
| 1 | 2 | $2 \times 720=1,440$ |
| 2 | 1 | $1 \times 720=720$ |
| 3 | 1 | $1 \times 720=720$ |
| 4 | 2 | $2 \times 720=1,440$ |


(2) At lighterage wharves.

| Wharf No. | $\underset{\text { berths }}{\substack{\text { Lighter }}}$ | Discharge rate (ST 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 |
|  |  |  |  | ,800 |

(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 wharves1,800 short tons per day.
(3) Transferred from ships to lighters- 3,600 short tons per day.
(4) The maximum discharge per day is 1,800 short tons because lighter wharfage is the limiting factor (par. 5.23a). Therefore the total daily terminal capacity is 6,120 short tons: 4,320 short tons alongside; 1,800 short tons by lighter.

[^20]

Figure 5.19. Harbor chart for terminal capacity estimation.
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.

### 5.30 Inland Waferways 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.

### 5.31 Estimating Inland-Waterway 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 clearance of bridges.
c. Location of dams or other bars to naviagation.
d. Location of locks; dimensions, timing, method of operation, and other limiting factors.
$e$. Frequency, duration, and effect of seasonal floods and droughts.
f. Normal freezeup and opening dates.
g. Navigation hazards-rapids, falls, etc.
$h$. Speed and fluctuation of current.
$i$. Waterway maintenance requirements.
j. Changes of channel.
$k$. Availability of civilian and/or military craft.
$l$. Availability of skilled bargemen, pilots, and tugboat operators from civilian and/or military sources.
$m$. Number of terminals.
$n$. Terminal facilities, including wharves, cranes, materials handling equipment, marine maintenance shops, and port clearance.
o. Ability of the waterway to displace its capacity daily over a considerable period of time.

### 5.32 Defermination of Inland-Waterway Movement Capability

a. General. The actual capacity of a waterway, the availability of craft, and the adequacy of terminal facilities are factors that must be considered when estimating inland-waterway movement capability. Any of these factors may limit an inlandwaterway operation; each one must be examined to determine its impact upon the waterway-movement capability. It is necessary, in the absence of definite information, to make certain assumptions when making an actual estimate of inland-waterway movement capability.
b. Assumptions. It is assumed that:
(1) Waterway is useable.
(2) Weather is favorable.
(3) Civilian use of the waterway has been suspended.
(4) Manpower and fuel are available and adequate.
(5) Vessels are weight-loaded to 60 percent of capacity.
(6) Average deadline rate is 20 percent.
(7) Waterway operations are 15 hours per day.
(8) Average speed is 4 miles per hour ( 6.4 kmph).
(9) Port operations are 20 hours per day.
(10) Cargo handling averages 30 tons per hour per barge.
(11) Average locking cycle is 45 minutes.
(12) Empties pass through the locks on the return trip.
(13) Effect of current is ignored.
(14) Cargo movement is only in one direction.
c. Waterway Movement Capability. There are two types of waterways-open and restricted. In this discussion, lakes, rivers, channels, canals, and other navigable inland bodies of water without locks or other restrictive features are "open waterways," while waterways with locks or other restrictive features are "restricted waterways." The actual movement capability of the waterway depends upon the length of time that the daily capacity can be maintained.
(1) Open waterways. In general, open waterways can accommodate a large volume of traffic. The Mississippi River is an example of such a waterway: tows on the Mississippi and Ohio Rivers are usually
$1 / 4$-mile long. Movement is limited only by availability of craft and adequacy of terminal facilities.
(2) Restricted waterways. An inland waterway that has locks or other restrictive features, such as narrow bridge spans or narrow passage ways, is a restricted waterway. A narrow passageway or narrow bridge span may be the most limiting factor in an inland-waterway movement. For example, if there is only one underbridge passageway, the safe distance between tows is the governing factor. The safe distance between tows may vary from 1,000 to 2,000 feet ( 305 to 610 meters). Changing the number of tows per mile can make a great difference in movement capability.
(3) Capacity formulas.
(a) General. The formulas given below may be used to determine movement capability over waterways. In these formulas and in the formulas for determining barge and tug requirements discussed in $d$ below, the letters used have the following meanings:

$$
\left.\begin{array}{rl}
\mathrm{A}= & \text { number of barges } \\
\mathrm{B}= & \text { tons per barge } \\
\mathrm{C}= & \text { percentage of useable barges } \\
\mathrm{D}= & \text { factor for military loading. } \\
& \quad \text { This is the reduction fac- } \\
& \text { tor that must be applied to } \\
& \text { each operation: it is de- } \\
& \text { termined by the loading } \\
& \begin{array}{l}
\text { and unloading of personnel, }
\end{array} \\
& \quad \text { equipment, and facilities }
\end{array}\right)
$$

[^21]$\mathrm{L}=$ length of longest locking cycle in minutes
$\mathrm{M}=$ lock-operating hours per day
$\mathrm{N}=$ tows per mile
$0=$ number of passages per day
$P=$ daily tonnage requirement
$Q=$ turnaround time in days for barges
$R=$ number of barges per tow
$S=$ turnaround time in days for tugs
(b) Turnaround time. The turnaround time in days for barges and tugs used in the formulas is the sum of navigating time, port time, and lock time. Methods of determining these times are:
\[

$$
\begin{aligned}
& \text { Navigating time }=\frac{\mathrm{E} \times 2}{\overline{\mathrm{~F}} \times \mathrm{G}} \\
& \text { Port time }=\frac{\mathrm{H} \times 2}{\mathrm{I} \times \mathrm{J}} \\
& \text { Lock time }=\frac{\mathrm{K} \times \mathrm{L}}{\mathrm{M} \times 60}
\end{aligned}
$$
\]

(c) Formula for open waterway. A simple formula applicable only to open water. ways is-
Capacity in tons per day $=N \times G \times F \times B \times D$
(d) Formula for restricted waterway. When the waterway is restricted but the number of possible passages per day is known, a simple formula is-
Capacity in tons per day $=\mathrm{B} \times$ $0 \times D$
(e) Formula for both open and restricted waterways. If the number of possible passages per day is not known, but the basic information (information represented by the letters A through M in (a) above) is available, the following formula may be used for an open or restricted waterway.
Capacity in tons per day $=$

$$
\frac{A \times B \times C \times D}{\frac{\mathrm{E} \times 2}{\mathrm{~F} \times \mathrm{G}}+\frac{\mathrm{H} \times 2}{\mathrm{I} \times \mathrm{J}}+\frac{\mathrm{K} \times \mathrm{L}}{\mathrm{M} \times 60}}
$$

Example: How many tons of military stores per day can be moved on a 300 mile (483-kilometer) waterway that has 10 locks if-

One hundred 1000-ton capacity, selfpropelled barges are available.
The percentage of useable barges is 80 .
The factor for military loading is 0.6 .
Navigating-operating hours per day are 15.
Average speed is 4 miles per hour ( 6.4 kmph ).
Load of each barge is 600 tons.
Port-handling rate per hour is 30 tons.
Length of port-working day is 20 hours.
The locking cycle is 45 minutes.
Lock-operating hours per day are 15 .

$$
\begin{aligned}
& \text { Capacity }=\frac{100 \times 1000 \times .80 \times 0.6}{\frac{300 \times 2}{15 \times 4}+\frac{600 \times 2}{30 \times 20}+\frac{10 \times 45}{15 \times 60}} \\
& =3,840 \text { tons per day }
\end{aligned}
$$

d. Availability of Craft.
(1) Barges. Barge requirements can be determined after the route capability is computed or after the daily tonnage requirements are established. The formulas given below may be used to determine the number of barges required for open and restricted waterways.
(a) Open waterway.

$$
\text { Barges required }=\frac{P \times Q}{B}
$$

(b) Restricted waterway.

Barges required $=\mathbf{O} \times \mathbf{Q}$
(2) Tugs. When tugs are used, the arrangement of the tows must be considered. It is sometimes possible to operate with fewer tugs than tows because the tugs do not have to wait in port while the cargo is being transferred. Moreover, one tug can often tow more than one barge. In planning a towing operation, the fit of the tow in the locks must be considered. The following formula can be used to determine the number of tugs or towboats required to move the available barges.
Number of tugs or towboats required $=\frac{A \times S}{R \times Q}$
e. 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 in-land-waterway movement capability. This problem cannot be solved by using formulas; its solution requires careful analysis and sound judgment.

### 5.33 Inland Terminal Capacity

Checklist for estimation of inland terminal throughput capacity.*

## Collect these data:

Compute these factors:
To determine:

| Channel depths_ |  |  |
| :---: | :---: | :---: |
| Obstructions. |  |  |
| Capacity of rail facilities. |  |  |
| Capacity of highway facilities. |  |  |
| Capacity of pipeline facilities |  |  |
| Capacity of air facilities. | (1) Evaluate to determine inland terminal |  |
| Enemy air activity. | reception capacity. |  |
| Enemy surface activity. |  |  |
| Climate and seasons. |  |  |
| Weather and tide characteristics. |  |  |
| Contaminated areas. |  |  |
| Capabilities in combating obstacles |  |  |
| Tactical dispersion requirements. |  |  |
| Wharf and/or platform facilities. |  |  |
| Discharge rates. . |  |  |
| Unloading rates |  | Inland terminal throughput |
| Loading rates. |  | capacity. |
| Extent of destruction or contamination. |  |  |
| Climate and seasons.. |  |  |
| Weather and tide characteristics. | (2) Evaluate to determine inland terminal discharge (input) capacity. |  |
| Materials-handling equipment available |  |  |
| Cargo-handling equipment available. . |  |  |
| Floating craft and equipment available. |  |  |
| Airfield capabilities.-.-..------- |  |  |
| Transit sheds, yards, and areas |  |  |
| Local labor available. |  |  |
| Space reserved for local economy |  |  |
| Capacity of rail facilities. . |  |  |
| Capacity of highway facilities |  |  |
| Capacity of inland-waterway facilities | (3) Evaluate to determine inland terminal clearance (output) capacity |  |
| Capacity of pipeline facilities. |  |  |
| Capacity of air facilities..- |  |  |

* Capacity in tons for one 20-hour working day.


### 5.34 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 twothirds are vessel personnel. Excluding the Great Lakes system, the inland-waterway service uses over 5,000 self-propelled and 14,000 nonself-propelled vessels. Typical cargo carried on these waterways is shown below.

| Type of cargo | Percent of total cargo | Type of cargo | Percent of total cargo |
| :---: | :---: | :---: | :---: |
| Sea shells | 5.27 | Clays and earths. | . 51 |
| Animal products (inedible) | . 22 | Sulphur. | . 72 |
| Grain and grain products. | 1.34 | Limestone | . 81 |
| Coffee, raw or green. | . 04 | Salt. | . 09 |
| Sugar.- | . 23 | Sand, gravel, crushed rock. | 13.30 |
| Molasses | . 23 | Iron and steel | 2.43 |
| Soybeans. | . 32 | Aluminum ores and scrap. | . 05 |
| Logs_ | 5.35 | Copper ores and scrap | . 09 |
| Lumber and lumber produc | . 49 | Construction and mining machinery | . 09 |
| Pulpwood. | . 48 | Motor vehicles and parts. | . 13 |
| Woodpulp. | . 10 | Coal tar products. | . 35 |
| Paper and paper products. | . 31 | Sulphuric acid | . 47 |
| Anthracite coal. | . 30 | Industrial chemicals. | . 74 |
| Bituminous coal and lignite. | 25.00 | Fertilizer | . 13 |
| Coke | . 14 | Chemical products, miscellaneous | . 01 |
| POL | 34.50 | Miscellaneous. | 5.23 |
| Building cement. | . 48 |  |  |

## b. Depths, Navigable Distances, and Average Freight for Principal Waterways. ${ }^{1}$



I Great Lakes not included.
2 Mississippi River not included.
${ }^{2}$ Quantitiea in parentheses represent kilometers.
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.

| Name of waterway | Principal terminals | Critical distances | Controlling depths for specified locations | Typical cargo carried commerically |
| :---: | :---: | :---: | :---: | :---: |
| Allegheny River- | Pittsburgh, Pa., New Kensington, Pa., Kittanning, Pa., East Brady, Pa. | 325 miles ( 523 km ) from its rise in northern Pennsylvania to its mouth at Pittsburgh | 9 feet for improved portion, Pittsburgh, to above East Brady, 72 miles (116 km); no | Coal, coke, sand, gravel, POL and POL prod ucts, glass, furnace slag, lignite crushed |


| Name of waterway | Princlpal terminals | Critical distances | Controlling depths for specified locations | Typical cargo carried commercially |
| :---: | :---: | :---: | :---: | :---: |
|  |  | where it joins the Monongahela River to form the Ohio River. The Allegheny River consists of two sections: the improved portion (locks and dams), Pittsburgh, to above East Brady, Pa., 72 miles ( 116 km ); and the open channel (unimproved) portion above East Brady, Pa. | specific depths for open channel portion (unimproved) above East Brady. | rock, nonmetallic minerals and products, iron and steel, iron ore, industrial chemicals. |
| Atlantic intracoastal waterway. | Norfolk, Va., Elizabeth City, N. C., Washington, N. C., Wilmington, N. C., Georgeton, 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. | The main route extends 1,262 miles ( $2,300 \mathrm{~km}$ ) from Norfolk to Key West, Fla., with a $65-$ mile ( $\mathbf{1 0 4 . 5} \mathrm{km}$ ) alternate channel, know as the Dismal Swamp Canal Route (west of, and generally parallel to, the main route) extending south from Noriolk, 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 Albermarle Sound, S. C. | (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 ). <br> (2) Dismal Swamp Canal route: 8.6 feet in Deep Creek, Va., 3 miles ( 4.83 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 ). | Logs, paper pulp, sand, gravel, fish, POL and POL products, fertilizer, pulp, acid phosphate, paperboard and pulpboard, sea food, seashells, automobiles, grain and grain products, sugar, soybeans, limestone, salt, iron and steel, industrial chemicals. |


| Name of waterway | Principal terminals | Critical distances | Controlling depths for specified locations | Typical cargo carried commercially |
| :---: | :---: | :---: | :---: | :---: |
| Black Warrior, Warrior, and Tombigbee River System | Birmingham, Ala., Tuscaloosa, Ala., Demopolis, Ala., Mobile, Ala. | The Black Warrior and Warrior Rivers, a single stream, rise in northern Alabama above Birmingham 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 ). | 9 feet from Mobile to Mile 444.6 on Mulberry Fork, Mile 447.6 on Sipsey Fork, and Mile 420.6 on Locust Fork of the Black Warrior River. | Iron ore, manganese ore, sulphur, coal, POL and POL products, clay and bentonite, logs, stone and rock, pulpwood, iron and steel articles, cast iron pipe and fittings, sea shells, molasses, lignite, cement, limestone, sand, gravel, iron ore concentrates, nonferrous metals and scrap, industrial chemicals. |
| 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. | 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. |
| 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. |  |  | Logs, paper pulp, POL, fish, fertilizer, sea shells, sea food, 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. |
| Columbia River .-. | Astoria, Ore., Vancouver, Wash., Portland, Ore., The Dalles, Ore., Kennewick, Wash., Rickland, Wash. | Mouth to Canadian border, 745 miles ( 1,200 km). | 33 feet or deeper between mouth of Columbia River and mouth of Willamette River (Mile 101.5); 30 feet to Interstate Bridge, Vancouver, Wash. (Mile 106.5); 15 feet from Vancouver to Bonneville, Ore. (Mile 145.3); 24.2 feet over miter sills at Bonneville Lock and Dam; 20 feet from Bonneville to The Dalles-Celilo Canal (Mile 191); 7 feet through The DallesCelilo Canal; 7 feet from Celilo, Ore. (Mile | 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 articles, wrapping paper, canned foods, cement, salt, crushed rock, chemicals and |


| Name of waterway | Principal terminals | Critical distances | Controlling depths for specified locations | Typical cargo carried commerclally |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | 201) to McNary 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. | 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. | 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. | Sand, gravel, sulphur, fluorspar, railroad ties, POL and POL products, sugar, molasses, coal, lignite, limestone, crushed rock, iron, steel. |
| Delaware River-.-- | Wilmington, Del., Phila delphia, 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 )). | 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 ). | POL and POL products, glass, furnaceslag, 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, coaltar products, sulphuric acid, industrial chemicals, fertilizer and fertilizer minerals. |
| Green and Barren Rivers. | Bowling Green, Ky..-. - | Green River- 197.8 miles ( 318 km ) from mouth to Mammoth Cave, Ky.; Barren River30.1 miles ( 48.5 km ) from mouth (Mile $149.5(241 \mathrm{~km})$, Green River) to Bowling Green. | 5.5 feet for entire distance of both rivers-228 miles ( 367 km ). | Bituminous coal and lignite, POL and POL products, limestone, sand, gravel, crushed rock, iron and steel. |
| Gulf intracoastal | St. Marks, Fla., Carra- | The main route extends | 1) Main route: 12 feet | ea shells, coal, POL and |


| Name of waterway | Principal terminals | Critical distances | Controlling deptha for apecified locations | Typical cargo carried commerically |
| :---: | :---: | :---: | :---: | :---: |
| waterway. | belle, 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. | 1,116 miles ( $1,795 \mathrm{~km}$ ) from St. Marks River to the Mexican border at Brownsville, Tex., with a $55-\mathrm{mile}$ ( 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). | 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 Freoport, Tex., 42 miles ( 67.6 km); 11 feet from Freeport to Port O'Connor, Tex., 79 miles (127 km ); 11.6 feet from Port O'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 ). | 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 products, lignite, cement, clays and earths, sulphur, sand, gravel, crushed rock, coal-tar products, industrial chemicals. |
| Houston Ship Channel. | Houston, Tex., Galveston, Tex. | 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 branch channel in the old channel of Buffalo Bayou behind Brady Island. | 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. | Sea shells, grain and grain products, coffee, molasses, cotton, newsprint paper, other paper and products, coal and lignite, POL and POL products, cement, clays and earths, sulphur, sand, gravel, crushed rock, iron and steel, coal-tar products, sulphuric acid, industrial chemicals, fertilizer and fertilizer materials. |
| Hudson River- | New York, N. Y., Tarrytown, N. Y., Waterford, N. Y., Poughkeepsie, N. Y., Albany, N. Y., Troy, N. Y. | $155(249 \mathrm{~km})$ miles from New York City (Battery) to Waterford. | 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 | Copper ore and concentrates, sand and gravel, sugar, coal, lumber, shingles and lath, stone and rock, POL and POL products, coal-tar, copper, syrup and molasses, wood pulp, grain and grain products, |


| Name of waterway | Principal terminals | Critical distances | Controlling depths for specified locations | Typleal cargo carried commercially |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | ( 17.7 km ). | automobiles, cement, brick. |
| Illinois waterway . | Grafton, Ill., Pekin, Ill., Peoria, Ill., Chicago, Ill. | Includes the Illinois River from its mouth on Mississippi River at Grafton to Lockport, Ill., 291 miles ( 469 km ); the Chicago Sanitary and Ship Canal (Chicago Drainage Canal) from Lockport to Damen Avenue, Chicago, 30 miles ( 48.3 km ); the Chicago River (South Branch) from Damen Avenue to Lake Street, Chicago, 4.5 miles ( 7.24 km ); and the CalumetSag 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 ). | 9 feet in the Illinois River from its mouth on Mississippi River at Grafton to Lockport, 291 miles ( 469 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 Calumet-Sag Channel from its junction with the Chicago Sanitary and Ship Canal to Blue Island, Ill., to Little Calumet and Calumet Rivers to Turning Basin No. 5, 23.8 miles ( 38.3 km ). | Newsprint paper, 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, paper and products, lignite, crushed rock, coal-tar products, fertilizer and fertilizer materials. |
| Kanawha River--- | Henderson, W. Va., Point Pleasant, Va. | 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. | 9 feet for the 90 miles ( 145 km ) above 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 | Beattyville, Ky., Carrollton, Ky. | 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. | 6 feet for entire length.- | Sand, gravel, crushed rock, gasoline and other motor fuels, coal and lignite. |
| Mississippi River.-- | Minneapolis, Minn., St. Paul, Minn., St. Louis, Mo., Cairo, Ill., Memphis, Tenn., Vicksburg, Miss., Baton Rouge, La.. New Orleans, La. | 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., | 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 ( $2,560 \mathrm{~km}$ ); 35 feet, Baton Rouge to Head | 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 prod- |


| Name of waterway | Principal terminals | Critical distances | Controlling depths for specified locations | Typical cargo carried commercially |
| :---: | :---: | :---: | :---: | :---: |
|  |  | and 20 miles ( 32.2 km ) from Head of Passes to Gulf of Mexico through Southwest Pass). | 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). | ucts, alcohol, other chemicals, sea shells, 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. |
| Missouri River-...- | 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. | 2,464 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 Kansas City, Mo., and 386 miles ( 622 km ) from Kansas City to the mouth. | 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. | 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- | Pittsburgh, Pa., Fairmont, W. Va. | 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. | 9 feet for entire length -- | 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. |
| New York State Barge Canal. | New York, N. Y., Albany, N. Y., Buffalo, N. Y. | 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 Water- | 14 feet in earth cuts, rock cuts, canalized rivers and lakes and in open rivers; 12 feet in locks. | 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. |


| Name of waterway | Principal terminala | Critical distances | Controlling depths for specified locations | Typical cargo carried commercially |
| :---: | :---: | :---: | :---: | :---: |
|  |  | ford) 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 con necting channels to canal harbors at Utica, Syracuse, and Rochester. |  |  |
| Ohio River | Pittsburgh, Pa., Cincinnati, O., Louisville, Ky., Evansville, Ind., Cairo, Ill. | 981 miles $(1,580$ km $)$ from Pittsburgh Cairo. | 9 feet for entire distance. | Grain and grain products, coal, railroad ties, coke, 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. |
| 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. | 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 km). | Grain and grain products, sugar beets, rock and stone, POL and POL products, canned foods, beet pulp, sand, gravel, fresh vegetables. |
| San Joaquin River-- | Stockton, Calif. ------- | 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 Chan- | 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 | 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, |


| Name of waterway | Principal terminala | Critical distances | Controlling depth for specified locations | Typical cargo carried commercially |
| :---: | :---: | :---: | :---: | :---: |
|  |  | nel to Hills Ferry (navigable April through June), 86 miles 138.5 km). | (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). | industrial chemicals. |
| 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. | 9 feet from mouth to Knoxville, 647.6 miles ( $1,040 \mathrm{~km}$ ). | Grain, coal, coke, clay, POL and POL products, sand, gravel, railroad ties, automobiles, lumber, soybeans, pulpwood, sulphur, limestone, salt, iron and steel, manganese, coaltar products, chemicals. |

## ORGANIZATION FOR TRANSPORTATION INLAND WATERWAYS SERVICE



Figure 5.20. Organizational chart, transportation inland waterways service.

### 5.35 Amphibious Operations

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 detailed 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 will normally 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 maximum use of troop billeting and cargo spaces. There is no regard for tactical considerations, unit integrity, or priority for unloading. 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 when tactical employment immediately upon landing is not required. Technical details pertaining to administrative loading are contained 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 and 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 loaded 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 assault 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.
. These 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 without 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 aften 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.

### 5.36 Estimating Wheeled Amphibian Requirements

a. Characteristics.
(1) $D U K W$. The combat payload of the $21 / 2$-ton, $6 \times 6$ wheeled landing vehicle (DUKW) ranges from 5,000 to 9,000 pounds, depending on the operating conditions. For planning purposes, the combat payload of the DUKW is 9,000 pounds under ideal operating conditions, 7,500 pounds under favorable conditions, and 5,000 pounds under difficult contions. Very unfavorable conditions of wind, waves, or obstacles would possibly prevent even a payload of 5,000 pounds or cause operations to cease entirely.
(2) $L A R C-5$. The combat payload of the LARC- 5 amphibian ranges from 5,000 to 10,000 pounds, depending on the operating conditions. For planning purposes, the combat payload of the LARC-5 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.
(3) BARC. The combat payload of the BARC ranges up to 100,000 pounds, depending upon operating conditions. In extreme cases and, if very ideal conditions exist, the BARC 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 affectingoperating conditions | Operating conditions |  |  |
| :---: | :---: | :---: | :---: |
|  | Ideal | Favorable | Difficult |
| Wind Waves | $\left\|\begin{array}{cc} 10 \mathrm{mph} & (16 \\ \mathrm{kmph}) & \text { or } \\ \text { less. } & \\ \text { Less than } 1 \mathrm{ft} \end{array}\right\|$ | $\left\lvert\, \begin{gathered} 10 \text { to } 15 \mathrm{mph} \\ \text { (16 to } 24 \\ \text { kmph). } \\ 1 \text { to } 3 \mathrm{ft} \end{gathered}\right.$ | Over 15 mph <br> ( 24 kmph ). <br> Over 3 ft. |
| Beach. | Gentle slope, hard sand. | Abrupt slope, soft sand. | Construction required Mud. |
| Obstacles | None | Some | Prevalen |
| Area behind beach. | Good road net. | Trails.--.-.-- | $\begin{aligned} & \text { Cross-coun- } \\ & \text { try. } \end{aligned}$ |

c. Estimating Wheel Amphibian Requirements. This requires computation of turnaround 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.

|  | DUKW | LARC-5 | BARC |
| :---: | :---: | :---: | :---: |
| Loading time | 8-10 min | $8-10$ min | 25 min (heavy vehicles) |
| Unloading time. | 8-10 min | 8-10 min. | $\begin{aligned} & 5 \text { min (with } \\ & \text { unloading } \\ & \text { pit pre- } \\ & \text { pared). } \end{aligned}$ |
| Water speed. | $\begin{gathered} 5 \mathrm{mph}(8 \\ \mathrm{kmph}) . \end{gathered}$ | $\begin{gathered} 10 \mathrm{mph}(16 \\ \mathrm{kmph}) . \end{gathered}$ | $\underbrace{8 \mathrm{mph}}_{8}(13$ |
| Land speed. - | $\begin{gathered} 10-20 \mathrm{mph} \\ (16-32 \\ \mathrm{kmph}) . \end{gathered}$ | $\begin{gathered} 25 \mathrm{mph}(40 \\ \mathrm{kmph}) . \end{gathered}$ | $\begin{gathered} 14 \mathrm{mph} \\ \mathrm{kmph}) \end{gathered}$ |

d. Turnaround Time. Turnaround time for wheeled amphibians may be estimated by using the following formula:

$$
\mathrm{TT}=\frac{\mathrm{W} \times 60}{\mathrm{R}}+\frac{\mathrm{L} \times 60}{\mathrm{R}^{\prime}}+\mathrm{a}+\mathrm{b}+\mathrm{c}
$$

where
$\mathrm{TT}=$ turnaround time in minutes
*W = water distance (round trip) in miles or kilometers
${ }^{*} \mathrm{~L}=$ land distance (round trip) in miles or kilometers
*R $=$ speed on water in miles or kilometers per hour

* $\mathrm{R}^{\prime}=$ speed on land in miles or kilometers per hour
$\mathrm{a}=$ loading time in minutes
$\mathrm{b}=$ unloading time in minutes (not to exceed loading time)
$\mathrm{c}=$ known delays in minutes
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.

$$
\mathrm{V}=\frac{\mathrm{H} \times \mathrm{TT}}{\mathrm{X}}
$$

[^22]where
$\mathrm{V}=$ number of operational vehicles
$\mathrm{H}=$ number of hatches to be worked
$\mathrm{TT}=$ turnaround time in minutes
$X=$ most restrictive factor ( $\mathbf{a}, \mathrm{b}$, or c , whichever is greatest in solution of turnaround time in $d$ above.)

### 5.37 Logistical Over-The-Shore (LOTS) Operations

a. In other than amphibious operations, LOTS operations provide for the movement of cargo and personnel over the shore between ocean transportation and shoreside facilities. Beaches and other more difficult shore lines 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.
(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


Figure 5.21. A typical transportation terminal battalion organized for a LOTS operation.
is accompanied by a detailed profile sketch of the beach and landing area as shown in figure 5.23 .

### 5.38 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 a nd 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).

### 5.39 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 5.22. Characteristics of beaches and landing areas.


Figure 5.2s. Beach profile diagram.

| LEFT SIDE <br> FROM SEAWARD | OBSTRUCTION | FAIRWAY | RIGHT SIDE <br> FROM SEAWARD | RANGE <br> LIGHTS |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | OAY (FLAGS) |  |  |  |
| BLINKING |  |  |  |  |

Figure 5.24. Hydrographic markings for landing operations.


Figure 5.25. Beach and debarkalion point markers.

## Section IV. HOISTING AND CONVEYING DATA

### 5.40 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.

### 5.41 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 one-fifth from the safe working load of manila rope of the same size.

| Nominal diameter (inchea) | Circum(erence (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 |
| 5/8 | 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 |
| 11/8 | 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 |
| 13/4 | $51 / 2$ | 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 |

* Safety factor of 4.


### 5.42 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.

| double-sheet bend <br> Tojoin two wet ropes of different diameters. | METHOD <br> 2. <br> 3. <br> BOWLINE <br> Toform aloop of any desired size that will not slip. | BOWLINE ON A BIGHT <br> To form a loop with a double purchase. 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> To jointworopes of different diameters. | Toobtain a double bearing surface on a hook. | To shorten a rope when ends are not available. To bypass a weak section of a rope when ends are not available. |
| ROLLING HITGH <br> To form ahitch which will hold on aspar or rope yet will slide readilyupona slight adjustment. | clove hitch <br> Tofasten guy lines to anchorages and spars. | TIMBER HITCH WITH TWO half hitches <br> To haul a 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.

### 5.43 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 stablized 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:

| Diameter (inches) | Approximate weight per 100 feet (pounds) | Breaking strength (short tons) |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | $\begin{aligned} & \text { Mild } \\ & \text { plow steel } \end{aligned}$ | Plow steel | Improved plow steel |
| 1/4 | 10 | 2.07 | 2.39 | 2.74 |
| 5/6 | 16 | 3.31 | 3.82 | 4.23 |
| 8/8 | 23 | 4.6 | 5.3 | 6.1 |
| 7/6 | 31 | 6.2 | 7.1 | 8.9 |
| 1/2 | 40 | 8.5 | 9.4 | 10.8 |
| 916 | 51 | 10.8 | 12.0 | 13.7 |
| 5/8 | 63 | 12.6 | 14.4 | 16.6 |
| $3 / 4$ | 90 | 18.0 | 20.6 | 23.7 |
| 7/8 | 123 | 24.3 | 28.0 | 32.2 |
| 1 | 160 | 31.6 | 36.5 | 42.0 |
| 11/8 | 203 | 39.8 | 46.0 | 53.0 |
| $11 / 4$ | 250 | 48.8 | 56.5 | 65.0 |
| 18/8 | 304 | 59.4 | 68.7 | 80.0 |
| 11/2 | 360 | 69.6 | 80.5 | 92.5 |
| 15/8 | 424 | 81.9 | 94.9 | 104.5 |
| 13/4 | 492 | 95.0 | 110.0 | 124.5 |
| 2 | 640 | 123.6 | 143.2 | 155.5 |
| 21/4 | 812 | 156.9 | 181.5 | 207.0 |
| 21/2 | 1,000 | 193.4 | 223.3 | 254.5 |
| 23/4 | 1,216 | 235.0 | 271.0 | 306.0 |

### 5.44 Wire Rope Safety Factors

| Type of service | Minimum safety factor | Type of service | Minimum safety factor Iact |
| :---: | :---: | :---: | :---: |
| Track cables | 3.2 | Haulage ropes . . . - | 6.0 |
| Guys.--- | 3.5 | Derricks | 6.0 |
| Miscellaneous hoisting equipment | 5.0 | Small electric and air hoists. $\qquad$ | 7.0 |

### 5.45 Properties of Chains

| $\begin{aligned} & \begin{array}{c} \text { Normal } \\ \text { gize } \\ \text { (diameter } \\ \text { of stock } \end{array} \\ & \text { in lnches) } \end{aligned}$ | $\begin{gathered} \text { Approxi- } \\ \text { mate } \\ \text { weight } \\ \text { per } 100 \mathrm{ft} \\ (\mathrm{lbs}) \end{gathered}$ | Safe working load* |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Common iron (pounds) | Highgrade iron (pounds) | $\begin{gathered} \text { Soft } \\ \text { steel } \\ \text { (pounds) } \end{gathered}$ | $\begin{gathered} \text { Special } \\ \text { steel } \\ \text { (pounds) } \end{gathered}$ |
| 1/4 | 73 |  | 1,530 | 1,800 | 2,620 |
| 516 | 110 |  | 2,160 | 2,540 | 3,700 |
| 8/8 | 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 |
| 18/8 | 2,120 | 34,600 | 38,100 | 46,300 | 67,600 |
| $11 / 2$ | 2,520 | 41,200 | 45,400 | 55,200 | 80,400 |
| $15 / 8$ | 2,940 | 48,000 | 52,900 | 64,300 | 93,600 |
| $13 / 4$ | 3,360 | 55,300 | 61,000 | 74,200 | 108,000 |
| 17/8 | 3,880 | 63,100 | 69,600 | 84,700 | 123,200 |
| 2 | 4,400 | 71,300 | 78,700 | 95, 800 | 139,400 |

* If the type of iron in a chain is unknown, a safe working load (in short tons) is figured by multiplying 8 by the square of the diameter (in inches) of the metal stock on one side of any link. This appliea only to chains made of ferrous metals.'


### 5.46 Safe Working Loads of Slings

$a$. 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 formulas:

$$
\begin{gathered}
\mathrm{T}=\frac{\mathrm{WL}}{\mathrm{NV}} \\
\text { or } \\
\mathrm{T}=\frac{\mathrm{W}}{\mathrm{~N} \times \text { sine } \mathrm{A}}
\end{gathered}
$$

where
$\mathrm{T}=$ 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)
$\mathrm{W}=$ weight lifted, in pounds
$\mathrm{L}=$ length of the leg, in inches
$\mathrm{N}=$ number of slings legs
$\mathrm{V}=$ vertical distance from the sling platform or sling bar to the hook, in inches
A = angle leg makes with the horizontal
b. 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, three-strand manila-rope sling with a splice in each end.)

| Size |  | Single sling | Double efling |  |  | Quadruple sling |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Circumference (inches) | Diameter (inchea) | $\underset{\text { (pounds) }}{\substack{\text { Vertleal lift } \\ \text { (poun }}}$ | $\begin{aligned} & 60^{\circ} \text { angle } \\ & \text { (pounds) } \end{aligned}$ | $\begin{aligned} & \mathbf{4 5}^{\circ} \text { angle } \\ & \text { (pounds) } \end{aligned}$ | $80^{\circ}$ angle (pounds) | $60^{\circ}$ angle (pounde) | $\begin{aligned} & 45^{\circ} \text { angle } \\ & \text { (pounds) } \end{aligned}$ | $80^{\circ}$ angle (pounds) |
| 8/4 | 1/4 | 108 | 187 | 153 | 108 | 374 | 306 | 216 |
| $11 / 8$ | 8/8 | 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 | $8 / 4$ | 970 | 1,680 | 1,375 | 970 | 3,360 | 2,750 | 1,940 |
| 28/4 | 1/8 | 1,382 | 2,395 | 1,945 | 1,382 | 4,790 | 3,890 | 2,764 |
| 2 | 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 |
| $38 / 4$ | 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 | 18/4 | 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.)

| Link atock diameter (lnchea) | Slngle elling | Double eling |  |  | Quadruple eling |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Vertleal lift (pounds) | $60^{\circ}$ angle (pounds) | $45^{\circ}$ angle (pounds) | $80^{\circ}$ angle (pounds) | $60^{\circ}$ angle (pounds) | $\begin{aligned} & 45^{\circ} \text { angle } \\ & \text { (pounds) } \end{aligned}$ | $\begin{aligned} & 40^{\circ} \text { andle } \\ & \text { (pounds) } \end{aligned}$ |
| 8/8 | 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 |
| 96 | 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 |
| $8 / 4$ | 9,160 | 15,850 | 12,950 | 9,160 | 31,700 | 25,900 | 18,320 |
| 1/8 | 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 |
| $18 / 8$ | 44,600 | 77,200 | 63,050 | 44,600 | 154,400 | 126,100 | 89,200 |
| 18/4 | 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 (Inchea) | Single aling | Double aling |  |  | Quadruple sling |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & \text { Vertical lift } \\ & \text { (pounds) } \end{aligned}$ | $\begin{aligned} & 60^{\circ} \text { angle } \\ & \text { (pounds) } \end{aligned}$ | $\begin{aligned} & \text { 45 angle } \\ & \text { (poundg) } \end{aligned}$ | $\begin{aligned} & \hline 30^{\circ} \text { angle } \\ & \text { (pounds) } \end{aligned}$ | $\begin{aligned} & 60^{\circ} \text { angle } \\ & \text { (pounds) } \end{aligned}$ | $\begin{aligned} & 45^{\circ} \text { angle } \\ & \text { (pounda) } \end{aligned}$ | $\begin{aligned} & 80^{\circ} \text { angle } \\ & \text { (pound } \end{aligned}$ |
| 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 |
| 8/8 | 2,460 | 4,260 | 3,485 | 2,460 | 8,520 | 6,970 | 4,920 |
| 7/6 | 3,560 | 6,170 | 5,040 | 3,560 | 12,340 | 10,080 | 7,120 |
| 1/2 | 4,320 | 7,475 | 6,105 | 4,320 | 14,950 | 12,210 | 8,640 |
| 916 | 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 |
| $8 / 4$ | 9,480 | 16,400 | 13,400 | 9,480 | 32,800 | 26,800 | 18,960 |
| 1/8 | 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 |
| $18 / 8$ | 32,000 | 55,400 | 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 |
| 18/4 | 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 |
| 28/4 | 122,500 | 212,000 | 173,500 | 122,500 | .424, 000 | 347, 000 | 245,000 |

### 5.47 Safe Loads on Hooks.

The data below are keyed to figure 5.27.

| Diameter of metal A (Inchea) | Inside diameter (inchea) | Width of opening C (inches) | Length of hook D (inchea) | Safe load on hook (pounds) |
| :---: | :---: | :---: | :---: | :---: |
| 11/66 | 7/8 | 11/16 | 415/6 | 1,200 |
| 8/4 | 1 | 11/8 | 513/2 | 1,400 |
| 7/8 | 11/8 | 11/4 | 61/4 | 2,400 |
| 1 | 11/4 | 18/8 | 67/8 | 3,400 |
| 11/8 | 18/8 | $11 / 2$ | 75/8 | 4,200 |
| 11/4 | $11 / 2$ | 111/6 | 819 | 5,000 |
| $13 / 8$ | $15 / 8$ | $17 / 8$ | 91/2 | 6,000 |
| $11 / 2$ | $18 / 4$ | 21/60 | 101162 | 8,000 |
| $18 / 8$ | 2 | 21/4 | 1127 $\mathbf{1 2}^{2}$ | 9,400 |
| 17/8 | 23/8 | $21 / 2$ | 13\% ${ }^{2}$ | 11,000 |
| 21/4 | 28/4 | 3 | 1413/6 | 13,600 |
| 25/8 | 31/8 | 38/8 | 161/2 | 17,000 |
| 3 | $31 / 2$ | 4 | 193/4 | 24,000 |

5.48 Minimum Groove Diameter of Sheaves and Drums

| $\begin{gathered} \text { Rope } \\ \text { dlameter } \\ \text { (inchea) } \end{gathered}$ | 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 |
| $8 / 8$ | 158/4 | 123/4 | 63/4 | 93/4 |
| 1/2 | 21 | 17 | 9 | 13 |
| 5/8 | 261/4 | $211 / 4$ | 111/4 | 161/4 |
| $8 / 4$ | 311/2 | 251/2 | 131/2 | 191/2 |
| 7/8 | 363/4 | 293/4 | 153/4 | 223/4 |


| Rope <br> diameter <br> (inches) | Minimum groove diameter in inches for given rope <br> constructions |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | $6 \times 7$ | $6 \times 19$ | $6 \times 37$ | $3 \times 19$ |
| 1 | 42 | 34 | 18 | 26 |
| $11 / 8$ | $471 / 4$ | $381 / 4$ | $201 / 4$ | $2911 / 4$ |
| $11 / 4$ | $521 / 2$ | $421 / 2$ | $221 / 2$ | $321 / 2$ |
| $11 / 2$ | 63 | 51 | 27 | 39 |

* Rope constructlon is in strands times wires per strand.


Figure 5.27. Cargo hook: critical dimensions

### 5.49 Blocks and Tackle

a. Blocks and tackle consist of sheaves (blocks) 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-, doubleand triple-sheave blocks are shown. Numbers on the illustration indicate the number of lines in the rigging.
(1) Block and tackle rigging for manila 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.

|  | Total number of sheaves in blocks |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2 aingle | 1 aingle, 1 double | 2 double | $1 \text { double, }$ | 2 triple | (in tons) |
| Rope | 1/2 | 7/66 | 8/8 | 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 | 5/6 | 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 | 2,220 | 1,780 | 1,480 |  |
| Rope | ----- | $11 / 2$ | 15/16 | 11/4 | $11 / 8$ | 6 |
| 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.

|  | Total number of sbeaves in blocks |  |  |  |  | Load to be lifted (in tons) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2 single | 1 single, <br> 1 double | 2 double | 1 double, 1 triple | 2 triple |  |
| Rope | 3/8 | 3/8 | $3 / 8$ | $3 / 8$ | $8 / 8$ | 1 |
| Pull | 1,100 | 740 | 560 | 445 | 370 |  |
| Rope | $1 / 2$ | $3 / 8$ | $3 / 8$ | $3 / 8$ | $8 / 8$ | 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 | 2,220 |  |
| 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.

| Wire rope |  | Manila rope |  |
| :---: | :---: | :---: | :---: |
| Rope diameter (incbes) | Outside diameter of abeave (incbes) | Rope diameter (inches) | Lengtb of block (inc bes) |
| 3/8 | 6 to 8 | 1/2 | 4 |
| 1/2 | 8 to 10 | 5/8 | 6 |
| 5/8 | 10 to 12 | $3 / 4$ | 6 to 7 |
| 3/4 | 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 (par. 5.42), 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.-

| Rope diam(in.) | 6 strands, each with 7 wires |  |  |  |  |  |  |  |  | 6 strands, each with 19 wires |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Sheave or drum diameter (ft) |  |  |  |  |  |  |  |  | Sheave or drum diameter (ft) |  |  |  |  |  |  |  |  |
|  | 1 | 2 | 3 | 4 | 6 | 8 | 10 | 15 | 20 | 1 | 2 | ${ }^{3}$ | 4 | 6 | 8 | 10 | 15 | 20 |
| $1 / 4$ |  |  |  |  |  |  |  |  |  | 6.4 | 3.4 | 2.3 | 1.9 | 1.1 |  |  |  |  |
| 92 |  | 4.5 | 3.0 | 2.2 | 1.5 | 1.1 | . 9 | . 6 |  |  |  |  |  |  |  |  |  |  |
| $5 / 16$ |  | 8.0 | 5.2 | 4.1 | 2.7 | 2.0 | 1.6 | . 9 |  | 8.9 | 4.5 | 3.2 | 2.4 | 1.6 |  |  |  |  |
| $3 / 3$ |  | 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 |  |  |
| 916 |  | 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 |  |  |
| 84 |  | 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 | 3.0 | 2.0 | 1.5 |
| 11/8 |  |  |  | 16.7 | 11.2 | 8.3 | 6.7 | 4.5 |  |  | 16.9 | 11.3 | 8.4 | 5.7 | 4.2 | 3.4 | 2.3 | 1.7 |
| 11/4 |  |  |  | 18.2 | 12.2 | 9.1 | 7.3 | 4.9 |  |  | 18.8 | 12.6 | 9.4 | 6.3 | 4.7 | 3.8 | 2.5 | 1.9 |
| 18/8 |  |  |  | 20.2 | 13.5 | 10.1 | 8.1 | 5.4 |  |  | 20.2 | 13.5 | 10.1 | 6.7 | 5.1 | 4.0 | 2.7 | 2.0 |
| $11 / 2$ |  |  |  | 23.1 | 15.4 | 11.6 | 9.2 | 6.2 |  |  |  | 15.3 | 11.5 | 7.7 | 5.8 | 4.6 | 3.1 | 2.3 |
| 15/8 |  |  |  |  |  |  |  |  |  |  |  | 17.0 | 12.8 | 8.5 | 6.4 | 5.1 | 3.4 | 2.6 |
| 18/4 |  |  |  |  |  |  |  |  |  |  |  | 17.9 | 13.4 | 8.9 | 6.7 | 5.4 | 3.6 | 2.7 |
| 2 |  |  |  |  |  |  |  |  |  |  |  |  | 16.0 | 10.7 | 8.0 | 6.4 | 4.3 | 3.2 |
| 21/4 |  |  |  |  |  |  | , |  |  |  |  |  | 17.1 | 11.4 | 8.6 | 6.9 | 4.6 | 3.4 |
| $21 / 2$ |  |  |  |  |  |  |  |  |  |  |  |  |  | 12.7 | 9.6 | 7.6 | 5.1 | 3.8 |
| 28/4 |  |  |  |  |  |  |  |  |  |  |  |  |  | 14.1 | 10.6 | 8.5 | 5.6 | 4.2 |

5.50 Cubic Capacities, Weights, and Dimensions of Various Grab Buckets (Clamshells)

| $\underset{(\mathrm{cu} \mathrm{yd})}{\text { Capacity }}$ | $\underset{(16)}{\text { Weight }}$ | Overall length of opened bucket (in.) | Overali length of closed bucket (in.) | Width of bucket (in.) |
| :---: | :---: | :---: | :---: | :---: |
|  |  | General-purpose bucket with ore bowl |  |  |
| 1/2 | 1,700 | 72 | 48 | 36 |
| $3 / 4$ | 2,700 | 85 | 60 | 40 |
| 1 | 3,200 | 99 | 67 | 40 |
| 11/4 | 3,400 | 99 | 67 | 47 |
| 11/2 | 4,400 | 108 | 74 | 50 |
| 15/8 | 4,600 | 108 | 74 | 54 |
| 2 | 5,500 | 108 | 76 | 62 |
| 21/2 | : . 7,400 | 120 | 84 | 63 |
| 3 | 8,000 | 120 | 84 | 74 |
| 4 | 12,000 | 141 | 104 | 74 |
|  |  | General-purpose bucket |  |  |
| 1/2 | $\cdots 1,500$ | 70 | 56 | 29 |
| 3/4 | 3,000 | 83 | . 71 | 37 |
| 1 | 3,500 | 90 | 76 | 41 |
| 11/4 | 3,900 | 94 | 80 | 44 |
| 11/2 | 5,175 | 102 | 87 | 46 |
| 13/4 | 5,300 | 108 | 92 | 46 |
| 2 | 5,800 | 101 | 87 | - 52 |
| 21/2 | - 7,300 | 106 | 91 | 58 |
| 3 | 9,000 | 111 | 97 | 64 |
|  |  | Electric single-rope grab bucket |  |  |
| 1/4 | 1,200 | 51 | 40 | 33 |
| $3 / 4$ | 2,600 | 65 | 49 | 46 |
| 1 | 4,600 | 76 | 56 | 48 |
| 11/4 | 4,700 | 88 | 61 | 51 |
| 11/2 | 4,900 | 88 | 61 | 59 |
| 2 | 9,000 | 105 | 73 | 67 |
| $21 / 2$ | 10,000 | 117 | 84 | 60 |
| 3 | 10,500 | 117 | 84 | 70 |


(1) SIMPLE TACKLE


Figure 5.28. Examples of simple and compound tackle.


Figure 5．29．Sample block and tackle rigging for manila and wire rope．

## 5．51 Data on Chain Hoists

|  | Differential holata |  |  |  |  | Worm－gear hoista |  |  |  |  | Spur－gear hoists＊ |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 2 | 8 | 4 | 6 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 18 | 14 | 15 | 16 |
|  | 気 |  |  |  |  | $\begin{aligned} & \Xi \\ & \text { E } \end{aligned}$ |  |  |  |  | 魚 |  |  | 篤 |  |
| 1／4 | 6 | 22 | 72 | 18 | 17 |  |  |  |  |  | 8 | 58 | 50 | 121／2 | 13 |
| 1／2 | 7 | 30 | 122 | 24 | 21 | 8 | 46 | 68 | 40 | 13 | 8 | 58 | 62 | 21 | 13 |
| 1 | 8 | 51 | 216 | 30 | 26 | 8 | 59 | 87 | 59 | 16 | 8 | 92 | 82 | 31 | 16 |
| 11／2 | 81／2 | 81 | 246 | 36 | 32 | 8 | 81 | 94 | 80 | 19 | 8 | 132 | 110 | 35 | 18 |
| 2 | 9 | 122 | 308 | 42 | 49 | 9 | 104 | 115 | 93 | 21 | 9 | 202 | 120 | 42 | 21 |
| 3 | 9112 | 180 | 557 | 38 | 44 | 10 | 187 | 132 | 126 | 25 | 10 | 209 | 114 | 69 | 32 |
| 4 |  |  |  |  |  | 10 | 221 | 142 | 155 | 29 | 10 | 299 | 124 | 84 | 37 |
| 5 |  |  |  |  |  | 12 | 331 | 145 | 195 | 31 | 12 | 411 | 110 | 126 | 45 |
| 6 |  |  |  |  |  | 12 | 310 | 145 | 252 | 33 | 12 | 411 | 130 | 126 | 46 |
| 8 |  |  |  |  |  | 12 | 416 | 160 | 310 | 36 | 12 | 500 | 135 | 168 | 49 |
| 10 |  |  |  |  |  | 12 | 578 | 160 | 390 | 45 | 12 | 610 | 140 | 210 | 54 |
| 12 |  |  |  |  |  |  |  |  |  |  | 12 | 855 | 260 | 252 | 54 |
| 16 |  |  |  |  |  |  |  |  |  |  | 12 | 1，041 | 270 | 336 | 62 |
| 20 |  |  |  |  |  |  |  |  |  |  | 12 | 1，350 | 280 | 420 | 70 |

＊Spur－gear hoists of 12－，16－，and 20－ton capacity have two operating chaing．The pull on chaina（column 14）and the amount of chain overhauled（column b）if the total for the two chains．

## Section V．TERMS

## 5．52 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 well－balanced general cargo vessel will have from 10 to 15 per－ cent 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．

### 5.53 Vessel

a. After Perpendicular. The vertical line through the intersection of the afterside of the sternpost with the load water plane.
b. Base Line. 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 base line 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. The vertical distance measured on the vessel's side amidships from the load waterline to the upper side of the freeboard deck or a point corresponding to it.
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 mem-
ber 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 travelled and the season of the year. The top of the line AB (line S ) in figure 5.30 indicates the summer loadline. For ease of observation, the circled line $A B$ is usually placed next to the Plimsoll mark on a vessel that habitually loads in the same kind of water.
n. Midships Section


The intersection of the ship's form with a transverse vertical plane midway between the forward and after perpendiculars.
o. Sagging. The opposite of hogging. A vessel is said to be sagging when the midships portion has a tendency to sink below the bow and the stern. Sagging is caused by excessive weight amidships and insufficient weight in the bow and stern.
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 Factor. The vessel 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 deck load) of 8,000 long tons.
(2) Solution:

Vessel 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.

### 5.54 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


Figure 5.30. Loadline or Plimsoll mark.
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, $2,240 \mathrm{lb}$ avoirdupois ( 1016.106 kg ), usually divided into 20 hundred-weight ( 112 lb ).
$k$. 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 knows 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 $2,000 \mathrm{lb}$ ( 907.2 Kg ).

### 5.55 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 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 (FOB). A mercantile expression used in sale contracts which denotes that the goods gave 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 denotes 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.
$l$. Space Charter. Agreement made between the chartering party and the owner of a vessel which provides that a specified number of cubic feet of shipping space is allocated by means of voyage commitment orders for use on specified voyages from and to designated ports.

## Section VI. MISCELLANEOUS

### 5.56 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- |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Boaton | New York | Charleston | New Orleans | Los Angeles | $\begin{aligned} & \text { San } \\ & \text { Francisco } \end{aligned}$ | Seattle |
| Caribbean and South America: |  |  |  |  |  |  |  |
| Argentina, Buenos Aires. | 5,800 | 5,900 | 5,800 | 6,300 | - 8,300 | - 8,700 | - 9,600 |
| Brazil, Rio de Janeiro. | 4,700 | 4,800 | 4,700 | 5,200 | - 7,200 | - 7,600 | - 8,400 |
| Chile, Valparaiso | - 4,800 | - 4,600 | - 4,200 | - 4,100 | 4,800 | 5,100 | 5,900 |
| Panama, Panama | 2,200 | 2,000 | 1,600 | 1,400 | 2,900 | 3,200 | 4,000 |
| Puerto Rico, San Juan | 1,500 | 1,400 | 1,100 | 1,500 | - 3,900 | - 4,300 | - 5,100 |
| Trinidad, Port of Spain | 2,000 | 1,900 | 1,700 | 2,100 | - 4,100 | - 4,400 | - 5,300 |
| Europe: |  |  |  |  |  |  |  |
| Belgium, Antwerp | 3,200 | 3,400 | 3,800 | 4,800 | - 7,700 | - 8,000 | - 8,800 |
| France: |  |  |  |  |  |  |  |
| Bordeaux | 3,000 | 3,200 | 3,700 | 4,700 | - 7,600 | - 7,900 | - 8,700 |
| Brest | 2,900 | 3,100 | 3,500 | 4,500 | - 7,400 | - 7,700 | - 8,500 |
| Le Havre | 3,000 | 3,200 | 3,600 | 4,600 | - 7,500 | - 7,800 | - 8,600 |
| Norway, Oslo - | 3,900 | 4,100 | 4,400 | 5,300 | - 8,200 | - 8,600 | - 9,400 |
| United Kingdom: |  |  |  |  |  |  |  |
| Belfast | 2,900 | 3,000 | 3,400 | 4,400 | - 7,200 | - 7,500 | - 8,300 |
| Liverpool. | 3,000 | 3,200 | 3,700 | 4,700 | - 7,600 | - 7,900 | - 8,700 |
| Southhampton | 3,000 | 3,200 | 3,600 | 4,600 | - 7,500 | - 7,800 | - 8,600 |
| Far East: |  |  |  |  |  |  |  |
| China, Shanghai. | -10,800 | -10,600 | -10,800 | -10,000 | 5,700 | 5,400 | 5,100 |
| Formosa, Keelung | -10,932 | -10,750 | ${ }^{10} 10,339$ | ${ }^{\text {a }} 10,176$ | 5,858 | 5,570 | 5,310 |
| Hong Kong. | -11,400 | -11,200 | -10,800 | -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 | ${ }^{\bullet} 10,365$ | - 9,954 | - 9,791 | 5,229 | 4,914 | 4,649 |
| India-Burma-Pakistan: |  |  |  |  |  |  |  |
| Burma, Rangoon | b 9,600 | b 9,800 | ${ }^{\text {b }} 10,200$ | ${ }^{\text {b }} 11,200$ | 9,000 | 8,600 | 8,200 |
|  |  |  |  |  | - b13,900 | - b14,200 | - b 15,000 |
| India: |  |  |  |  |  |  |  |
| Bombay | - 8,000 | ${ }^{\text {b }} 8 \mathbf{8 , 2 0 0}$ | b 8,600 | b 9,500 | - b 12,200 | - b12,600 | - b13,400 |
|  |  |  |  |  | 10,300 | 9,800 | 9,500 |
| Calcutta | - 9,600 | b 9,800 | ${ }^{\text {b }} 10,200$ | ${ }^{\text {b }} 11,200$ | - b 13,900 | - b14,200 | - b 15,000 |
|  |  |  |  |  | 9,500 | 9,000 | 8,700 |
| Pakistan, Karachi | - 7,800 | b 8,200 | - 8,400 | - 9,300 | 10,700 | 10,200 | 9,900 |
|  |  |  |  |  | s12,000 | -12,400 | -13,200 |
|  |  |  |  |  |  |  |  |
| Algeria, Algiers. | - 3,400 | b 3,600 | b 4,000 | b 5,000 | - b 7,700 | - b 8,000 | - b 8,800 |
| France, Marseilles | b 3,700 | b 3,900 | b 4,300 | b 5,300 | - b 8,000 | a b 8,200 | a b 9,000 |
| Greece, Piraeus. | b 4,500 | ${ }^{\text {b }} 4,700$ | b 5,100 | b 6,100 | - b 7,800 | a b 8,100 | a b 8,900 |
| Italy: |  |  |  |  |  |  |  |
| Leghorn | b 3,900 | b 4, 100 | b 4,500 | - 5,500 | a b 8,200 | - b 8,400 | - b 9,200 |
| Naples. | b 4,000 | b 4,200 | - 4,600 | b 5,600 | - b 8,300 | - b 8,500 | - b 9,300 |
| Lebanon, Tripoli | b 4,100 | b 4,300 | - 4,700 | - 5,700 | - b 8,400 | a b 8,600 | - b 9,400 |
| Strait of Gibraltar | 3,000 | 3,200 | 3,600 | 4,600 | - 7,300 | = 7,500 | - 8,300 |
|  |  |  |  |  |  |  |  |
| Aden. | ${ }^{\text {b }} 6,300$ | b 6,500 | b 6,900 | - 7,900 | -10,600 | -10,900 | 811,700 |
| Egypt, Port Said | b 4,900 | b 5,110 | b 5,500 | b 6,500 | - 9,200 | - 9,500 | 110,300 |
| Iraq, Basra | b 8,300 | b 8,500 | b 8,900 | - 9,800 | -12,600 | -12,900 | -13,700 |
| Turkey, Istanbul | b 4,800 | b 5,000 | b 5,400 | - 6,400 | - 9,100 | - 9,400 | 10,200 |

[^23]| Distance from- | Distance to - |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Boston | New York | Charleston | New Orleans | Los Angeles | $\xrightarrow[\text { Francisco }]{\text { San }}$ | Seattle |
| Middle Pacific: |  |  |  |  |  |  |  |
| Hawaii, Honolulu | - 6,900 | * 6,700 | a 6,300 | - 6,100 | 2,200 | 2,100 | 2,400 |
| Marianas Islands, Guam | ${ }^{1} 10,200$ | ${ }^{\text {a }} 10,000$ | - 9,600 | - 9,400 | 5,600 | 5,100 | 4,900 |
| Marshall Islands, Kwajalein. | - 9,200 | - 9,000 | - 8,600 | a 8,400 | 4,200 | 4,410 | 4,500 |
| North Atlantic: |  |  |  |  |  |  |  |
| Bermuda, Hamilton. | 700 | 700 | 800 | 1,700 | 2 4,600 | - 4,900 | a 5,800 |
| Greenland, Ivigtut. | 1,700 | 1,900 | 2,400 | 3,400 | - 6,500 | a 6,800 | - 7,600 |
| Iceland, Reykjavik | 2,300 | 2,500 | 3,000 | 4,000 | - 7,100 | - 7,400 | - 8,200 |
| Newfoundland, St. Johns. | 900 | 1,100 | 1,700 | 2,600 | - 5,700 | a 6,000 | - 6,800 |
|  |  |  |  |  |  |  |  |
| Alaska, Dutch Harbor | - 7,400 | - 7,300 | a 6,900 | -6,700 | 2,400 | 2,100 | 1,700 |
| Southwest Pacific: |  |  |  |  |  |  |  |
| Brisbane. | a 9,900 | - 9,600 | a 9,300 | - 9,100 | 6,300 | 6,200 | 6,500 |
| Melbourne | ${ }^{\text {a }} 10,100$ | - 9,900 | a 9,500 | - 9,400 | 7,000 | 7,000 | 7,300 |
| Indonesia, Djakarta | ${ }^{\text {b }} 10,200$ | ${ }^{\text {b }} 10,400$ | ${ }^{\text {b }} 10,800$ | -12,000 | 8,100 | 7,600 | 7,300 |
|  |  |  |  | ${ }^{\text {b }} 11,800$ |  |  |  |
| Malaya, Singapore | b 9,900 | ${ }^{\text {b }} 10,100$ | ${ }^{\text {b }} 10,500$ | ${ }^{\text {b }} 11,500$ | 7,900 | 7,500 | 7,100 |
| New Guinea, Finschafen | ${ }^{1} 10,200$ | -10,000 | a 9,600 | - 9,400 | 6,100 | 5,900 | 6,000 |
| Philippines, Manila | : 11,600 | -11,300 | -11,000 | :10,800 | 6,600 | 6,300 | 6,100 |
| Union of Soviet Socialist Republics: |  |  |  |  |  |  |  |
| Archangel... | 4,000 | 4,200 | 4,800 | 5,800 | - 8,800 | a 9,200 | -10,000 |
| Murmansk | 3,700 | 3,800 | 4,400 | 5,400 | - 8,500 | - 8,900 | 2 9,700 |
| Vladivostok | a 9,500 | - 9,300 | - 8,900 | a 8,700 | 5,000 | 4,600 | 4,400 |
| United States: |  |  |  |  |  |  |  |
| Boston. |  | 200 | 900 | 2,000 | a 5,100 | - 5,400 | - 6,200 |
| Charleston | 900 | 600 |  | 1,200 | - 4,500 | - 4,900 | - 5,600 |
| Los Angeles. | - 5,100 | - 4,900 | - 4,500 | - 4,300 |  | 400 | 1,100 |
| New Orleans. | 2,000 | 1,700 | 1,200 |  | - 4,300 | 2 4,700 | - 5,500 |
| New York- | 200 |  | 600 | 1,700 | 2 4,900 | - 5,300 | - 6,000 |
| San Francisco | - 5,400 | - 5,300 | 2 4,900 | - 4,700 | 400 |  | 800 |
| Seattle | a 6,200 | a. 6,000 | - 5,600 | 2 5,500 | 1,100 | 800 |  |

- Via Panama Canal.
b Strait of Gibraltar.


### 5.57 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 buoyage system used in United States waters 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. As all channels do not 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:
(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 mid-channel, 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 tlie 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 mid-channel, 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 of 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 ER-ER 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. Mid-channel 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. Mid-channel buoys have shortlong flashing lights-groups consisting of a short flash and a long flash repeated at the rate of about eight per minute.

### 5.58 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


Figure 5.31. Buoyage system used in United States waters.

## DAYTIME SIGNALS



Figure 5.38. Storm warning signals.
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.

### 5.59 Beaufort's Scale

| $\begin{gathered} \text { Beaufort } \\ \text { No. } \end{gathered}$ | Description of wind | Miles per hour (statuta) | 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 |

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, including reference to a standard plan or annex on rendezvous, location, and movements of commander and command posts, statement of command relationship reference to signal operating instructions, electronic policy, and liaison.
ACKNOWLEDGMENT 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
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. TASKS 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. Services.
(1) Organization. Service groups, trains, and depots; bivouacs and movement of unit trains; assignment or attachment of service units to subordinate units or commands.
(2) Technical services. Service 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, impregnation, and maintenance.
(b) Engineer. Construction, fire fighting, 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.
(f) Signal. Signal communication, construction, photography, and maintenance.
(g) Transportation. Procurement, supply, and maintenance, covering all modes.
(3) Labor. Policies pertaining to the use of civilian (U. S. and non-U. S.) and pris-oner-of-war personnel.
(4) Responsibilities.

## 5. MEDICAL: EVACUATION AND HOSPI-

 TALIZATION.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
Branch of aupply
T'upe 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
(1) Chemical
(2) Engineer
(3) Medical
(4) Ordnance
(5) Quartermaster
(6) Signal
(7) Transportation
(8) Miscellaneous
(1) General depot
(2) Branch depot
(3) Supply point
(4) Railhead
(5) Truckhead
(6) Miscellaneous
b. Transportation. Terminals and installations (rail stations, airfields, ports, and beaches), operating units, schedules (march tables, time tables,
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
(5) Rail
(2) Inland waterway
(6) Pipeline
(3) Coastal
(7) Air
(4) Motor
(8) Miscellaneous
c. Services.
(1) Organization. Service groups, trains, and depots; bivouacs and movement of unit trains; assignment or attachment of service units to subordinate units or commands.
(2) Technical services. Service installations, locations, operating units, and assignments to supported units, and special missions not covered in other orders.
(a) Chemical
(e) Quartermaster
(b) Engineer
(f) Signal
(c) Medical
(g) Transportation
(d) Ordnance
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; and 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, organization, 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; issu-
ance of proclamations, laws, ordinances, and notices.
(1) Law. Jurisdiction 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; authorized military use.
(10) Public communications. • Reestablish: ment, 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:
Annex (Transportation) to ADMINO
No.
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. - __, Hq 10th U. S. Army, dated $\qquad$
c. TALOG furnishes necessary rail and water terminal transportation service in support of 10th U. S. Army.
d. 5th U. S. Air Force furnishes necessary air transportation service in support of 10 th U.S. Army.

## 2. MISSION

Transportation elements will provide transportation service support for assigned and attached troops of 10th U. S. Army and transportation service support for Air Force units to base level.

## 3. EXECUTION

a. 48th Trans Gp (Trk), $\xlongequal[(\text { coordinates) }]{ } \text {, furnishes }$ highway transportation service as directed.
(1) 264th Trans Bn (Trk), $\frac{}{\text { (coordinates) }}$.
(2) 265th Trans Bn (Trk), $\overline{(\text { coordinates) }}$.
(3) 266th Trans Bn (Trk), $\overline{\text { (coordinate9) }}$.
(4) 267th Trans Bn (Trk), $\overline{\text { (coordinatea) }}$.
b. 54th Trans Gp (Trk), $\overline{\text { (coordinatea) }}$, furnishes highway transportation service as directed.
(1) 465th Trans Bn (Trk), $\overline{(\text { coordinatee) }}$.
(2) 467th Trans Bn (Trk), $\overline{\text { (coordinates) }}$.
(3) 468th Trans Bn (Trk), $\frac{}{(\text { (coordinatea) }}$
(4) 469th Trans Bn (Trk), $\xlongequal[\text { (coordinates) }]{ }$.
(5) 488th Trans Bn (Trk), $\xlongequal[\text { (coordinates) }]{ }$.
c. 429th Trans Gp (TAAM \& Sup), $\frac{}{(\text { coordinates) }}$, furnishes field maintenance and supply support for Army fixed-wing and rotary-wing aircraft as required.
(1) 233d Trans Bn (TAAM \& Sup, DS), (coordinates)
(2) 234th Trans Bn (TAAM \& Sup, DS), (coordinates)
(3) 235th Trans Bn (TAAM \& Sup, DS), (coordinatea)
(4) 322d Trans Bn (TAAM \& Sup, GS), $\xlongequal[\text { (coordinatea) }]{ }$; operates depot 631, Cl III-A items only, 5 -day level; operates depot 632, Cl IV-A items only, 10 -day level; supports all Army aircraft maintenance units.
d. 112th Trans Bn (Transport Acft), $\overline{(\text { (coordinates) }}$.
(1) Annex G (Army Aviation to OPORD No. 8, Hq 10th U. S. Army, dated $\qquad$
(2) Furnishes administrative support to Hq , 10th U. S. Army.
e. 113th Trans Bn (Transport Acft), $\overline{\text { (coordinates) }}$ : Annex G (Army Aviation) to OPORD No. 8, Hq 10th U. S. Army.
f. 433d Trans Bn (Trk), $\xlongequal[\text { (coordinates) }]{ }$, attached to 1st Corps effective $\qquad$
g. 263d Trans Bn (Trk), $\xlongequal[\text { (coordinates) }]{ }$, attached to 2d Corps effective $\qquad$
h. 463d Trans Bn (Trk), $\underbrace{}_{\text {(coordinates) }}$, attached to 3d Corps effective $\qquad$
i. 257th Trans Gp (Trans Movements), $\overline{\text { (coordinatea) }}$, regulates transportation movements within army area; operates TMO's and maintains liaison with appropriate technical services.
j. 230th Trans Co (Car), $\underset{\text { (coordinatee) }}{ }$, supports Hq, 10th U. S. Army.
k. 3460th, 3461st, and 3462d Trans Intelligence Teams (HA-Collection), $\xrightarrow[\text { (coordinates) }]{ }$, perform information collection missions for Transportation Section, Hq, 10th U. S. Army.
l. 2460th Trans Intelligence Team (HB-Research), $\xrightarrow[\text { (coordinates) }]{ }$, produces and reports transportation technical intelligence for Transportation Section, Hq, 10th U. S. Army; selects, processes, and expedites the flow of enemy transportation materiel.
m. Alternate command posts and dispersal areas will be selected and maintained. All transportation units will be prepared to relocate on order.
$n$. 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 Transportation Officer:
(coordinates) phone
c. Communications: Annex G, 10th U. S. Army SOP.
ACKNOWLEDGMENT INSTRUCTIONS

Commander (name and grade)


STANDING OPERATING PROCEDURE
(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. RECISIONS. Any publications superseded or recinded by the SOP, including fragmentary SOP's, 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) Depuity 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 transporta-tion-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 operations (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 taskforce commanders.
(4) Landing force embarkation and tonnage and the breakdown of equipment and supplies as indicated in tables to be submitted by task-force commanders.
(5) Arranging and coordinating through channels for training appropriate personnel in unit loading and embarkation.
(6) Movement to the embarkation areas and delivery of equipment and supplies to include 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 equip. ment and personnel to embarkation points or assembly areas.
(4) 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 net for coordination of transportation.
b. Methods of ground-to-air contact to provide coordination with airdrops and land transportation.
c. Cross-reference to communications-net diagram.

Commander (name and grade)
Annexes
Distribution
Authentication

### 6.6 Outline for Transportation Standing Operating Procedure for Units

STANDING OPERATING PROCEDURE


TABLE OF CONTENTS
Section I. GENERAL

1. APPLICATION. (Operations to which SOP applies.)
2. PURPOSE.
3. REFERENCES. (FM's, TM's, SOP's 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) Form 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. HANDLING 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 25-10).
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.
(1) Movement policy.
(2) Troop list.
(3) Transportation movements personnel.
b. Action by S2.
(1) Reconnaissance report.
(2) Security.
c. Action by S3.
(1) Determination of rolling stock required.
(2) Coordination of loading plan.
(3) Preparation of loading schedule and areas.
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.
27. AIR MOVEMENT.
a. Action by S1.
b. Action by S 2 .
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 S4.
(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.
b. Action by S2.
c. Action by S3.
(1) Determination of shipping required.
(2) Coordination of loading plan.
(3) Preparation of loading schedule and areas.
d. Action by S 4 .
(1) Initiation of transportation request.
(2) Provision for troop mess.
(3) Preparation of shipping documents.

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, bacteriological, 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, bacteriological, 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. TYPES USED.
37. COMMUNICATION BETWEEN UNITS.
a. Radio net.
b. Telephone system.
c. Teletypewriter system.
d. Responsibility for installation.
38. COMMUNICATION PROCEDURE.
a. Radiotelephone voice and radioteletype procedure.
b. Visual, sound, messenger procedure.
c. Communications security.
d. Citation of SOI and SSI of higher headquarters.
39. SIGNAL MAINTENANCE RESPONSIBILITY.
a: Commander.
b. Communications officer.
c. Users and operators.

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.

## Section VIII. SUPPLY AND MAINTENANCE

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 procedure.
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. Echelon 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

Adjutant (name and grade)
Annexes. (May include Wearing of the Uniform, Reports Formats, Destruction of Classified Documents, Duties of Staff Officers, Staff Section SOP's, 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: (SOP's, 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.

## ACKNOWLEDGMENT INSTRUCTIONS

By Command of Major General
8/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 $\qquad$

## Section II. INTELLIGENCE

### 6.8 Transportation Infelligence

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 55-8.

### 6.9 Transportation Infelligence Estimate

a. General. Transportation intelligence esti-
mates 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 transportation plans, intelligence estimates may be disseminated directly to the ultimate users-the 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

TRANSPORTATION 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 technical service 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 technical service 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 ( $k$ ). (a) Rail. Tabulate as shown.

Unit Location \begin{tabular}{c}
Strength <br>
Actual- <br>
Auth

 

Facilities <br>
Aciual <br>
Required

$\quad$ Equipment 

Capability <br>
Actuali-
\end{tabular}

(b) Motor.
(c) Inland waterway.
(d) Air.
(e) Water.
(f) Transportation movements.
(g) Staging areas.
(h) Transportation depots.
(i) Transportation technical intelligence units.
(j) Pipelines (even though not operated by transportation units.)
(k) 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 $2 c(5)$ 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 |
| :---: |
| capabilities |

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 (par. 1) 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.

$$
/ \mathrm{s} /
$$

Transportation Officer
(name and grade)
Annexes
Distribution

[^24]
### 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 $\qquad$
(Number)

Trangportation 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 lints 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. Slaging 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 $b$ 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.)
l. Coordinating instructions. I.
(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, Intellgence.
(4) Effective time and date.

## 4. ADMINISTRATION AND LOGISTICS.

a. Administration.
(1) Policies. Reference to paragraph $1 c$.
(2) Procedures. SOP's 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 SOP's 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.
(l) 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 CP's of major commands.
(2) Locations of transportation movements branches.
ACKNOWLEDGEMENT 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 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.

## Section I. CAPABILITIES OF TRANSPORTATION MEDIUMS

### 7.1 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 | $\underset{S T}{T o n s} \begin{aligned} & \text { per day } \\ & L T \end{aligned}$ |  | Adequate to maintain |
| :---: | :---: | :---: | :---: |
| Highway: ${ }^{1}$ |  |  |  |
| Gravel | 1,600 | 1,430 | 1 division |
| Medium condition. | 3,600 | 3,220 | 3 divisions |
| First-class | 10,000 | 8,900 | 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 |

### 7.2 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 temperate 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 dog most commonly

[^25]used in the arctic and subarctic is the Eskimo or husky. The German shepherd is usually 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 ${ }^{1}$ | Distance in hour ${ }^{2}$ <br> $\mathrm{K}_{\boldsymbol{m}} \quad \underset{\text { miles }}{ }$ |  |
| :---: | :---: | :---: | :---: |
| Flat | 50 | 9.6 | 6 |
| Hilly | 50 | 4.8 | 3 |
| Moun | 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 |  | Distance in hour |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Cargo pack | Messages or mail | Cargo pack |  | Messages or mail |  |
|  |  |  | Km | Mi | Km | Mi |
| Flat | 35 | 5 percent | 3.2 | 2 | 24 | 15 |
| Hilly | 30 | of dog's | 3.2 | 2 | 16 | 10 |
| Mountainous | 25 | weight | 1.6 | 1 | 8 | 5 |

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.

[^26](9) Average daily distance:
(a) Mountainous 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

Trailer, 2-horse van
Capacily (horses of mules)

Truck, $1 / 2$-ton, cargo 2
--------- 2
Truck, $21 / 2$-ton, cargo 4

Semitrailer, 6-ton, combination
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.

### 7.3 Human Bearers

For planning purposes, the following may be assumed:

* May be transported st altitudes up to 18,000 feet with no ill effects.


## a. Average Cargo Loads.

(1) Male bearer- 80 pounds.
(2) Female bearer- 30 to 35 pounds.
b. Personnel Loads. 8 to 12 bearers per liter 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.

$$
\mathrm{T}=\mathrm{t}+\mathrm{a}+\mathrm{d}
$$

where:

$$
\begin{aligned}
& \mathrm{T}=\text { total time required } \\
& \mathrm{t}= \text { time required to march a given } \\
& \text { map distance } \\
& \mathrm{a}= \text { total ascent in feet during march } \\
& 1,000 \\
& \mathrm{~d}= \frac{\text { total descent in feet during march }}{1,500}
\end{aligned}
$$

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 II. DIMENSIONS AND WEIGHT DATA

### 7.4 Transportation Unit Equipment

Listed below are some of the principal items of u nit equipment pertaining to one or more types of transportation units. This information, when applied to authorized quantities of the listed items,
aids planners and operators in the formulation of loading plans. When preparing the loading plan, this information should be used in conjunction with configuration data and equipment characteristics to be found elsewhere in the manual.

| Item (uncrated unless otherwise noted) | $\begin{gathered} \text { Length } \\ \text { (in.) } \end{gathered}$ | $\begin{aligned} & \text { Width } \\ & \text { (in.) } \end{aligned}$ | $\underset{\text { (in.) }}{\text { Height }}$ | $\mathrm{Cu} . \mathrm{ft}$. | $\underset{\text { (lb.) }}{\text { Weight }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| CHEMICAL: |  |  |  |  |  |
| Breathing apar, oxygen-generating- |  |  |  | 2.2 | 40 |
| Kit, chemical agent detector |  |  |  | 0.2 | 4 |
| Mask, protective, field - |  |  |  | 0.47 | 4.1 |
| Respirator, paint spray |  |  |  | 0.5 | 0.4 |
| Tool set, gas-mask rep---.--.---- |  |  |  | 0.1 | 4 |
| ENGINEER: |  |  |  |  |  |
| Adapters, piledriver lead, for crane shovel, 10T |  |  |  | 1.46 | 175 |
| Backhoe for crane shovel, 10T |  |  |  | 417 | 6,400 |
| Book set, celestial navigation------ |  |  |  | . 72 | 29 |
| Boom for crane shovel, 10T, 35-ft- | 420 |  |  | 319 | 2,450 |
| Breaker, paving, pneu, 80 psi, $11 / 4 \times 6$ in. chuck. |  |  |  | 3.17 | 112 |


| Item (uncrated unless otherwise noted) | $\underset{\text { (in.) }}{\text { Length }}$ | Width (in.) | $\underset{\text { (in.) }}{\text { Height }}$ | $\mathrm{Cu} . \mathrm{ft}$. | $\begin{gathered} \text { Weight } \\ \text { (lb.) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| ENGINEER-Continued |  |  |  |  |  |
| Bucket, clamshell, $8 / 4$ cu yd |  |  |  | 585 | 4,850 |
| Bucket, dragline, $8 / 4 \mathrm{cu} y \mathrm{yd}$ |  |  |  | 210 | 6,125 |
| Carpenter set No. 1 engr sqd. |  |  |  | 17 | 330 |
| Carpenter equip set No. 3 engr plat |  |  |  | 8 | 230 |
| Carpenter equip set No. 2 engr---- | 38 | 24 | 11 | 5.8 | 132 |
| Compressor, air, gas, 105 cfm , skidmtd $\qquad$ | 120 | 90 | 74 | 463 | 6,605 |
| Compressor, air, set No. 1, 55 cfm, airborne $\qquad$ | 60 | 48 | 39 | 65 | 1,358 |
| Compressor, air, tlr-mtd, 315 cfm-- | 180 | 84 | 84 | 735 | 12,000 |
| Compressor, tlr-mtd, 500 cfm , diesel | 184 | 85 | 98 | 940 | 14,400 |
| Crane, revolving, tractor-mtd, $7,500-\mathrm{lb}, 35-\mathrm{ft}$ boom |  |  |  | 1,395 | 9,785 |
| Crane, shovel, crawler, 10T, gasoline, $8 / 4$ cu yd. | 137 | 116 |  | 1,760 | 44,000 |
| Crane, shovel, trk-mtd, 20T, 8/4 cu yd, gasoline | 387 | 108 | 138 | 3,350 | 54,000 |
| Crane, shovel, crawler, 40T, 2 cu yd, diesel | 196 | 147 |  | 3,619 | 85,000 |
| Crane, tractor, wheeled, $40,000-\mathrm{lb}$, 20 -ft boom. |  |  |  | 3,045 | 48,000 |
| Diving equip, 2 persons, $200-\mathrm{ft}$ depth. |  |  |  | 234 | 8,219 |
| Diving equip, 2 persons, $100-\mathrm{ft}$ depth | 48 | 30 | 36 | 29 | 711 |
| Drafting set, GP |  |  |  | 13 | 225 |
| Drill, pneu, ptbl, rock, 55 psi, $1 \times$ 41/4-in. hex chuck |  |  |  | 2 | 42 |
| Drill, pneu, ptbl, rotary, steel, No. 3 Morse taper, $11 / 4 \mathrm{in}$. cap-- |  |  |  | 3.75 | 115 |
| Drill, ptbl, rotary steel, No. 3 Morse taper, $11 / 4-\mathrm{in}$. cap. |  |  |  |  | 28 |
| Extinguisher, fire, $\mathrm{CO}_{2}, 15-\mathrm{lb}$ cap.- |  |  |  | 2.8 | 71 |
| Extinguisher, fire, $\mathrm{CO}_{\mathbf{2}}$, wheeled, 50-lb cap |  |  |  | 27 | 385 |
| Fire and salvage equip set, marine |  |  |  | 2,630 | 45,000 |
| Floodlighting set No. 2, ptbl...-.- |  |  |  | 126 | 1,900 |
| Generator, gas, skid-mtd, 1.5-kw .- |  |  |  |  | 114 |
| Generator, ptbl, gas, skid-mtd, 5-kw- |  |  |  |  | 1,300 |
| Generator, ptbl, skid-mtd, diesel, 15-kw $\qquad$ | 84 | 30 | 54 | 73 | 3,455 |
| Generator, ptbl, skid-mtd, diesel, 30-kw $\qquad$ | 108 | 36 | 69 | 156 | 5,000 |
| Grinder, ptbl, rotary, $8 \times 1$-in. wheel | 15 | 12 | 15 | 1.5 | 90 |
| Hoist, chain, 3T |  |  |  | 1.09 | 48.5 |
| Lamp, elec, ptbl, CP, set No. 1-..- | 31 | 20 | 16 | 5.8 | 180 |
| Light set, gen illum, 25 -outlet $\ldots$.-. |  |  |  | 53.1 | 880 |
| Light set, gen illum, $15-\mathrm{kw}$ - |  |  |  | 240 | 5,950 |
| Lubricator, mtd on M105E3 tlr...- | 147 | 69 | 69 | 405 | 3,150 |
| Metalizing set------------------- |  |  |  | 23 | 650 |
| Pioneer equip set, engr plat------- |  |  |  | 221 | 2,705 |
| Pioneer equip set, engr sqd.-...-.-- |  |  |  | 26 | 752 |
| Power control unit, cable, 1 drum, front mounting, 12,000 -17,000-lb DBP |  |  |  | 23.4 | 1,430 |

[^27]| Item (uncrated unless otherwise noted) | $\begin{gathered} \text { Length } \\ \text { (in.) } \end{gathered}$ | Width <br> (in.) | $\underset{\text { (in.) }}{\substack{\text { Height }}}$ | Cu. ft. | Weight <br> (lb.) |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |
| Pump, centrifugal, gas, 55 gpm , $50-\mathrm{ft}$ head |  |  |  | 14.2 | 250 |
| Pump, centrifugal, gas, 2-in. disk, 2 -in. suction, $166 \mathrm{gpm}, 80-\mathrm{ft}$ total dynamic head |  |  |  | 32.7 | 685 |
| Pump, centrifugal, tlr-mtd, 500 gpm, 20 -ft total dynamic head |  |  |  | 151.6 | 1,980 |
| Pump, centrifugal, gas, base-mtd, $500 \mathrm{gpm}, 90-\mathrm{ft}$ total dynamic head |  |  |  | 173.4 | 2,510 |
| Pump, centrifugal, gas tlr-mtd, $1,000 \mathrm{gpm}, 80-\mathrm{ft}$ total dynamic head |  |  |  | 556 | 8,335 |
| Pump, sump, 175 gpm at $25-\mathrm{ft}$ head, $21 / 2$-in. discharge. |  |  |  | 3 | 190 |
| Reproduction set, black and white process. |  |  |  | 10 | 230 |
| Reproduction set, gelatin process.-- |  |  |  | 3.4 | 104 |
| Saw, circular, wood, ptbl, 10-in.--- | 13 | 9 | 11 | . 75 | 11 |
| Semitrailer, low-bed, 20T, front loading. $\qquad$ | 435 | 115 | 76 | 2,145 | 23,900 |
| Sheet metal handset No. 1........- |  |  |  | 65 | 2,600 |
| Shop equip, base maint elec rep |  |  |  | 224 | 5,720 |
| Shop equip, mach shop, base maint. |  |  |  | 3,590 | 75,000 |
| Shop equip, GP rep, stir-mtḋ----- |  |  |  | 1,910 | 22,700 |
| Shop equip, org rep, lt-trk-mtd...- | 318 | 94 | 129 | 2,230 | 22,120 |
| Shop equip, set No. 8 welding |  |  |  | 320 | 6,250 |
| Shovel, front, for crane, crawler, 10 T |  |  |  | 433 | 6,700 |
| Sign painting set. |  |  |  | 9 | 268 |
| Supplementary equip, hv shop co.- |  |  |  | 545 | 47,100 |
| Supplementary equip, maint co.- |  |  |  | 523 | 17,650 |
| Surveying set, GP |  |  |  | 28 | 474 |
| Tool kit, blacksmith, gen .-. |  |  |  | 29 | 1,160 |
| Tool kit, diesel injector rep, fld maint |  |  |  | 2.6 | 62 |
| Tool kit, mason and concrete finishers |  |  |  | 7.6 | 103 |
| Tool kit, pipefitters, gen--..------ |  |  |  | 7 | 200 |
| Tool kit, pipefitters, supplemental.- |  |  |  | 9 | 45 |
| Tool kit, precision inst rep..------ |  |  |  | 11 | 308 |
| Tool kit, rigging, wire------------ | 34 | 16 | 10 | 3.5 | 167 |
| Tool kit, sheet metal workers, hand. |  |  |  | 7 | 176 |
| Tool set No. 6, engr machinist's --- | 20 | 8 | 11 | 1 | 20 |
| Torch outfit, cutting and underwater welding | 48 | 36 | 57 | 57 | 1,120 |
| Torch outfit, cutting and welding -- |  |  |  | 50 | 1,300 |
| Tractor, whl, gas, 3,725 to 5,175-lb DBP $\qquad$ | 116 | 58 | 73 | 261 | 3,282 |
| Tractor, crawler, diesel, 12,000 - to 17,000-lb DBP, w/bulldozer | 190 | 95 | 73 | 764 | 22,800 |
| Tractor, tracked, diesel, w/angle dozer 17,000- to $24,000-\mathrm{lb}$ DBP | 219 | 98 | 80 | 995 | 35,600 |
| Tractor, tracked, diesel, w/bulldozer, 24,100- to $32,000-\mathrm{lb}$ DBP | 240 | 104 | 90 | 1,300 | 40,000 |
| Trailer, 4W, tandem, 10T, flatbed | 50-330 | 93 | 48 | 1,188 | 7,200 |



[^28]


See footnotes at end of table.


| Item (uncrated unless otherwise noted) | $\begin{aligned} & \text { Length } \\ & (\text { in. } \end{aligned}$ | $\begin{gathered} \text { Width } \\ \text { (in.) } \end{gathered}$ | $\underset{\text { (in.) }}{\text { Height }}$ | Cu. ft. | Weight (lb.) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| TRANSPORTATION-Continued |  |  |  |  |  |
| Drier, sand, external grating, 7T to 10 T |  | 52 (dia) | 56 | 87.6 | 1,137 |
| Fender, marine, rubber-filled.----- | 24 | 7 (dia) |  |  |  |
| Forge, blacksmith, ptbl, w/blower, $401 / 2 \times 37 \times 3 \mathrm{in}$. |  |  |  | 130 | 200 |
| Forge, blacksmith, ptbl, 220V, 42 $\times 38 \times 7 \mathrm{in}$. |  |  |  | 130 | 200 |
| Forge, riveting, ptbl, $10 \times 10 \times 5$ in. w/burner, oil-fired |  |  |  | 3.75 | 216 |
| Former, slip-roll, bench, hand, 2in., dia rolls, $36-\mathrm{in}$. cap., 22 gage_ |  |  |  | 33.7 | 480 |
| Grinder, bench, 2 -spindle, $220 \mathrm{~V}, 3$ to 4 in . dia | 15 | 12 | 15 | 1.6 | 90 |
| Grinder, bench, tool and cutter, $220 \mathrm{~V}, 12$-in. dia work | 18 | 16 | 25 | 4.17 | 64 |
| Helicopters (See ch 2) |  |  |  |  |  |
| Landing craft, diesel, steel, Mark VIII, LCM (8), $70-\mathrm{ft}$ <br> (8), $70-\mathrm{ft}$--------- | 884 | 252 | 164 | 21,090 | 134,400 |
| Landing craft, diesel, steel, $115-\mathrm{ft}$-- | 1,380 | 408 | 261 | 85,043 | 403,200 |
| Lathe, eng, hv dy, $201 / 2$-in. swing, 48-in. centers, 16 -spd. . |  |  |  | 453 | 13,730 |
| Lighter, amphibious, 5T (LARC-5)_ | 420 | 120 | 122 | 3,570 | 9,000 |
| Lighter, amphibious, 60T (BARC) - | 751 | 319 | 233 | 32,542 | 199,000 |
| Locomotive, diesel-elec, $36-, 393 / 8$-, 42-in., 48T, 0-4-4-0 road switcher. | 420 | 102 | 136 | 3,380 | 116,000 |
| Locomotive, diesel-elec, $561 / 2-, 60$-, $63-$ - $66-\mathrm{in}$., 60T, $0-4-4-0$ road switcher $\qquad$ | 420 | 102 | 136 | 3,380 | 116,000 |
| Locomotive, diesel-elec, $361 / 2^{-}$ $393 / 8$-, 42 -in., $80 \mathrm{~T}, 0-6-6-0$ road switcher. $\qquad$ | 504 | 108 | 131 | 4,130 | 144,000 |
| Locomotive, diesel-elec, $561 / 2-, 60$-, $63-$, $66-\mathrm{in}$., 120T, $0-6-6-0 \mathrm{road}$ switcher $\qquad$ | 642 | 116 | 163 | 3,380 | 232,400. |
| Locomotive, steam, 36 -, 393/8-, 42in., 60T, 2-8-2 tender | $\begin{aligned} & 429 \\ & 285 \end{aligned}$ | 103 103 | 136 136 | 3,465 2,285 | 104,000 41,600 |
| Propelling unit, diesel, outboard, 165 hp . |  |  |  |  | 39,300 |
| Pump, reciprocating, 12.5 gpm , $2-\mathrm{in}$. suction, steam, $3 / 4-\mathrm{in}$. discharge ${ }^{k}$ $\qquad$ |  |  |  | 8 | 300 |
| Railway car, push, multigage, 6T, 4W |  |  |  |  | 630 |
| Railway motor car, multigage, 8man, 4W |  |  |  |  | 2,600 |
| Railway car, 36-, $393 / 8$-, 42-in. |  |  |  |  |  |
| Ambulance, kitchen-diner-storage. | 735 | 100 | 134 | 5,650 | 91,000 |
| Ambulance, pers | 735 | 100 | 134 | 5,650 | 90,000 |
| Ambulance, ward.-.---------- | 735 | 100 | 134 | 5,650 | 92,000 |
| Railway car, $561 / 2$-, 60 -, $63-, 66$-in. <br> Flat, depressed center, 80T. | 492 | 116 | 40 105 | 1,334 3,640 | $76,000$ <br> 35,400 |
| Gondola, high-side, 40T <br> Shaper, metal work, floor, $20-\mathrm{in}$., std dy | 531 | 114 | 105 | 3,640 190 | 35,400 5,100 |

[^29]| Item (uncrated unless otherwise noted) | $\underset{\text { (in.) }}{\substack{\text { Length }}}$ | Width (in.) | $\underset{\text { (in.) }}{\text { Height }}$ | Cu. ft . | Weight <br> (b.) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| TRANSPORTATION-Continued |  |  |  |  |  |
| Shear, sheet metal, $52-\times 18$-in., 16 gage $\qquad$ |  |  |  |  | 1,995 |
| Sheet metal mach, cap. 18-gage iron $\qquad$ |  |  |  | 33.7 | 480 |
| Tool set, boiler and smith shop co.. |  |  |  | 432 | 18,238 |
| Tool set, car repair co. |  |  |  | 169 | 9,663 |
| Tool set, diesel-elec plat. |  |  |  | 34 | 3,117 |
| Tool set, erecting and mach shop- |  |  |  | 536 | 22,105 |
| Tool set, railway maint of way, No. 4 |  |  |  | 334 | 10,283 |
| Tool set, railway maint of equip, No. 5 |  |  |  | 1,525 | 41,645 |
| Tug, harbor, diesel, steel, 240 hp , $45-\mathrm{ft}$, Des 320 | 543 | 150 | -180 | 8,475 | 56,000 |
| Tug, harbor, diesel, steel, 600 hp , $65-\mathrm{ft}$ | 852 | 246 | 357 | 30,054 | 224,000 |
| Tug, harbor, diesel, steel, $1,200 \mathrm{hp}$, 100 ft | 1,284 | 318 | n444 | 104,914 | P660,800 |

- Weight will vary slightly with different makes and models.
b Folded.
- Less explosives.
d 10-ton may be issued.
- Data are for one section.

Without forks.
a Add 30 percent for crating.
${ }^{5}$ Less components.
Less wire.

1. Without diesel engine.

1 In place on 11-gpm.
${ }^{m}$ Towed overseas after special preparation.
a Minimum height with top hamper removed.

- Hull only.
- Capable of moving over seas under own power.


### 7.5 Packaged Missiles and Other Special Ammunition

| Weapon | Container and contents | Container dimensions (in.) |  |  | $\underset{(\mathrm{cuft})}{\text { Cube }}$ | Gross (Ib) | Remsrks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Length | Width | Height |  |  |  |
| Hawk | Complete round. | 216 | 28 | 42 |  | 3,270 |  |
|  | Guidance section | 90 | 29 | 34 |  | 715 | Date applicable only when guidance section is shipped separately. |
| Nike-Ajax | Warhead, M-2 | 151/4 | 71/8 | 10132 | 35.4 | 35.4 | Wood crate (2 per crate) |
|  | Warhead, M-3 | 28 | 14 | 17 | 3.85 | 212 | Wood crate |
|  | Warhead, M-4--------- | 26 | 12 | 16 | 2.9 | 153 | Wood crate |
|  | Missile body section, M-2 | 2651/2 | 385/32 | 41 | 250 | 2,495 | Reusable steel container |
|  | Fin JATO, M-12...----- | 421/4 | 4011/16 | 1211/16 | 12.6 | 166 | Wood crate (3 per crate) |
|  | Fin control and stabilizer- | $761 / 4$ | $221 / 8$ | 27 | 26.5 | 220 | Wood crate ( 4 M-9 fins and $4 \mathrm{M}-10$ fins per crate). |
|  | Rocket motor, M-5..---- | 1751/4 | 243/4. | 261/2 | 66.5 | 1,883 | Wood crate |
|  | Igniter, rocket motor, M-24. | 251/8 | 157/8 | 17112 | 4.3 | 191 |  |
|  |  |  |  |  |  |  | ( 18 cans in a wood crate). |
|  | Propellant mixture, M-3 . | 205/8 | 205/8 | $111 / 2$ | 2.8 | 63.3 | Aluminum drum |


| Weapon | Container and contents | Container dimensions (in.) |  |  | $\begin{gathered} \text { Cube } \\ \text { (cuft) } \end{gathered}$ | Grossweight (1b) | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Length | Width | Height |  |  |  |
|  | Starting mixture.-.-.--- | 11 5/8 | 101/8 | 121/8 | 82 | 18 | Wood crate (4 bottles plus 1 filling assembly per crate). |
|  | Nitric acid- | $213 / 4$ | 213/4 | 28 | 7.67 | 380 | Reusablealuminum drum |
|  | bly M-45. | 243/16 | 1415/66 | $83 / 2$ | 1.7 | 36.5 | Wood crate ( 1 assembly per sealed can-10 cans per crate). |
| Nike-Hercules.--- | Warhead assembly, HE - | 100 | 54 | 62 | 193.5 | 3,170 | Reusable metal container |
|  | Missile body section.--.- | 224 | 55 | 62 | 435.5 | 4,606 | Reusable metal container |
|  | Rocket motor, XM-30..- | 106 | 44 | 48 | 124.8 | 3,844 | Wood crate |
|  | Rocket motor, XM-42E2_ | 180 | 43 | 54 | 243 | 6,520 | Special reusable wood container. |
|  | Rocket motor, M5E1.-.- | 177 | 251/4 | 54 | 81.5 | 1,883 | Wood crate |
|  | Rocket motor, XM-42 (fin assembly) | $\begin{array}{r} 52 \\ 148 \end{array}$ |  | $\begin{aligned} & 52 \\ & 42 \end{aligned}$ | $\begin{array}{r} 46.9 \\ 104.3 \end{array}$ | $\begin{array}{r} 600 \\ 1,050 \end{array}$ | Wood crate <br> Wood crate (4 main fins, 4 center fins, and 4 elevons per crate). |
|  | Fin assembly ---------- |  | $29$ | $42$ |  |  |  |
|  | Booster thrust structure ${ }_{\text {- }}$ | 148 383 | 383/4 | $461 / 4$ | 40.1 | 395 | Wood crate |
|  | Safety and arming device, M30A1 | 16 | 10 | 8 | . 66 | $\begin{array}{r} 25 \\ 65 \\ 280 \end{array}$ | Wood crate <br> Wood crate <br> Pressurized cylindrical container. |
|  | Battery, BB401/V.------ | 20 | 13 | 11 | 1.54 |  |  |
|  | Ethylene oxide.--------- | 151/2 | 151/2 | 491/2 | 6.82 |  |  |
| Little John _ | Warhead section, XM50 <br> Warhead, practice, 318mm, XM8 $\qquad$ <br> Rocket motor, 318 mm , XM26E1 $\qquad$ | 100 | 2888/100 | 34 ${ }^{38} / 100$ | 50 | 962 | Reusable metal container |
|  |  | 100 | 2888/100 | 3488/100 | 50 | 962 | Reusable metal container |
|  |  | 126 | 38 | 38 | 105.5 | 1,392 | Reusable metal container |
| Lacrosse..-.-.-.- | Warhead, HE T34E2 <br> Body assembly $\qquad$ <br> Rocket motor, XM10E1_- <br> Computer, missile guidance. $\qquad$ | $\begin{gathered} 96 \\ 182 \\ \\ 117 \\ \\ 241 / 2 \end{gathered}$ | $36$ | 39 | $\begin{gathered} 78 \\ 194.3 \end{gathered}$ | $\begin{aligned} & 1,200 \\ & 3,497 \end{aligned}$ | Reusable metal container XM4E2 reusable metal container. |
|  |  |  | $41$ | $45$ |  |  |  |
|  |  |  | 26 | 293/4 | 52.4 | 1,232 | Reusable wood container |
|  |  |  | 173/4 | $131 / 2$ | 3.25 | 70 | Wood crate |
| Sergeant------- | Warhead and forebody --- | 164 | 49 | 51 | 234 | 2,430 | XM421 reusable aluminum container. |
|  | Rocket motor---------.- | 224 | 48 | 51 | 319 | 8,000 | XM419 reusable aluminum container. |
|  | Guidance section-.......- | 125 | 49 | 51 | 177 | 2,100 | Reusable aluminum con-tainer.- <br> Reusable aluminum container. |
|  | Fin assembly. .-.-- - . .-. | 56 | 12 | 36 | 13.7 | 120 |  |
| Honest John -.-.- | Warhead assembly, 762mm rocket, M1A2, with flash smoke, XM4E3, XM4E4 | 146 | 46 | 53 | 205 | 3,410 | Wood crate |
|  | Warhead assembly, 762mm rocket with flash smoke, XM38........- | 146 | 46 | 53 | 197 | 3,099 | Wood crate |
|  | Rocket motor, XM50 <br> Rocket motor, M3A2 | 235 | 38 | 47 | 242.8 | 5,590 | Wood crate |
|  |  | 240 | 39 | 49 | 264 | 6,538 | Wood crate |



| Weapon | Contsiner snd contents | Contsiner dimensions (in.) |  |  | $\begin{gathered} \text { Cube } \\ (\mathrm{cu}(\mathrm{t}) \end{gathered}$ | $\begin{gathered} \text { Gross } \\ \text { weight } \\ \text { (Ib) } \end{gathered}$ | Remarks |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Length | Width | Height |  |  |  |
| Davy Crockett-.- | Complete round. | $373 / 4$ | 16 | 16 | 5.6 |  | Wood box (weight is classified). |
| 8-in. Howitzer---- | Shell | 50 | 12 | 12 | 4.2 | 163 |  |
|  | Charge, propellant-...-.- | 30 | 10 | 10 | 1.7 | 53 |  |
|  | Accessories parts can...-- | 12 | 12 | 15 | 1.25 | 33 |  |
|  | Spare accessories.------ | 12 | 12 | 15 | 1.25 | 30 |  |
|  | Restructor. | 34 | 101/2 | $111 / 2$ | 2.37 | 57 |  |
|  | Carrying case, M102 | 25 | 16 | 16 | 3.7 | 135 |  |
|  | Carrying case, M102.-..- | 25 | 16 | 16 | 3.7 | 230 |  |
| 280-mm gun..-.- | Shell.----------------- | 75 | 21 | 24 | 21.8 | 770 |  |
|  | Charge, propellant.-.-.-- | 84 | 13 | 13 | 8.2 | 221 |  |
|  | Spare accessories can.-.-- | 32 | 9 | 9 | 1.5 | 56 |  |
|  | Carrying can, M102...-. | 25 | 16 | 16 | 3.7 | 230 |  |
|  | Carrying can, M102....- | 25 | 16 | 16 | 3.7 | 135 |  |
|  | Carrying can, M103..--- | 25 | 16 | 16 | 3.7 | 160 |  |
| UFD/ADM*--- | FDAC | 37 | 24 | 24 | 12.3 | 100 |  |
|  | Munition warhead. | 60 | 40 | 40 | 55.5 | 1,500 |  |
|  | Accessories can. | 24 | 24 | 32 | 10.66 | 100 |  |
| TADM* | Munition warhead | 69 | 25 | 34 | 33.8 | 825 |  |
|  | Misc container | 24 | 24 | 27 | 8.98 | 150 |  |
| Project A ADM* | Munition warhead.------ | 93 | 37 | 45 | 89.5 | 1,540 |  |
|  | DFD, T46E2-.-------- | 53 | 30 | 30 | 27.6 | 500 |  |
|  | Power supply, MK 2....- | 25 | 23 | 23 | 7.65 | 118 |  |
|  | Accessories can-.------- | 12 | 12 | 15 | 1.25 | 22 |  |
|  | Testers.- | 25 | 25 | 23 | 8.32 | 50 |  |
|  | Spares can------------ | 12 | 12 | 19 | 1.58 | 37 |  |
|  | Carrying case, M102---- | 25 | 16 | 16 | 3.7 | 130 |  |
|  | Wire.. | 50 | 24 | 26 | 18.0 | 520 |  |
| T4 ADM**----- | Tube assembly --------- | 26 | 9 | 9 | 1.22 | 41 |  |
|  | Base assembly - -------- | 11 | 11 | 11 | . 77 | 60 |  |
|  | Tools------------------ | 20 | 12 | 10 | 1.39 | 35 |  |
|  | Squab cans------------ | 7 | 7 | 5 | . 14 | 10 |  |
|  | Igniter container-------- | 5 | 4 | 2 | . 023 | 1 |  |
|  | Carrying case, M102.---- | 25 | 16 | 16 | 3.7 | 135 |  |
|  | Carrying case, M102.--- | 25 | 16 | 16 | 3.7 | 230 |  |
|  | Fuze.- | 12 | 11 | 10 | . 76 | 20 |  |

* ADM refers to atomic demolition munitions.


### 7.6 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 are not normally 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.)

| Cspacity <br> (lb) | $\begin{aligned} & \text { Lift height } \\ & (\text { in. }) \end{aligned}$ | Free lift (in.) | $\underset{\text { (in.) }}{\substack{\text { Fork length }}}$ | Load center (in. Irom 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 <br> (Ib) | Lift <br> (in.) | Fork length <br> (in.) | Gradeability <br> (percent) | Turning radius <br> (f) | Lift tilt (degrees) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 6,000 | -144 | 48 | 45 | 15 | 45 | Forward | Back |
| 10,000 | 144 | 60 | 45 | 17 | 45 | Left-right |  |

c. Warehouse Tractors. (Gasoline power, pneumatic tires.)

| Drawbar pull (lb) | Towing capacity (ton) | Loaded speed (mph) | Weight (lb) | Dimensions (in.) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | 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 (lb) | Sluing range | Loaded speed (mph) | Weight (lb) | Dimensions (in.) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Height | Length | Width |
| 10,000 | $180^{\circ}$ | 15 | 20,800 | 95 | 295 | 94 |
| 10,000 | $180^{\circ}$ | 12 | 20,000 | 260 | 273 | 96 |

e. Warehouse Trailers.

| Capacity <br> (lb) | Tires | Construction | $\begin{aligned} & \text { Length } \\ & \text { (in.) } \end{aligned}$ | Width <br> (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.)

| Capacity (lb) | Loaded speed (mph) | Weight (lb) | Dimensions (in.) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | 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 table 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 name plate or in the vehicle technical manual. The letters used in the table indicates the following:
$R=$ 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

| R | A | c | D | A | c | D | A | c | D |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 45-foot boom |  |  | 50-foot boom |  |  | 55-foot boom |  |  |
| 12 | 80 | 52,100 | 49'9" | 80 | 52,100 | $54^{\prime} 10^{\prime \prime}$ |  |  |  |
| 15 | 76 | 37,100 | $49^{\prime} 2^{\prime \prime}$ | 77 | 36,800 | $54^{\prime} 3^{\prime \prime}$ | 78 | 36,600 | $59^{\prime \prime} 5^{\prime \prime}$ |
| 20 | 69 | 24,500 | $47^{\prime \prime}{ }^{\prime \prime}$ | 71 | 24,300 | $52^{\prime} 11^{\prime \prime}$ | 73 | 24,100 | $58^{\prime} 2^{\prime \prime}$ |
| 25 | 62 | 18,100 | $45^{\prime \prime} 4^{\prime \prime}$ | 65 | 17,800 | $50^{\prime} 11^{\prime \prime}$ | 68 | 17,600 | $56^{\prime} 4^{\prime \prime}$ |
| 30 | 55 | 14,200 | $42^{\prime \prime} 3^{\prime \prime}$ | 59 | 14,000 | $48^{\prime \prime} 3^{\prime \prime}$ | 61 | 13,800 | $54^{\prime \prime} 0^{\prime \prime}$ |
| 35 | 46 | 11,600 | $38^{\prime \prime} 2^{\prime \prime}$ | 51 | 11,300 | $44^{\prime} 9^{\prime \prime}$ | 56 | 11,100 | $40^{\prime} 11^{\prime \prime}$ |
| 40 | 36 | 9,700 | $32^{\prime} 6^{\prime \prime}$ | 43 | 9,400 | $40^{\prime} 3^{\prime \prime}$ | 49 | 9,200 | 47' ${ }^{\prime \prime}$ |
| 45 | 24 | 8,200 | $24^{\prime \prime} 1^{\prime \prime}$ | 34 | 7,900 | $34^{\prime} 2^{\prime \prime}$ | 42 | 7,800 | 42'2" |
| 50 |  |  |  | 23 | 6,800 | $25^{\prime \prime} 1^{\prime \prime}$ | 33 | 6,700 | $35^{\prime} 8^{\prime \prime}$ |
| 55 |  |  |  |  |  |  | 22 | 5,800 | $26^{\prime \prime}{ }^{\prime \prime}$ |
|  |  |  |  |  |  |  |  |  |  |
|  | 60-foot boom |  |  | 65-foot boom |  |  | 70-foot boom |  |  |
| 20 | 75 | 23,900 | $63^{\prime} 4^{\prime \prime}$ | 76 | 23,700 | $68^{\prime \prime} 6^{\prime \prime}$ |  |  |  |
| 25 | 69 | 17,400 | $61^{\prime} 9^{\prime \prime}$ | 71 | 17,200 | $67^{\prime \prime} 0^{\prime \prime}$ | 73 | 17,000 | $72^{\prime} 3^{\prime \prime}$ |
| 30 | 64 | 13,600 | $59^{\prime \prime} 7^{\prime \prime}$ | 66 | 13,400 | $65^{\prime} 1^{\prime \prime}$ | 68 | 13,200 | $70^{\prime} 6^{\prime \prime}$ |
| 35 | 59 | 10,900 | $56^{\prime} 11^{\prime \prime}$ | 62 | 10,700 | $62^{\prime \prime} 8^{\prime \prime}$ | 64 | 10,600 | $68^{\prime} 3^{\prime \prime}$ |
| 40 | 53 | 9,000 | $53^{\prime \prime} 6^{\prime \prime}$ | 56 | 8,800 | $59^{\prime} 8^{\prime \prime}$ | 59 | 8,700 | $65^{\prime \prime} 7^{\prime \prime}$ |
| 45 | 47 | 7,600 | $49^{\prime} 4^{\prime \prime}$ | 51 | 7,400 | $55^{\prime} 11^{\prime \prime}$ | 54 | 7,300 | $62^{\prime} 3^{\prime \prime}$ |
| 50 | 40 | 6,500 | 44'1" | 45 | 6,300 | 51'5" | 49 | 6,100 | $58^{\prime} 3^{\prime \prime}$ |
| 55 | 32 | 5,600 | 37' ${ }^{\prime \prime}$ | 38 | 5,400 | 45' $10^{\prime \prime}$ | 43 | 5,200 | $53^{\prime} 6^{\prime \prime}$ |
| 60 | 21 | 4,900 | $27^{\prime \prime}{ }^{\prime \prime}$ | 30 | 4,600 | $38^{\prime} 6^{\prime \prime}$ | 36 | 4,500 | $4^{47} \mathbf{6}^{\prime \prime}$ |
| 65 |  |  |  | 20 | 4,100 | $28^{\prime} 0^{\prime \prime}$ | 29 | 3,900 | 38'10" |
| 70 |  |  |  |  |  |  | 19 | 3,400 | $28^{\prime} 10^{\prime \prime}$ |




- With bipod and shoulder stock.
b Weight does not include recoil sdapter assembly, which weighs $41 / 4$ pounds.
- Trscers used for fire direction.
d Riffe grensde.
- Hand grenade.

Average (varies with different types of grenades).
s M15 sight mounted on rifle.
b Outaide dismeter of tube.
i Trsversing rsnge without releasing mechsnism is 100 mils.
, Figures shown are controlled elevation and depression. Free elevstlon is 445 miles; free depression is 445 mils.
${ }_{k}$ Traversing range without releasing elevsting mechaniern is 800 mils.
${ }_{1}$ Weight shown includes mount, which weighs $1 \mathrm{lb}, 4 \mathrm{oz}$.
${ }^{5}$ Length shown includes mount, which is 1.69 inches long.

- Height of burst.

Varies between 1 and $11 / 2 \mathrm{lh}$.

- Firing weight is $10 \mathrm{lb}, 2 \mathrm{oz}$.
- With flash suppressor.

Firing weight is 11 lb .

### 7.8 Telephone Poles

| Class | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Minimum top circum | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| Transverse breaking | 4,500 | 3,700 | 3,000 | 2,400 | 1,900 | 1,500 | 1,200 |
| Type |  |  |  | ge weight |  |  |  |
| W estern cedar | 700 | 600 | 500 | 400 | 300 | 225 | 200 |
| Northern cedar | 720 | 600 | 540 | 350 | 300 | 230 | 190 |
| Creosoted pine. | 635 | 555 | 479 | 418 | 353 | 310 | 259 |
| Western cedar. | 850 | 720 | 600 | 480 | 400 | 320 | 250 |
| Northern cedar | 1,020 | 780 | 600 | 515 | 420 | 300 | 250 |
| Creosoted pine. | 898 | 808 | 686 | 602 | 508 | 423 | 362 |
| Western cedar. | 1,000 | 850 | 730 | 610 | 500 | 420 | 350 |
| Northern cedar | 1,320 | 1,170 | 870 | 630 | 520 | 420 | 350 |
| Creosoted pine. | 1,241 | 1,076 | 921 | 780 | 672 | 573 | 489 |
| Western cedar | 1,200 | 1,000 | 850 | 750 | 650 | 560 | 470 |
| Northern cedar | 1,620 | 1,380 | 1,060 | 820 | 720 | 510 | 450 |
| Creosoted pine. | 1,603 | 1,410 | 1,213 | 996 | 865 | 733 | 616 |

Western and northern cedars are furnished butt-treated; pine is treated full length. To estimate required shipping space, use the following formula.

$$
\begin{aligned}
\frac{\text { Average weight }(\mathrm{lb}) \times \text { constant }}{40} & =\text { measurement tons } \\
\text { Values of the constants are: } & \text { Cedar }-0.052 \\
& \text { Pine }-0.026
\end{aligned}
$$

### 7.9 Sled Train

a. Power Vehicle Specifications.

| Type | $\begin{aligned} & \text { Gross } \\ & \text { weight } \\ & (\mathrm{lb}) \end{aligned}$ | $\begin{aligned} & \text { Cubic } \\ & \text { feet } \end{aligned}$ | Dimensions (in.) |  |  | Per- | $\begin{aligned} & \text { Fuel } \\ & \text { cupp } \\ & \text { (gal.) } \end{aligned}$ | Speed (mph) |  |  |  |  | Drawbar pull (1b) |  | Paylosd towed | Fuel consumption (avg) | $\begin{aligned} & \text { Turn- } \\ & \text { ing } \\ & \text { radius } \\ & \text { (It) } \end{aligned}$ | Engine |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Length | Width | Height |  |  | Gear |  |  |  |  | $\begin{aligned} & \text { Direct } \\ & \text { drive } \\ & \text { dri } \end{aligned}$ | Torque converter |  |  |  |  |
|  |  |  |  |  |  |  |  | 1 | 2 | 3 | 4 | 5 |  |  |  |  |  |  |
| M29C Weasel | 5,971 | 403 | 193 | 67.3 | 71 | 4 | 35 | 4 | 7 | 10 | 12 | 20 | NA | None | $3,800 \mathrm{lb}$ | 5 mpg | 12 | Studebaker Champion |
| M76 Otter | 12,162 | 1,180 | 193 | 98 | 103.3 | 10 | 60 |  | $\begin{gathered} 18 \\ \text { avg } \end{gathered}$ | $\begin{aligned} & 28 \\ & \max \end{aligned}$ |  | ---- | $\begin{gathered} \text { Cross } \\ \text { drive } \end{gathered}$ | None | $6,000 \mathrm{lb}$ | 2.3 mpg | 12 | $\begin{aligned} & \text { Continental } \\ & \quad \text { Model, A01, } \\ & 268-38 \end{aligned}$ |
| M116 Husky. | 10,000 |  | 182 | 80.5 | 79.5 | 12 | 65 |  |  |  |  |  |  |  |  | 4.6 mpg |  | Chevrolet |
| D7 LPG--.-. | 47,515 | 1,870 | 232 | 132 | 123.75 | 1 | 65 | 2 | 3 | 5 | 7 | 10 | 15,000 | None | $\begin{gathered} 30 \text { to } 40 \\ \text { tons } \end{gathered}$ | 135 gal. per day | 24 | Caterpillar D337 |
| D8 LPG M54. | 58,780 | 3,360 | 288 | 160 | 126 | 2 | 100 | 2 | 3 | 5 | 7 | 10 | 20,000 | 27,500 | 30 to 40 <br> tons | 135 gal. <br> per day | 24 | Caterpillar D337 |
| D8 LPG M55 | 83,000 | 3,360 | 288 | 160 | 126 | 2 | 918 | 1.5 | 1.9 | 2.8 | 3.8 | 5.2 | 32,000 | None | $30 \text { to } 40$ <br> tons | 135 gal. <br> per day | 24 | Caterpillar D342 |

b. Sled Specifications. ${ }^{1}$

| Characteristics | 1-ton recon sled |  | $\begin{aligned} & 2 \text { 1/2-ton } \\ & \text { farm gled } \end{aligned}$ | $\begin{gathered} \text { 10-ton ATACO } \\ \text { steel skis } \end{gathered}$ | 10-ton ATACO Micarts skis | $\underset{\text { Fransporter }}{\text { Fin }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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. | $10^{\prime} 9^{\prime \prime}$ | $13^{\prime} 101 / 2^{\prime \prime}$ | $15^{\prime} 8^{\prime \prime}$ | $\begin{gathered} 22^{\prime} 4^{\prime \prime} \text { w/o } \\ \text { tongue } \end{gathered}$ | $22^{\prime} 4^{\prime \prime}$ | $24^{\prime}$ |
| Width | $5^{\prime}$ | 7'11/2" | $7{ }^{\prime \prime}{ }^{\prime \prime}$ | $8^{\prime \prime} 6^{\prime \prime}$ | $8^{\prime \prime} 6^{\prime \prime}$ | $10^{\prime}$ |
| Height. | $1^{\prime \prime} 5^{\prime \prime}$ | $1^{\prime} 43^{\prime \prime}$ | $2^{\prime} 6^{\prime \prime}$ | $\begin{array}{r} 7^{\prime} 3^{\prime \prime} \text { to top } \\ \text { of stakes } \end{array}$ | $\begin{aligned} & 7^{\prime \prime} 8^{\prime \prime} \text { to top } \\ & \text { of stakes } \end{aligned}$ | $4^{\prime \prime} 6^{\prime \prime}$ |
| Capacity--- | 2,000 lb | $2,000 \mathrm{lb}$ | 21/2 tons | 10 tons | 10 tons | 3,021 gal. |

1 A plastic boat-type sled is also available and used extensively in northern areas. It weighs $\mathbf{3 8}$ pounds, is 88 inches long, 25 inches wide, and 8 inches deep, and has a 200 -pound capacity.
c. Wanigan Specifications. A wanigan is a small house, normally constructed of plywood, lumber, and insulating material; usually mounted on runners; and transported in tractor-drawn sled trains. Interior designs vary; it may be used as a kitchen, shop, bunk-house, etc.

\begin{tabular}{|c|c|c|c|c|c|c|c|c|}
\hline Characteristics \& \[
\underset{\mathbf{M} 54}{\text { Command, }}
\] \& \[
\begin{aligned}
\& \text { Passenger, } \\
\& \text { M52 }
\end{aligned}
\] \& \(\underset{\text { M54 }}{\text { Passenger }}\) \& \[
\underset{\mathbf{M} 55}{\text { Command, }}
\] \& \[
\begin{aligned}
\& \text { Crew, } \\
\& \text { M53 }
\end{aligned}
\] \& Crew mess, M54 \& Crew \& Mess,
M55 \\
\hline Weight, empty (b) \& 10,500 (est) \& 10,500 (est) \& 11,400 (est) \& 15,000 \& 16,000 (est) \& 18,000 \& 19,000 \& 19,000 \\
\hline Cubic feet \& 1,560 \& 1,560 \& 1,870 \& 2,600 \& 3,310 \& 2,868 \& 3,790 \& 3,790 \\
\hline Dimensions: \& \& \& \& \& \& \& \& \\
\hline \begin{tabular}{l}
Length \\
Width
\end{tabular} \& 20
\(10^{\prime}\) \& \(20^{\prime}\)
\(10^{\prime}\) \& \(24^{\prime}\)
\(10^{\prime}\) \& 26
\(12^{\prime}\) \& \(35^{\prime}\)
\(8^{\prime} 7^{\prime \prime}\) \& \(45^{\prime}\)
\(8^{\prime} 6^{\prime \prime}\) \& 38
\(12^{\prime}\) \& \[
\begin{aligned}
\& 38^{\prime} \\
\& 12^{\prime}
\end{aligned}
\] \\
\hline Width
Height \& \(10^{\prime}\)
7
\(2^{\prime \prime}\) \& \(10^{\prime}\)
7
7

$\prime \prime$ \& $10^{\prime}$
$8^{\prime} 6^{\prime \prime}$ \& $12^{\prime} 3^{\prime \prime}{ }^{\prime \prime}$ \& $8^{\prime} 7^{\prime \prime}$
$7^{\prime \prime} 8^{\prime \prime}$ \& $8^{\prime} 6^{\prime \prime}$
$7^{\prime \prime} \mathbf{6 \prime \prime}^{\prime \prime}$ \& ${ }^{12^{\prime}} 3^{\prime \prime}$ \& $12^{\prime}$
$10^{\prime} 3^{\prime \prime}$ <br>
\hline Number of persons a modated \& 4 \& 10 \& 12 \& 6 \& 18 \& 16 \& 24 \& 18 <br>
\hline Fuel used. \& Diesel oil \& Diesel oil \& Diesel oil \& Diesel oil \& Diesel oil \& Coal \& Diesel oil \& Diesel oil <br>
\hline
\end{tabular}

d. Other Data.
(1) Fuel consumption per day.
(a) Coal stove for heating.

1. 20 pounds of coal or 12 Presto logs for summer operations ( $10^{\circ} \mathrm{F}$. or above).
2. 50 pounds of coal or 30 Presto logs for winter operations ( $10^{\circ} \mathrm{F}$. or below).
(b) Coal stove for cooking.
3. 50 pounds of coal, or
4. 30 Presto logs.
(c) Generator fuel consumption.

1 . 5 -kw generators burn approximately 20 gallons of gasoline in continuous operation.
2. 30 -kw generators burn 30 gallons of diesel fuel oil (VVF 800).
3. $45-\mathrm{kw}$ 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 $10-\mathrm{man}$ Artic 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 operation per day are rated at 0.2 of a gallon of gasoline.
(2) Lubrication consumption.
(a) Engine oil consumption for 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 .006 gallon per mile.
(b) The rate of gear oil consumption is .45 gallon per mile for a large, generalpurpose tractor; .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 .005 of a 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 (par. 7.11).

### 7.10 Load-Bearing Capacity of Ice

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 fresh-water ice.

| Load | Iee thickness in CM ${ }^{1}$ |  | Distance in meters between units ${ }^{2}$ |
| :---: | :---: | :---: | :---: |
|  | Risk | Normal |  |
| Single soldier on skis.-- | 4 | 5 | 5 |
| File of soldiers-2-pace |  |  |  |
| Vehicles: |  |  |  |
| Truck, 1/4T | 15 | 20 | 15 |
| Truck, 3/4T | 20 | 25 | 20 |
| Truck, $21 / 2 \mathrm{~T}$ | 35 | 40 | 25 |
| Truck, 5T | 45 | 55 | 60 |
| Tractor and trailer |  |  |  |
| 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 | - |
| 0-1A. | 15 | 20 | -- |
| U-6A. | 20 | 25 |  |
| U-8D | 20 | 25 | -- |
| U-1A. | 25 | 30 | -- |

[^30]7.11 $\begin{gathered}\text { Guide for Preparation of Antifreeze } \\ \text { Solutions }\end{gathered}$

| Lowest expected $\underset{\text { tempera- }}{\text { ambient }}$ $\left.\stackrel{\text { ture }}{ }{ }^{\circ} \mathrm{F}.\right)$ | $\begin{aligned} & \text { Arctic grade antilreeze } \\ & \text { (MIL-90. } \mathrm{C}-11755) \end{aligned}$ | Ethylene-glycolantireze $\left(-60^{\circ}\right.$ F. $)$(spec. $0-E-771 a$, type I) |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Pinta per gallon or capacity ${ }^{2}$ | $\begin{aligned} & \text { Specific } \\ & \text { gravity } \\ & \left(68^{\circ}\right. \text { F.) } \end{aligned}$ |  |
| +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. | 28/4 | 1.047 | 23/4 |
| -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 | 5 |
| - 50 |  | 41/2 |  |  |
| -60 |  | 43/4 |  |  |

${ }^{1}$ Used as temporary emergency expedient when neither arctic grade antifreeze nor ethylene-glycol antifreeze is available.
${ }^{2}$ Includes heaters, etc.

### 7.12 Temperature, Snow cover, and Precipitation in Arctic and Subarctic Areas

Figures below may be used as guides 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 7.1. 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 table 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 precipitation of snow, 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 10 inches of snow). Generally speaking, most of the precipitation above $70^{\circ}$ latitude is snow, while that below $70^{\circ}$ 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.



## THE WINDCHILL FACTOR

## TEMPERATURE FAHRENHEIT



Figure 7.1. The windchill factor.

### 7.13 Storage Batteries

$a$. The electrolyte in acid-type storage batteries is normally 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.

| Parts concentrated sulphuric <br> acid to one part of water | Specific gravity | Approximate <br> freezing point <br> ${ }^{\circ}$ F. |
| :---: | :---: | :---: |
| By volume | By weight |  |
| 0.232 | 0.416 | 1.200 |
| 0.250 | 0.454 | 1.210 |
| 0.294 | 0.527 | 1.240 |
| 0.364 | 0.667 | 1.280 |

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 $+30^{\circ} \mathrm{F}$. This is normally 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
approximate state of charge for various temperatures are given below.

| Temperature <br> ${ }_{\text {F F }}$ | Specific gravity (cor- <br> rected for temperature) | Approximate state <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 (cor-) <br> rected for temperature) | Approximate state <br> of charge (peremt) |
| :---: | :---: | :---: |
| -30 | $1.231-1.256$ | 63 |
| -25 | $1.233-1.258$ | 64 |
| -20 | $1.235-1.260$ | 65 |
| -15 | $1.237-1.262$ | 68 |
| -5 | $1.239-1.264$ | 70 |
| -5 | $1.241-1.266$ | 73 |
| 0 | $1.243-1.268$ | 75 |
| +5 | $1.245-1.270$ | 77 |
| +10 | $1247-1.272$ | 79 |
| +15 | $1.249-1.274$ | 80 |
| +20 | $1251-1.276$ | 82 |
| +25 | $1253-1.278$ | 84 |
| +30 | $1.255-1.280$ | 85 |
| +80 | $1275-1.300$ | 100 |

## Section IV. CARGO CONTAINERS, PALLETS, AND MARKINGS

### 7.14 Reusable Metal Shipping Box and Containers Inserts

(fig. 7.2)
Figure 7.2 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.

### 7.15 General-Purpose Pallet

(fig. 7.3)
The general-purpose pallet is a four-way-entry, wooden pallet, 48 inches long, 40 inches wide, and about $5 \frac{1}{4}$ 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.

### 7.16 Sled Pallet

(fig. 7.4)
The sled pallet consists of a heavy, timbered platform ( 4 by 6 feet) and runners ( 4 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 LVTP's wheeled landing vehicles, or similar craft. Rations, water, fuel in 5 -gallon containers, and ammunition are the most suitable supplies for pallet loading.

### 7.17 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-129C, 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. A combination of six letters and numbers which depict the in-the-clear address.
(3) Required delivery date ( $R D D$ ). A numeric calendar date indicating when material is required by the consignee.
(4) Port designator. Three numbers identifying a specific surface terminal or geographic area or location for discharge of cargo.
(5) Project code. Three letters and numbers identifying a specific contingency plan, movement, etc.
(6) Air movement designator (AMD). A

## U.S. ARMY - U. S. AIR FORCE

BOX, METAL, SHIPPING, REUSABLE (CARGO TRANSPORTER)


Figure 7.2. Characteristics and security of cargo transporters.

(2.) $S I D E$


CROB section chowine


DETAIL OF CHAMFER EDEE FOR ALL BOTTOM BOARDS


Figure 7.3. Dimensions of general-purpose pallet.


Figure 7.4. Sled-pallet dimensions.
group of letters and numbers assigned to control the movement of shipments by military aircraft.
b. CONUS Address Marking. Address marking and AMD, when applicable, are shown on labels or stenciled directly on the container as outlined in the regulations above.
(1) Example.

FROM: ROSSFORD ORD DEP TOLEDO 1 OHIO
TO: TRANS OFF
RARITAN ARSENAL METUCHEN N J 234
A15034-2182 0001K/75 XYZ
(2) Explanation.

FROM: ROSSFORD ORD DEP, TOLEDO 1 OHIO: Consignor
Line 1. TO: TRANS OFF, RARITAN ARSENAL, METUCHEN N.J.: In -the-clear address
Line 2. 234: Required delivery date
Line 3. A15043-2182 0001K/75: Document number and total containers
A15043: Shipping address
A-Service designator
1-Continental Army area
5-State within Army area
04-Depot, DSU, or location within State
3-Requisitioner or recipient within depot, DSU, or location
2182: Date of requisition
0001: Requisition serial number
$K$ : Suffix to requisition serial number (when applicable)
75: 'Total number of exterior containers
Line 4. XYZ: Project code (when applicable)
For shipments via air, the air movement designator is added as line 5.
Line 5. FFO-WRI-2H-2345-RA-7
FFO-Aerial origin terminal
WRI-Aerial discharge terminal
2-Transportation priority
H-Commodity
2345-Control serial number
RA-Sponsoring agency
7-Month shipped
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.

BRANCONNE GEN DEP FR
AK6500 234354
AK6500-1207-0120K/98
HAA
(2) Explanation.

Line 1. BRANCONNE GEN DEP FR: In-the-clear address
Line 2. AK6500 234 354: Shipping address, required delivery date, port designator

AK6500: Shipping address
A-Service designator
K6-Area and sub-area
500-Depot or DSU
234: Required delivery date
354: Port designator
Line 3. AK6500-1207-0120K/98:
Document number and total containers
AK6500: Shipping address (see above)
1207: Date of requisition
0120: Requisition serial number
$K$ : Suffix to requisition serial number (when applicable)
98: Total number of exterior containers
Line 4. HAA: Project code (when applicable)
d. Domestic Address. Domestic address for oversea shipments is marked as outlined in MIL-STD-129C. Composition of domestic address is as follows:
(1) FROM: (Name of consignor and address) (City and State)
(2) TO: (Terminal and Address)
(City and State)
(3) Air movement designator when applicable

### 7.18 Service-Color Marking

Service-color markings on export shipment containers facilitate identification of shipments or service and assist in the dispersion of supplies to the proper oversea depots. Generally, these markings consist of an equal-size triangle in the prescribed service color painted on each adjacent face of two diagonally opposite cornors of the top of the containers. The altitude of the triangle may vary from 3 to 8 inches and should be in proportion to the size of the container. See MIL-STD-129C. The assigned service colors are shown below; the number in parentheses is the Federal color specification number.
a. Army Technical Services.
(1) Chemical Corps-dark blue (35044).
(2) Corps of Engineers-red (11136).
(3) Medical Service-maroon (10049).
(4) Quartermaster Corps-willow green (14187).
(5) Ordnance Corps-yellow (13538).
(6) Signal Corps-orange (12246).
(7) Transportation Corps-light gray (16376).
b. Navy. Black (37038) except as noted below:
(1) Naval electronics-green (14187).
(2) Naval medical supplies-maroon (10049).
c. Marine Corps.
(1) Ordnance-yellow (13538).
(2) Aviation-blue (15193).
(3) Engineer-red (11136).
(4) Chemical-dark blue (35044).
(5) Electronics-orange (12246).
(6) Medical-maroon (10049).
(7) Quartermaster--willow green (14187).
(8) Post Exchange-willow green (14187) with 3-inch X marked above.
(9) Motor transport-willow green (14187) with 3 -inch MT marked above.
d. National Security Agency. Purple (27144).
e. U.S. Coast Guard. Bright blue (15123).

## Section V. COMMUNICATIONS

### 7.19 Joint Nomenclature System

a. Classification. Signal equipment submitted to a joint Army-Navy board is classified by indicator letters as follows:
$\mathrm{AN}=$ System indicator for communicationelectronic equipment as described in TM 11-487C. AN does not mean that the set is used by both services.
First letter following slash = type of installation.

Second letter following slash = type of equipment.
Third letter following slash $=$ purpose of equipment.
Number following dash $=$ particular set.
b. Example. AN/VRC-18 = Complete set or major component, ground vehicular installed, radio communication set model 18.

## c. Interpretation.

### 7.20 Signals and the Phonetic System

 (fig. 7.5)a. Signals.
(1) Morse code. The Morse code is a language made up of long and short sounds or visual indications representing letters and numbers and used to transmit time and position signals necessary to avigation and navigation and radio and wire messages (FM 21-60). For general telegraphic procedures, see FM 24-18 and ACP 131. The uses of Morse code in avigation are explained in TM 11-2557 and in navigation in Knight's Modern Seamanship.
(2) Wig-wag. This is a system for sending international Morse code using a single flag or an improvised sending device (FM 21-60).
(3) Semaphore. This is a system for sending messages using the international alphabet and special prearranged signs. Two red
and white flags, 18 inches square, are used. Numerals in the message should be spelled out. All messages end with the ending sign AR. Detailed instructions may be found in Hydrographic Office Publication No. 87 or in FM 21-60.
b. Phonetic System. This is a list of standard words used to identify letters and numerals in messages transmitted by radio or telephone. It is used to phonetically spell difficult words or to pronounce code groups, single letters, and numbers that could be misunderstood. For more detail, see FM 24-18.

### 7.21 Ground-fo-Air Emergency Messages

Emergency messages may be sent from the ground to aircraft by arranging panels, torn clothing, parachutes, ditches, rocks, logs, brush fires, and other materials and formations in the shapes shown in figure 7.6. Signals may also be inscribed on snow, soil, or sand. The arrangement must be large enough to be seen from the air (at least 6 ft by 2 ft ) and of both color and texture in contrast to its background (FM 21-60).

ALPHABET: SEMAPHORE, PHONETIC, AND MORSE


## (1) GROUND SIGNALS

1. Require doctor
2. Will attempt takeoff
$1\rangle$
3. Require medical supplies
4. Aircraft seriously damaged

## 

3. Unable to proceed

4. Probably safe to land here

5. Require food and water

6. Require fuel and oil

7. Require firearms and ammunition

8. All well

9. Require map and compass $\square$ 15. No

10. Require signal lamp with battery and radio

11. Yes

12. Indicate direction to proceed
13. Not under stood

14. Am proceeding this direction
15. Require engineer


## (2) ACKNOWLEDGMENT BY AIRCRAFT

Message received and understood

Message not understood

1. Rocking from side to side
2. Green flashes from signal lamp
3. Aircraft will make complete right-hand circuit
4. Red flashes from signal lamp

Figure 7.6. Ground-to-air emergency code.

### 7.22 Radio Sets

| Radio set | Range |  |  |  |  |  |  |  | Modu- | Frequency range (mc) |  | Type aignal |  |  |  | Vehicle volt required ${ }^{\text {d }}$ | Wcight <br> (lb) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Voice |  |  |  | CW: |  |  |  |  | Transmitter | Receiver | Voice | MCWb | CW* | RATT* |  |  |
|  | Stationary |  | Moving |  | Stationary |  | Moving |  |  |  |  |  |  |  |  |  |  |
|  | KM | Mi | KM | Mi | км | Mi | км | Mi |  |  |  |  |  |  |  |  |  |
| AN/ARC-44 | e48 | e30 | -48 | e30 |  | No | ---- | No | FM | 24.0-51.9 | 24.0-51.9 | Yes | No | No | No | 24 | 36 |
| AN/ARC-51. | e48 | ${ }^{\text {e }} 30$ | ${ }^{-48}$ | -30 |  | No | --- | No | AM | 225.0-399.9 | 225.0-399.9 | Yes | No | No | No | 24 |  |
| AN/ARC-54. | e48 | e30 | ${ }^{\circ} 48$ | e30 |  | No | --- | No | FM | 30.0-70.0 | 30.0-70.0 | Yes | No | No | No | 24 |  |
| AN/ARC-55. | ${ }^{\text {e }} 48$ | e30 | ${ }^{\text {e }} 48$ | -30 |  | No | --- | No | AM | 225.0-399.9 | 225.0-399.0 | Yes | No | No | No | 24 |  |
| AN/GRR-5. |  | No |  | No |  | No | - | No | AM | No | 1.5-18.0 | No | No | No | No | 6,12, 24 | 110 |
| AN/GRC-7 | 24 | 15 | 16 | 10 |  | No | ---- | No | FM | 38.0-54.9 | 38.0-54.9 | Yes | No | No | No | 12, 24 | 541 |
| AN/GRC-7, Set 2 | 1.6 | 1 |  | No |  | No | ---- | No | FM | 47.0-58.4 | 47.0-58.4 | Yes | No | No | No | 12, 24 | 215 |
| AN/GRC-8. | 24 | 15 | 16 | 10 |  | No |  | No | FM | 38.0-54.9 | 38.0-54.9 | Yes | No | No | No | 12, 24 | 190 |
| AN/GRC-9. | 40 | 25 | 24 | 15 | 121 | 75 | 56 | 35 | AM | 2.0-12.0 | 2.0-12.0 | Yes | Yes | Yes | No | 12,24 | 256 |
| AN/GRC-19. | 80 | 50 |  | No | 121 | 75 | - -- | No | AM | 1.5-20.0 | 0.5-32.0 | Yes | No | Yes | $Y$ es | 24 | 254 |
| AN/GRC-46. | 80 | 50 | ----- | No | 121 | 75 | --- | No | AM | 1.5-20.0 | 0.5-32.0 | Yes | No | Yes | Yes | 24 | ${ }^{\text {'1, } 126}$ |
| AN/PRC-9. | 55-8 | ${ }^{8} 3-5$ | ${ }^{\text {h }} 13-31$ | h8-19 | .- | No |  | No | FM | 27.0-38.9 | 27.0-38.9 | Yes | No | No | No | 24 | '62 |
| AN/PRC-10. | 85-8 | 83-5 | ${ }^{\text {4, }} 13-31$ | ¢8-19 |  | No |  | No | FM | 38.0-54.9 | 38.0-54.9 | Yes | No | No | No | 24 | i62 |
| AN/PRC-25 | 5-8 | 3-5 | 5-8 | 3-5 |  | No | ---- | No | FM | 30.0-76.0 | 30.0-76.0 | Yes | No | No | No | 15 volt battery | 15 |
| AN/SRC-8. | 80 | 50-200 | 80 | 50-200 | -- | No | --- | No | AM | 2.0-3.5 | 2.0-3.5 | Yes | No | No | No | 12, 24, 115 | 98 |
| AN/TRC-34. | 40 | 25 |  | No | 24 | 15 |  | No | FM | 152.0-174.0 | 152.0-174.0 | Yes | No | No | No | (a.c.) | 172 |
| AN/VRC-7. | 1.6 | 1 |  | No | -- | No | ---- | No | FM | 47.0-58.4 | 47.0-58.4 | Yes | No | No | No | 12, 24 | 65 |
| AN/VRC-9 | 24 | 15 | 16 | 10 |  | No | ---- | No | FM | 27.0-38.9 | 27.0-38.9 | Yes | No | No | No | 12, 24 | 29.9 |
| AN/VRC-10 | 24 | 15 | 16 | 10 | -- | No | -- | No | FM | 38.0-54.9 | 38.0-54.9 | Yes | No | No | No | 12, 24 | 115 |
| AN/VRC 12 Series | 40 | 25 | 40 | 25 |  | No |  | No | FM | 30.0-75.95 | 30.0-75.95 | Yes |  |  |  | 24 | 90 |
| AN/VRC-19.- | 40 | 25 |  | No | 24 | 15 | 16 | 10 | FM | 152.0-174.0 | 152.0-174.0 | Yes | No | Yes | No | 12 | 113 |
| AN/VRC-19X. | 40 | 25 |  | No | 24 | 15 | 16 | 10 | FM | 152.0-174.0 | 152.0-174.0 | Yes | No | Yes | No | 6 | 240 |
| AN/VRC-29.. | 80 | 50 |  | No | 121 | 75 | --- | No | AM | 1.5-20.0 | 0.5-32.0 | Yes | No | Yes | Yes | 24 |  |
| AN/VRQ-2 | 24 | 15 | 16 | 10 | --- | No |  | No | FM | 27.0-38.9 | 27.0-38.9 | Yes | k | No | No | 12, 24 | 427 |
| AN/VRQ-3. | 24 | 15 | 16 | 10 |  | No | -- | No | FM | 38.0-54.9 | 38.0-54.9 | Yes | k | No | No | 12, 24 | 502 |

- Continuous wave (radiotelegraph).
b Modulated continuous wave (tone).
- Radioteletypewriter.
- Tactical vehiclea 24 volt only
- Altitude 1,000 feet

Including ahelter.

- Short antenna.
${ }^{4}$ Long antenna.
With battery.
, Ground mounted.
k 1,600-cycle ringing


## Section VI. FIRST AID AND CBR AND NUCLEAR WEAPONS DEFENSIVE AND PROTECTIVE MEASURES

### 7.23 First Aid

a. General. First aid is the care given to casualties before treatment can be administered by medical personnel. Wounds are the most common conditions needing first aid. The four lifesaver steps in first aid for the wounded are-
(1) Stop the bleeding. Mild bleeding usually stops naturally when a blood clot forms in the wound. For severe bleeding, apply direct pressure to the wound by hand through cleanest available dressing (bandage, cloth, or part of clothing). Elevate injured member if there is no fracture. If bleeding does not slow down then, apply a tourniquet between the wound and the heart. Leave the tourniquet exposed so that is can be seen readily. If possible, mark a "T" on the casualty's forehead (blood may be used) and indicate the time when the tourniquet was applied. The tourniquet should not be loosened or removed at any time except by competent medical personnel.
(2) Clear the airway. Maintain an open airway by tilting the casualty's head as far back as possible so that his neck is stretched with the chin in a "juttingout" position. Do not allow the chin to sag. Clear his mouth of any foreign matter or mucus. If he is having trouble breathing, start artificial respiration immediately ( $g$ below).
(3) Protect the wound. Do not touch the wound with your hands or with anything except the dressing. Do not try to clean the wound.
(4) Prevent or treat shock. A person in shock may tremble and appear to be nervous; he may be thirsty; he may become very pale, wet with sweat, and may pass out. Treat the wounded man for shock before it appears. Put him on his back with his head low and feet elevated. Loosen clothing. Keep him comfortably warm with a blanket, coat, poncho, etc. If he is conscious, can swallow, and has no
belly injury, give him hot coffee, milk, or water.
b. Burns. A minor burn (small area of reddened skin) should be protected by a sterile dressing if available; otherwise, the burn should be left uncovered. A serious burn (blistering or charring or involving large areas of the body) should be covered with a sterile dressing only. Carefully remove or cut away clothing. Do not clean the burn; do not break blisters; do not use any medication whatsoever. Treat for shock. If casualty is conscious, is not vomiting, and has no belly wound, instead of giving warm stimulants, give him small amounts of cool water with salt or salt and soda.
c. Fractures. Indications of a broken bone are pain and tenderness near fracture, partial or complete loss of motion; deformity, swelling, discoloration (blueness around point of injury). Handle anyone having a fracture or suspected fracture with gentleness; rough or careless handling causes pain, shock, and damage to blood vessels and nerves. Move the patient only if necessary. Do not attempt to straighten the limb. Support the limb on each side of the fracture until a splint is applied. Splints should be padded and must be long enough to reach beyond joints above and below the break. Do not move anyone with a broken leg before it has been splinted. One expedient method of splinting a broken leg is to place a folded poncho, blanket, or jacket between the legs and tie the legs together above and below the break so that the uninjured leg serves as a splint for the injured one. Treat for shock. If there is a wound with the fracture, apply a dressing as you would for any other wound.

## d. Effects of Heat.

(1) Heat exhaustion. Symptoms are dizziness and faintness; signs are paleness and moist, cool skin. Lay the casulty down in shade, loosen clothing, and give cool salt water if he is conscious.
(2) Heatstroke. In hot surroundings a stoppage of sweating with hot, dry, skin should serve as a warning. The casualty is bright pink and may be delirious. Lower body temperature rapidly by immersing him in cold water. If water is not available, place him in shade, re-
move clothing, and pour water over him. Fan him. Get medical aid. Heatstroke is serious.
e. Frostbite. This is localized freezing of body surfaces with stinging pain at onset, numbness, grayish or white skin. Remove clothes at part affected. Thaw quickly against the body or immerse in warm water (body temperature). After it has thawed, wrap it loosely in dry, sterile dressing. Do not apply medications. Do not open blisters. Get medical aid.
f. Snake Bites. . Immediately immobilize the bitten limb in a position below the level of the heart. Apply a tourniquet between the bite and the heart, about 2 to 4 inches above the bite. Tighten the tourniquet just enough to make the veins stand out prominently. If swelling occurs, release the tourniquet and reapply it further up the limb ahead of the swelling. If the patient stops breathing, start artificial respiration at once. Get medical aid immediately.
g. Drowning. The victim may appear to be dead but still be alive. Every moment of delay cuts down his chance of survival. Begin treatment at once. The most important thing is to get air into the victim's lungs immediately. Quickly sweep your fingers through his mouth to clear out foreign matter and mucus; draw his tongue forward. Position him properly to maintain an open airway. His head should be tilted back and his chin should not sag. Begin artificial respiration (the mouth-to-mouth method is preferable) and continue until the victim is breathing naturally or is pronounced dead. Don't wait for a mechanical resuscitator, but if one is available without delay, use it. As soon as victim can breathe for himself, loosen his clothing and treat for shock.
h. Electric Shock. Shock may be caused by contact with electric wires or lightning. The victim may appear to de dead but still be alive. If he has come in contact with an electric current, turn off the switch if it is nearby but do not waste time looking for it. Do not touch person in contact with wire or the wire itself with your bare hands. Use a dry wooden pole, dry clothing, dry rope, or some other material that will not conduct electricity to
remove person from wire. Start artificial respiration immediately, following procedure outlined in $g$ above.
i. Carbon-Monoxide Poisioning. Carbon monoxide is an odorless, invisible gas. Poisoning usually results from breathing vehicle exhaust fumes or stove fumes which accumulate in poorly ventilated shelters. It causes dizziness, weakness, headache, vomiting-and then unconsciousness. Get the victim to fresh air and start artificial respiration immediately ( $g$ above).
j. Care of Feet. Prevention of foot trouble is the best first aid for feet. Keep them clean; bathe them frequently and dry throughly between the toes. Use issue foot powder twice daily. If possible, put on clean socks every day. Don't wear socks with holes or poorly darned spots, or those that fit improperly. Make sure shoes fit properly; then break them in before wearing them on a march. Keep toenails clean and short and cut straight across. Don't cut a corn or callus for serious infection may result. If a blister develops and medical aid is not available, wash the spot with soap and water, sterilize a needle with a flame, open blister by sticking it at lower edge, and cover with a sterile dressing. If condition does not improve, see a medical officer.
k. Plant Poisioning. Poison ivy is a creeper with three prominently veined, shiny, pointed leaves on each stem. Poison oak is a woody vine or low shrub with three egg-shaped leaflets and greenish-white flowers in clusters. Poison sumac is a shrub which grows in swamps and has featherlike, shiney green leaves and greenish flowers followed by greenish-white berries. Upon exposure, wash affected parts of body promptly and thoroughly with water and strong soap. Rash starts with redness and intense itching, followed later by small blisters. If rash has already started, do not wash affected area. Scratching makes the condition worse. Get medical attention.
$l$. Unconsciousness. It is often impossible to find out the cause of unconsciousness, but it may have been caused by bleeding, heatstroke, or head injury. When the cause is known, give the treatment specified elsewhere in this paragraph. When the cause is not known, keep the patient lying
down. Do not move him unless absolutely necessary, and then use the utmost care. If he is cold, make him warm. Do not pour liquids into his mouth-this may choke him. Remove from mouth false teeth, chewing gum, or other objects. Take off his equipment. Loosen clothing. Get a medical officer. If the person has merely fainted, he will regain consciousness in a few minutes. Let him lie quietly and apply a wet, cool cloth to his face. If he is about to faint or has actually fainted while sitting up, lower his head between his legs so that blood may flow to his head, holding him so that he cannot fall and injure himself.

### 7.24 Nuclear Attack

a. Types of Nuclear Explosions. Nuclear explosions are classified according to the height of the burst.
(1) Airburst. A burst in which the fireball does not touch the surface.
(2) Surface burst. A burst in which the fireball does touch the surface.
(3) Subsurface burst. A burst exploded beneath the surface.
b. Effects of Nuclear Explosions.
(1) Blast. The blast effects of a nuclear explosion are comparatively localized and differ from the effects of a high explosive blast only in degree. Damage is caused by direct action of the overpressure and by the secondary action of flying debris, collapsing buildings, etc. The secondary actions cause more injuries to personnel; but the direct action causes more damage
to rigid objects with relatively large surface areas.
(2) Heat. When a nuclear weapon is detonated, the rapid release of energy produces temperatures approaching the interior temperature of the sun. The effects of the heat depend on the height of the burst, the energy yield, and the clarity of the atmosphere. Bare skin can be burned at great distances from the explosion; clothes or any other material which cast shadows give protection. Therefore, a minimum amount of skin area should be exposed. Flash heat starts forest, brush, and other types of fires, while fuel and short-circuits start still others.
(3) Radiation. The explosion of a nuclear weapon produces initial nuclear radiation and may also produce residual nuclear radiation. The initial nuclear radiation is given off in the first minute of the explosion, most of it during the first 2 seconds. If residual nuclear radiation results from the explosion, it is present in the target area immediately following the explosion and may occur in areas downwind of the target area later. The time at which it occurs in those areas depends to a large extent on the speed and direction of the winds through which the particles must pass during their fall to the ground. This type of residual nuclear radiation is commonly referred to as fallout.
(4) Relative effects of different types of bursts.

| $1 \begin{gathered}\text { Type of } \\ \text { burst }\end{gathered}$ | Blast | Heat | Initial nuclear radiation | Residual nuclear radiation contamination (target area and/or fallout) |
| :---: | :---: | :---: | :---: | :---: |
| Air. . .-.-- | Extensive. | Extensive. | Extensive and hazardous only during explosion. | Negligible, except as induced radioactivity in soil in target area following low airburst. |
| Surface.... | Concentrated in smaller area than airburst. | Affects smaller area than does airburst. | Generally less extensive than that from airburst of the same size, but still hazardous. | Generally extensive. Occurs in target area as induced radioactivity in soil and as fallout in target areas and in areas miles down wind of target areas. |
| Subsurface | Concentrated in a smaller area than airburst or surface burst. | Negligible; most of it is absorbed or deflected by ground or water. | Not considered hazardous. . | Generally a smaller pattern than a surface burst. Occurs as induced radioactivity in soil and as fallout, just as from a surface burst. |

c. Procedures to Follow in a Nuclear Attack.
$\left.\begin{array}{|c|c}\hline \text { If alert is sounded, follow unit SOP. If warned } \\ \text { before explosion, pick strongest shelter you can } \\ \text { find in a hurry. Underground shelters, basements, } \\ \text { deep foxholes, and tanks give good protection. }\end{array}\right]$

## d. Special Equipment and Protective Clothing for Use in CBR Decontamination Operations.

| Item | Remarks |
| :--- | :--- |
| Helmet_- | Normally worn in all decon- <br> tamination operations. <br> Protects against falling de- <br> bris or overhead obstruc- <br> tion. <br> Protects hair; worn under <br> conditions where other <br> headgear is not required. |
| Soft fatigue cappective hood_-. |  |

Iten
One-piece coveralls_-....-.
Impermeable protective out-
fit.

Rubber apron
Rubber gloves

Cotton or canvas gloves.--

Impregnated cotton gloves
Boots treated with vesicant gas resistant leather dressing.
Rubber boots.

Protective boot cover

Protective masks

Dust respirator

Other equipment:
Brushes
Shovels.

Portable water heater
Hose, fire and garden

Bulldozers

Remarks
Coveralls (whether impregnated or not) afford better protection against all toxic agents than the shirt or jacket and trousers combinations.
For use in special chemical decontamination and third echelon biological decontamination.
For use in chemical decontamination.
For use in chemical decontamination and wet operations.
For use in dry operations biological and radiological).
For use in chemical operations.
For use in chemical decontamination.

For use in chemical decontamination and wet operations.
For use in special chemical decontamination against inhalation of toxic chemical agents or decontaminants, biological agents, and radioactive dusts.
For protection of eyes and for protection against inhalation of toxic chemical agents or decontaminants, biological agents, and radioactive dusts.
For protection against inhalation of radioactive dusts. (The dust respirator filter should be monitored after each use to determine if it should be replaced.)

Scrubbing and brushing.
Disposal and burial of contaminated objects and materials.
Heating water for decontamination operations.
Hosing and scrubbing operations; also used in bulldozer and road grader operations to keep dust down.
Disposal of contaminated objects; large-scale burial.

| Item | Remarks |
| :---: | :---: |
| 400-gallon, power-driven, decontaminating apparatus. | Large-scale hosing and spraying operations (large areas. buildings, vehicles, and machinery). |
| Road graders | Scraping away contaminated surfaces. |
| Chemical service trucks. | Dipping or disposing of small objects. |
| Swinging-boom crane trucks. | Dipping or disposing of large objects. |
| Scrapers, long-handled. | Paint scraping. |
| Steam jennies. | Cleaning greasy or hard-dirt film surfaces and complicated machinery or other equipment. |


| Item | Remarks |
| :---: | :---: |
| Detection devices: |  |
| AN/PDR-27( ) radiac set. | Normally 3 per major installation. |
| IM-9( )/PD | Normally 1 perindividual entering contaminated area. |
| IM-174/PD | Normally 1 per survey party and 3 per major installation. |
| PP-1578A/PD (detector charger). | Normally 1 per 4 dosimeters. |
| MX2255/TD holder, film badge (with detecting film). | Normally 1 per individual entering contaminated area. |


| Method | Surfaces | Action | Technique | Advantages | Disadvantages |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Water washing -...-- | All nonporous surfaces (metal, paint, plastic). (Not suitable for porous materialssuch as wood, concrete, and canvas). | Acts as a solvent and erodes. <br> Action faster if water is hot. | For gross decontamination, use water shot from high pressure hose. Work from top to bottom to avoid recontamination and from upwind to avoid spray. Spray from distance of 15 to 20 feet. Use $30^{\circ}$ to $45^{\circ}$ angle on vertical surfaces. <br> Determine cleaning rate if possible, or use a rate of 4 square feet per minute. | All water equipment may be utilized. <br> Allows operation to be carried out from a distance. <br> Contamination may. be reduced by 50 percent. <br> Most readily available agent | Drainage must be controlled. (Runoff is contaminated and requires disposal.) Carries contaminant into porous materials. <br> Not applicable on dry contaminated surfaces (use vacuum) or oiled surfaces. |
| Using detergent solution. | Nonporous surfaces (especially films). | Emulsifying agent. Wetting agent. (Action faster if solution is hot.) | Rub surface 1 minute and wipe with dry rag; use clean surface of the rag for each application. (Moist application is all that is desired.) Do not allow solution to drip onto other surfaces. <br> Solution may be applied with a powered rotary brush, or from a distance by use of pressure sprays. | Dissolves films which hold contamination. <br> Contamination may be reduced by 90 percent. <br> Easily handled. <br> More efficient than water alone. | Requires close contact with surface. <br> Not efficient for long standing contamination. <br> Runoff requires disposal. |
| Steaming | Nonporous surfaces (especially painted or oiled surfaces.) | Solution and erosion.- | Work from top to bottom and from upwind. Clean surface at a rate of 4 feet per minute. The cleaning efficiency of steam may be greatly increased by use of detergents. | Reduces contamination by about 90 percent on painted surfaces. | Runoff requires disposal. <br> Waterproof clothing necessary. <br> Requires special equipment. |
| Scrubbing.-... | Porous and nonporous surfaces. | Physical removal of contaminant. | Use in conjunction with other processes. | Used on "hot spots" following other processes. <br> May be used on small objects and areas. | Slow and laborious. <br> Erosive action on some surface. |
| Using complexing agents. | Nonporous surfaces. | Forms soluble complexes with contaminant. | Use 3-percent (by weight) solution. <br> Spray solution on surface. Keep surface moist 30 minutes by spraying periodically; then flush with water. 1 gallon of solution decontaminates about 150 sq ft of surface. | Holds contamination in solution. <br> Reduces contamination of unweathered surfaces by 75 percent in 4 minutes. Solution can be prepared in tank of power-driven decontaminating apparatus. | Requires application for 5 to 30 minutes. <br> Little penetrating power. <br> Little value on weathered surfaces. |


| $\begin{aligned} & 0 \\ & 0 \\ & \text { b } \\ & 0.0 \\ & 0 \end{aligned}$ | Using caustic solution: Sodium bydroxide (lye), calcium hydroxide, potassium hydroxide. | Painted surfaces.....- |
| :---: | :---: | :---: |
|  | Using trisodium pbosphate solution. | Painted surfaces....- |
|  | Using organic solvents: Kerosene, gasoline, alcohol, turpentine, acetone, ether, commercial paint remover. <br> Using inorganic acids: Hydrochloric acid, sulfuric acid. | Nonporous surfaces (greasy or waxed surfaces, paint or plastic finishes). <br> Metal surfaces, especially those with porous deposits rust or calcareous growth); circulatory pipe systems. |
|  | Using acid mixtures: Hydrochloric acid or sulfuric acid witb acetates or citrates. | Nonporous surfaces, especially tbose having porous deposits; circulatory pipe systems. |

Using caustic soludroxide (lye), calcium hydroxide, potassium hydroxide.

Using trisodium pbosphate solution.
organic solvents: Kerosene, gasoline, alcohol, turpentine, acetone, ether, commover.
Using inorganic chlor H y chloric acid, sulfuric acid.
sing acid mixtures: or sulfuric acid witb acetates or citrates.

Removes paint _.....- Allow solution to remain on surface until paint softens, tben wasb off witb water; remove remaining paint witb long-bandled scrapers.
1 pound of caustic in $21 / 2$ gallons of water removes about 100 sq ft of paint; the addition of $11 / 2 \mathrm{lb}$ of trisodium pbosphate aids in removal; the addition of 3 oz of corn starcb holds solution to surface.
Apply hot 10-percent solution. When paint softens, flush from surface with water. Repeat as necessary.
Dissolves oil and other organic materials. Also removes paint. wipe with solvent
Wash in hot soapy water; then rinse in clear water

Strong dissolving ac- Use dip-bath technique for tion on metals and moveable objects. Keep porous deposits.

Dissolving action. acid at a concentration of 1 to 2 normal ( 9 - to 18 -percent hydrochloric acid, 3to 6-percent sulfuric acid). (Reaction time on weathered surfaces sbould be 1 bour; on pipe systems, to 4 hours.) Flush surface with water, neutralize or wash with hot soapy water, and then flush with water again.
Use same as inorganic acids.

Mixtures consist of $1 / 10$ gal. hydrochloric acid, 1/s lb sodium acetate, and 1 gal. water. Keep surface wet for 1 hour; then flush with water.

Time of contact varies with contaminated suriace- 15 minutes to 2 bours.
Can be prepared in steel tank of power-driven decontaminating apparatus.

Reduces activity to tolerance in 1 or 2 applications.
Fast acting.

Quick dissolving action.
Recovery of solvent possible by distillation.

Can cause severe burns; de stroys body tissue.
Corrosive to aluminum or magnesium surfaces.
Not recommended for vertical or overhead surface.

Solution harmful to body tissue.
Powder harmful if inbaled.
Corrosive to aluminum or magnesium surfaces.
Vapors are toxic.
Good ventilation required.
Fire precautions required.

Vapors are toxic. (Good ventilation required.)
Liquid is barmful to tbe skin.
Acid solutions should not be heated.
Rust inhibitor required to prevent corrosion.

Dissolving action may reduce contamination of unweathered surfaces by 90 percent in 1 hour.
Removes rust.

Weathered surface may require prolonged treatment. Harmful to personnel.

| Method | Surfaces | Action | Technique | Advantages | Disadvantages |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Vacuum blasting--.-- | Porous and nonporous surfaces. | Physical removal of contaminated surfaces. | Run unit over contaminated surfaces. | Safe and rapid. Contaminant controlled. | Wears away surfaces. Protective mask required. |
| Sand blasting . . . .-.- | Nonporous surfaces.-. | Physical removal of contaminated surfaces. | Wet sand prior to sand-blasting. Keep removed material wetted down. | Satisfactory method for nonporous surfaces. <br> Can be used for large-scale operations. | Wears away surfaces. <br> Not feasable for porous surfaces. <br> Spreads contamination. <br> Protective mask and hood required. |
| Sanding, filing, grinding, planning, chipping. | Porous and nonporous surfaces. | Physical removal of contaminated surfaces. | Remove surface and control residue. | Reduces "hot spots"... | Practical for small areas or objects only. <br> Time consuming. <br> Protective mask and gloves required. |
| Using earthmoving operations. | Soil and loose rock..-- | Physical removal of contamination. | Remove contamination with bulldozers, road graders, and similar equipment. | Work may begin quickly. <br> Tools or equipment usually available. <br> Reduces hazard quickly (if bulldozers are used). | Limited control of contaminated dust. <br> Disposal problem may become acute. <br> Equipment may become contaminated. <br> Protection mask should be worn. |
| Brushing-----.---- | Porous and nonporous surfaces. | Physical removal of loose contaminated dust. | Brush dust from surface....- | Work may begin quickly. Rapid action. <br> Brushes usually available. | Limited control of contaminated dust. <br> Little or no removal of dust within pores of many porous surfaces. <br> Protective mask should be worn. |
| Vacuum cleaning---- | Dry contaminated surfaces. | Removal of contaminated dust by suction. | Use conventional vacuum technique with efficient filter. | Rapid. <br> Good on dry porous surfaces. <br> Water not required. Contamination controlled. | All dust must be removed from exhaust system. <br> Machine may become contaminated. <br> Rubber gloves required for disposal of waste and filters. |

## f. Radiological Decontamination of Critical Items.

| Iterss | Recommended methods | Equipment or decontaminant | Remarks |
| :---: | :---: | :---: | :---: |
| Clothing---------------- | Wash. | Laundry. (See TM 3220 and FM 10-3 for details.) | Dispose of water used for washing and rinsing. |
|  | Brushing and shaking ---- | Brushes. |  |
| Equipment-------------- | Depends on nature of surface (brushing, washing, aging). |  | See paragraph 7.26c. |
| Buildings | Abrasion, caustics |  | See paragraph 7.26c. |
| Terrain | Decay | None. | Wait for natural decay. |
| Water--------------.- | Filter -- | Filters, stills, and purifiers (engineer equipment). | Must be pronounced safe by medical officer or water specialist. |
| Prepared food in open containers (see below). | Disposal by burial or as directed by medical officer. | Digging equipment. |  |
| Food hot protected in sealed containers. | Scrub or wash, peel.-...- | Brushes and hose.------- | Suspect contamination until monitored. Wash or scrub potatoes and hardskinned fruits and vegetables; peel or scrape and wash again. Brush visible dirt off meat and fish; pare off thin layer until dose-rate reading is less than 0.1 millirad per hour. |
| Food in cans or other sealed containers. | Decontaminate container before opening by scrubbing thoroughly. | Brushes, hose, soap-.-.-- | Contamination will only affect outer surface of sealed containers. Under no circumstances may cans be opened before decontamination. |
| Personnel | Bathing, scrubbing, showering, washing. | Brushes, hose, showers, soap. | Bathing and scrubbing must be continued until contamination is lowered to a safe level. When showering, hold head back in order to prevent runoff from entering eyes, nose, mouth. |

g. Permissible Radiation Dosage. See chapter 7, FM 3-12 and Title 10, part 20, Code of Federal Regulations.

### 7.25 Biological Attack

a. Precautions.
(1) Don't pick or eat fruits or berries.
(2) Don't chew grass or leaves.
(3) Don't eat native or any other non-U.S.

Armed Forces food or drink; even strong liquor may be contaminated. Boil any suspected water for at least 15 minutes.
(4) Don't take souvenirs.
(5) Don't bathe in lakes or ponds or in any water that has not been approved by proper authority.
(6) Don't touch animals.
(7) Don't neglect preventive medicine.
b. Procedures to Follow in a Biological Attack.

| WHEN | DO THIS | THEN IF | DO THIS |
| :---: | :---: | :---: | :---: |
| A TOXIC AGENT is sus-pected- <br> The ALARM sounds- <br> An ATTACK hits your position- | HOLD YOUR BREATH. MASK. <br> TAKE COVER-if tactical situation permits. | There is no apparent effect on anyone. | CONTINUE MISSION. Ob serve disease prevention rules; keep wounds and cuts clean eat and drink only approved food and water. |
| for example | Give the ALARM. | If later ( 1 to 10 days), you | Get medical aid and report |
| You are hit by ENEMY BOMBS, SHELLS, or ROCKETS- | DECONTAMINATE—remove wet spots from skin and clothes. | or your buddies get sick. | sickness. |
| SPRAY from an AIRPLANE falls on you- | CONTINUE MISSION. |  | . |
| A low CLOUD drifts over you- | REMAIN MASKED UNTIL AREA HAS BEEN DECLARED SAFE. |  |  |

c. Biological Decontaminants and Their Use.
Decontaminants

| Decontaminating agent, |
| :---: |
| biological, BPL (beta- | propiolactone).

Formaldehyde solution, USP, 5 parts formaldehyde, 3 parts methanol mixture.

| Limitations |
| :--- |
| Toxic to personnel. |
| BPL forms polymers above 3 |
| months' storage, which may | months' storage, which may be difficult to remove.

Corrodes certain metals; adversely affects some plastics (not recommended for decontamination of signal and optical equipment).
Recommended conditions are $75^{\circ}$ F., relative humidity 70 percent or higher, and 2 hours' contact time.
Aeration after decontamination 24 hours.
Can be used down to $40^{\circ} \mathrm{F}$., but still must have a high humidity.
Applied as va por by heat from standard Army insecticide sprayers or paint-type sprayers, or vaporized by heat or bubbling steam through pan of material.
One quart of undiluted formaldehyde solution, or 0.8 quart of formaldehydemethanol mixture per 1,000 cu ft above $70^{\circ} \mathrm{F}$. The amount for each $20^{\circ} \mathrm{F}$. drop in temperature should be doubled.
Correct time: 16 hours.
Aeration after decontamination: 24 hours.

Vapors highly toxic to personnel.
Vapors of pure formaldehyde are flammable; open flame not suitable for vaporizing. When steam is used, source of steam should be outside area being decontaminated.
Decontamination below $40^{\circ}$ F. not advisable.

Will not effectively penetrate cloth and similar fabrics. May cause damage to delicate instruments. Dampness may curl and ripple paper. Vapor polymerizes and deposits white powder
Remarks

| Residue formed if excess BPL is |
| :--- |
| used or sprayer is too close |
| to surface. |
| Standard insecticide sprayers |
| recommended. | recommended.

Once vaporization has started, even persons wearing masks should not enter area until process is completed.
Care must be exercised to prevent leakage of solution during storage.
Effective against bacterial toxins (slurry).

| Decontaminants | Application | Limitations | Remarks |
| :---: | :---: | :---: | :---: |
|  |  | on horizontal surfaces; this powder may be washed off with hot water. <br> Handlers required to wear compressed-air or oxygen generating breathing apparatus, masks, rubber gloves, and protective clothing. |  |
| Ethylene oxide..------- | Contaminated equipment should be exposed to vapors in airtight enclosure for 6 hours at $75^{\circ} \mathrm{F}$. <br> Thirty lbs ethylene oxide for each $1,000 \mathrm{cu} \mathrm{ft}$ of space at $75^{\circ} \mathrm{F}$. The amount and contact time for each $20^{\circ}$ drop in temperature should be doubled. | Requires airtight enclosure to be effective. <br> Highly explosive in most mixtures of air, not suitable for use in buildings. Flammaable. <br> Toxic to personnel if improperly used. <br> When ground under enclosure is wet or extremely porous, a protective cover over the ground is required. <br> Decontamination below $50^{\circ}$ $F$. is not advisable. <br> Liquid will damage plastics or leather. <br> Handlers are required to wear compressed-air or oxygengenerating breathing apparatus. | Personnel should wear protective masks during use. <br> Cylinders of ethylene oxide must be protected from rough handling and sparks and stored away from fire. Vapor highly penetrating but noncorrosive. |
| Carboxide. | Contaminated equipment should be exposed for 12-24 hours in airtight enclosure. Sixty lb per $1,000 \mathrm{cu} \mathrm{ft}$ of space above $80^{\circ} \mathrm{F}$. <br> For each $20^{\circ}$ drop in temperture the amount should be doubled. | Not as effective as ethylene oxide. <br> Requires airtight enclosure to be effective. <br> Toxic to personnel. <br> Decontamination below $50^{\circ} \mathrm{F}$ is not advisable. <br> Handlers are required to wear compressed-air to oxygengenerating breathing apparatus in the decontaminating area. | Carboxide is noncorrosive Packaged commercially in 60lb cylinders. <br> Nonflammable. |
| Methyl bromide.-.-..-- | Items should be exposed to vapors for 12 hours in quartermaster delousing bags; 5 ampules per bag. <br> Aeration time should be at least 2 hours. | Vapors are highly toxic. Should not be used in closed spaces where odorless vapors could accumulate. | Noncorrosive to metals and nonflammable. |
| STB (supertropical bleach). | For horizontal surfaces, slurry of 13 parts STB to 87 parts water should be used; for vertical surfaces, 40 parts STB to 60 parts water, preferably from a powerdriven decontaminating apparatus. <br> Average coverage: 1 gal. per 8 sq yd for porous surfaces such as concrete and $1 / 2$ gal. per sq yd for closely packed surfaces. | Corrosive to metals. <br> Should not be inhaled or come in contact with skin. <br> Protective mask should be worn when preparing slurries. | In ordinary storage, loss of available chlorine is less than 1 percent per month. When free chlorine falls below 10 percent, bleach should be salvaged. As available free chlorine is lost, STB content must.be increased. <br> Should be stored in unheated warehouse isolated from combustibles and metals subject to corrosion. |


| Decontaminants | Application | Limitations | Remarks |
| :---: | :---: | :---: | :---: |
| DANC solution. | Applied to surfaces with brushes, brooms, or swabs. Residue should be washed from surfaces with hot soapy water; then rinsed with clear water. Metal surfaces should be oiled and dried. | Highly toxic. Should not be inhaled or come in contact with skin. <br> Protective mask and clothing and rubber gloves should be worn when applying. Will soften paint, rubber, and plastics. | Contains about 30 -percent available chlorine when fresh. <br> Contents of white powder (RH195) must be mixed with solvent (acetylene tetrachloride) just prior to use. |
| Decontaminating agent, DS2. | Applied to surfaces with brushes, brooms, or swabs; or sprayed from M11 apparatus. Surfaces should be flushed after 30 minutes with water. | Flammable. <br> Should not come into contact with skin. Must be removed from skin and metals. <br> Ineffective against spore formers. | Packaged ready for use in 5 -gal. drums or $11 / 2$ qt containers (refill for M11 apparatus). <br> Effective against most spore formers; noncorrosive to most metals. |
| Calcium hypochlorite, HTH (70-percent available chlorine). | A slurry of 7 parts HTH and 93 parts water can be used for horizontal surfaces. Coverage same as STB. | HTH is highly corrosive to metal; cannot be used in power-driven decontaminating apparatus. <br> Loses chlorine content rapidly. Should not be inhaled or come in contact with skin and eyes. <br> Protective mask should be worn when preparing slurries. | Packaged in 5-lb cans and 100lb drums. <br> Contains about 70-percent available chlorine when packaged. |
| Sodium hypochlorite (household bleach). | Applied (undiluted) with brooms, brushes, or swabs, or sprayed from powerdriven decontaminating apparatus. <br> Should be diluted for cotton clothing ( $1 / 2$ cup to 1 gal. water). <br> Coverage same as for STB and HTH. | Undiluted, it is harmful to skin and clothing. <br> Corrosive to metals unless rinsed and protected after decontamination. | Removed from skin and clothing by flushing with large amounts of water. <br> Contains about 5-percent available chlorine. <br> Must be stored in cool place. |
| Caustic soda or lye (sodium hydroxide). | Ten-percent solution, by weight, should be used. <br> Average application: 1/8 gal. per sq yd on horizontal surfaces. | Corrosive to skin, eyes. Five-percent solution will deteriorate wool and cotton. Highly corrosive to most metals. Soulution should not be mixed in aluminum, tin, or zinc containers. | Should be removed immediately from skin and eyes. <br> Caustic soda solution may be kept in iron, steel, or glass containers equipped with rubber stoppers, wired or taped in place when not in use. |

### 7.26 Chemical Attack

a. Procedures to Follow in a Chemical Attack. The most important single item of equipment the soldier has for defense against chemical attack is his protective mask. It must be carried at all times, since nothing else can do its job. It should
be inspected often, and the valves should be kept clean. All rubber parts must be kept away from POL products, and water must not enter the canister. The mask should never be sat on or have any heavy objects placed upon it. Procedures as follows:

| WHEN | DO THIS | THEN IF | DO THIS |  |
| :---: | :---: | :---: | :---: | :---: |
| A TOXIC AGENT is sus－ pected－ <br> The ALARM sounds－ <br> AN ATTACK hits your | HOLD YOUR BREATH． <br> MASK． <br> Take COVER ．．．if tacti－ cal situation permits． | Your nose starts running suddenly－ <br> Your chest feels tight－ <br> Your eyesight gets dim－ <br> Breathing becomes diffi－ cult－ | Give yourself one atropine shot ${ }^{1}$ and fasten used tube on shirt or jacket pocket．CONTINUE MISSION． |  |
| for example <br> You are hit by ENEMY BOMB SHELLS，or ROCKETS－ <br> SPRAY from an AIR－ PLANE falls on you． | GIVE ALARM． <br> DECONTAMINATE ．．． remove wet spots from skin ${ }^{2}$ and clothes． <br> CONTINUE MISSION． | Your buddy： <br> has difficulty breath－ ing－ <br> slobbers，sweats，or vomits－ twitches，jerks，or stag－ gers，or has pinpointed pupils－ | Mask your buddy and give him the atropine shot ${ }^{1}$ if he has not taken it．CON－ TINUE MISSION． |  |
| A low CLOUD drifts over you． | REMAIN MASKED UN－ TIL AREA HAS BEEN DECLARED SAFE． | Your buddy： <br> has great difficulty get－ ting his breath or stops breathing－ | Same as above，BUT ALSO give him ARTI－ FICIAL RESPIRA－ TION．CONTINUE MISSION． |  |
|  |  | If liquid agent gets in eyes or face－ | Flush eyes with water and decontaminate skin．${ }^{2}$ CONTINUE MISSION． | 界 |
|  |  | You have wet spots on skin or clothes－ | Cut away spots and rub skin with protective oint－ ment．${ }^{2}$ CONTINUE MISSION． |  |
|  |  | You begin breathing rap－ idly or gasping for air－ | Move to fresh air if possible． Inhale amyl nitrite in－ serted inside mask． |  |
|  |  | You cough or choke．Your chest becomes tight－ | Loosen clothing．CON－ TINUE MISSION．If shortness of breath oc－ curs，keep warm and quiet． | $$ |

${ }^{1}$ To give atropine shot：（a）Remove needle cover，taking care to keep wire loop in place．（b）Push wire through seal，keeping needle end up．Gently squeeze tube until one drop of liquid appears at end of needlc．Pull wire out and discard．（c）Push needle deep into thigh muscle，injecting through clothing．（d）Squeeze tube empty．Massage area for quick effect．（e）Stick needle through pocket and bend it into a hook to fasten securely．USE ATRO－ PINE ONLY IN NERVE AGENT POISONING．Continue giving atropine at 10 minute intervals if symptoms persist．The officer or noncommissioned officer in charge will tell you when to give more then 3 injections．
${ }^{\mathbf{3}}$ To decontaminate skin：（a）Pinch－blot agent from skin．（b）Flush area with water．（c）Rub on protective（M－5）ointment．（d）Wipe off ointment． （e）Rub on second coat of ointment－let it stay．（f）If after masking you suspect that agent is on your face，take a deep breath and hold it，then raise mask and perform steps（a）through（e）again．Reseat and clear mask．Keep ointment away from eyes．
b．Chemical Decontamination Methods．${ }^{1}$


[^31]| Contaminated surface or object | Preferred decontamination method | Alternate decontamination methods | Field expedient methods |
| :---: | :---: | :---: | :---: |
| Roof | power-driven contaminating apparatus. <br> Flush with water............. Spray with slurry from power-driven decontaminating apparatus. | ble and personnel are nearby, use dry mix. Cover with STB or dry mix - | across roads with 4 inches of earth. <br> Weather. |
| Brick and stone: Roads ${ }^{2}$ $\qquad$ | Spray with slurry from power-driven decontaminating apparatus or apply with brushes and brooms. Let remain 24 hours before flushing. | Wash with soapy water, preferably hot. | Cover small areas or paths across roads with 4 inches of earth. <br> Weather. |
| Buildings | Spray with slurry from power-driven decontaminating apparatus or apply with brushes and brooms. Let remain 24, hours, then flush with water. | Wash with soapy water, preferably hot. <br> Use STB or dry mix around buildings, where waste water runs. | Weather. |
| Canvas: Tarpaulin, tentage, covers, mask carriers, cartridge belts. | Immerse in boiling soapy water for 1 hour. <br> Use 5-percent solution of sodium hypochlorite (household bleach) for Vagents. <br> Use 5 -percent solution of washing soda for G -agents. | Immerse in boiling water for 1 hour. <br> Launder by standard methods. (Refer to pertinent QM publications.) <br> Use DANC solution or DS2. Use slurry. | Aerate (except for V-agents). |
| Concrete: <br> Roads ${ }^{2}$ | Spray with slurry | Cover with STB or dry mix. | Weather. |
| Buildings, pillboxes, gun emplacements, tank obstacles. | power-driven decontaminating apparatus. <br> Spray with slurry from power-driven decontaminating apparatus or apply with brushes and brooms. Let remain 24 hours; then flush with water. | Wash with soapy water, preferably hot. <br> Apply STB or dry mix on ground surrounding structure where waste water flows. | Cover small areas or paths across roads with 4 inches of earth. <br> Cover small areas with 4 inches of earth, if practicable. |
| Earth: Roads ${ }^{2}$, gun emplacements, bivouac areas, pathways, bomb craters. | Spray with slurry from power-driven decontaminating apparatus. | Cover with STB or, when liquid contaminant is visible and personnel are nearby, use dry mix. | Weather. <br> Burn. <br> Cover small areas or paths across roads with 4 inches of earth. <br> Scrape layer of contaminated earth to side of road. |
| Leather: Boots, gloves, and other items. | Scrub with hot soapy water and rinse. <br> Immerse in soapy water at $120^{\circ} \mathrm{F}$. for 4 hours and rinse. | Immerse in a 5 -percent solution of sodium hypochlorite for V -agents. <br> Use 5-percent washing soda solution for G -agents. | Aerate. |
| Fabrics (cotton or wool ${ }^{3}$ ): Coveralls, shirts, trousers, field jackets, underwear, socks, gloves, overcoats, ties, hoods, barracks bags. | For Cotton Items <br> Immerse in boiling water for 1 hour; stir items; add 1 lb soap to 10 gal. water to make water alkaline. <br> Use 5-percent solution of sodium hypochlorite (bleach) for V-agents. <br> Use 5-percent solution of washing soda for V -agents. | Launder by standard methods. (Refer to pertinent QM publications.) <br> Dryclean. <br> Use DS2 for cotton items only. | Rub M5 protective ointment on small contaminated areas. <br> Aerate except for $V$-agents. |

Earth: Roads ${ }^{2}$, gun emplacements, bivouac areas, pathways, bomb craters.

Leather: Boots, gloves, and other items.
abrics (cotton or wools) Coveralls, shirts, trousers, field jackets, underwear, socks, gloves, overcoats, ties, hoods, barracks bags.

Scrub with hot soapy water and rinse.
$120^{\circ} \mathrm{F}$ for 4 hours and rinse.

For Cotton Items
Immerse in boiling water for 1 hour; stir items; add 1 lb soap to 10 gal. water to make water alkaline.
percent solution of sofor V-agents.
, 5-percent solution of

Alternate decontamination methods
ble and personnel are nearby, use dry mix.
Cover with STB or dry mix--

Wash with soapy water, preferably hot.

Wash with soapy water, preferably hot.
Use STB or dry mix around buildings, where waste water runs.

Immerse in boiling water for 1 hour.
Launder by standard methods. (Refer to pertinent QM publications.)
Use DANC solution or DS2.
Use slurry.

Cover with STB or dry mix.
Wash with soapy water, preferably hot.
Apply STB or dry mix on ground surrounding structure where waste water flows.

Cover with STB or, when liquid contaminant is visible and personnel are nearby, use dry mix.

Immerse in a 5-percent solution of sodium hypochlorite for V -agents.
-percent washing soda

Launder by standard methods. (Refer to pertinent QM publications.)
Dryclean.
Use DS2 for cotton items only.
across roads with 4 inches of earth.

Cover small areas or paths across roads with 4 inches of earth.
Weather.

Weather.

Aerate (except for V-agents).

Weather.
ver small areas or paths of earth.
over small areas with 4 able.

Weather.
Burn.
Cover small areas or paths across roads with 4 inches of earth.
Scrape layer of contaminated earth to side of road.
Aerate.

Rub M5 protective ointment on small contaminated areas.
Aerate except for V-agents.


[^32]| Contaminated surface or object | Preferred decontamination method | Alternste decontamination methods | Field expedient methods |
| :---: | :---: | :---: | :---: |
|  | For G-agents, use 10-percent washing soda solution, rinse off, and aerate. |  |  |
| Rubber (natural and synthetic: <br> Gloves, boots............ |  |  |  |
|  | Immerse in slurry solution for 4 hours, rinse off and aerate. | Immerse in hot soapy water for 2 to 8 hours; do not boil more than 4 times a year. | Apply M5 protective ointment immediately. Aerate. |
| Mask facepieces, and other rubber articles coming in direct contact with the skin. | Spray with DS2 and rinse. | Immerse in hot soapy water for 6 to 8 hours for heavy contamination and 3 hours for moderate contamination. Do not boil more than 4 times a year. | Apply M5 protective ointment immediately. (Apply to both sides of mask facepieces.) |
| Tires, hose, mats, insu- | Spray with DS2 and rinse_ | Immerse in water for 2 to 3 hours; do not boil more than 4 times a year. | Aerate. <br> Weather. |
| lation. | Apply thick slurry, allow slurry to remain at least 30 minutes, then flush with clear water. (May be left on tires.) |  |  |
| Sand ${ }^{2}$ (beaches, deserts) | Flush with water-------. | Spread STB or slurry over surface. | Weather. <br> Cover paths with roofing paper. <br> Scrape off 2 to 3 inches of contaminated top layer. |
| Undergrowth and tall grass (meadows, jungles, forests). ${ }^{2}$ | Burn | Spray slurry from powerdriven decontaminating apparatus. | Weather. <br> Explode drums of STB. <br> Clear paths with detonating cord, bangalore torpedoes, or demolition snakes. |
| Wood: |  |  |  |
| Buildings, vehicle bodies. | Apply slurry with powerdriven decontaminating apparatus, brooms, or swabs. Let slurry remain 12 to 24 hours; flush and repeat application; then flush again. | Scrub with hot soapy water and rise. | Weather. |
| Boxes, crates, gunstocks_ | Apply slurry with powerdriven decontaminating apparatus, brooms, or swabs. Let slurry remain 12 to 24 hours; flush and repeat application, then flush again. (Scrub slurry off gunstocks with soapy water and rinse.) | Scrub with hot soapy water and rinse. | Weather. |
| Wood (painted surface): 4 Buildings, boxes . | Apply slurry with powerdriven decontaminating apparatus, brooms, or swabs. Let slurry remain 12 to 24 hours, then rinse off with water. | Scrub with hot soapy water and rinse. <br> Use DS2 and rinse. | Weather. |

[^33]
## Section VII. POL CONTAINERS AND PIPELINES

### 7.27 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

$$
\mathrm{Q}=\mathrm{A} \times \mathrm{V}
$$

where
$Q=$ rate of discharge in cubic feet per second
$A=$ cross-sectional area of the pipe in square feet
$\mathrm{V}=$ mean velocity of fluid in feet per second
(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

$$
\mathrm{A}=0.7854 \mathrm{D}^{2}
$$

where
$A=$ cross-sectional area of the pipe in square feet
$\mathrm{D}=$ 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
$\mathrm{A}=0.7854 \times(0.67)^{2}=0.3525$ 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 Light-Weight Steel Tubing.

| Inside <br> diameter <br> of line <br> (in.) | Normal <br> design <br> capacity <br> (bbl per <br> yr) | Emer- <br> gency <br> capacity <br> (bbl per <br> hr) | Safe <br> working <br> pressure <br> (psi) | Maxi- <br> mum <br> morking <br> pressure <br> (psi) | Gallons <br> per day* | Short <br> tons <br> pcr <br> 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.
Gallons per foot of length

$$
\begin{aligned}
& =\frac{(3.1416)(\text { pipe or conduit radius })^{2}(12)}{231} \\
& =\frac{(9.4248)(\text { diameter })^{2}}{231} \\
& =(.0408)(\text { diameter })^{2}
\end{aligned}
$$

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 $d$ (par. 7.59). 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 compensated for by multiplying $\frac{\mathrm{P}}{14.7}$ 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 | Pounds per cu 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.

$$
\mathrm{D}=2.2 \times \frac{\mathrm{F}^{0.45}}{\mathrm{~d}^{0.81}}
$$

Where

$$
\begin{aligned}
\mathrm{D} & =\text { diameter of pipe in inches } \\
\mathrm{F} & =\text { calculated flow for the pipeline in } \\
& \text { thousands of pounds per hour. } \\
\mathrm{d}= & \text { density of the fluid to flow in the pipe } \\
& \text { in pounds per cubic foot }
\end{aligned}
$$

g. Data for Steel Pipe. The figures shown below can be used by the transportation planner 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 by 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.

| $\begin{gathered} \text { Common } \\ \text { pipe } \\ \text { size } \\ \text { (in.)*** } \end{gathered}$ | $\begin{aligned} & \text { Actual } \\ & \text { ingide } \\ & \text { radius } \\ & \text { (ft) } \end{aligned}$ | Capacity in cubic feet per second at a flow (velocity) of $1 / \mathrm{ft}$ per sec | Weight of 100 ft of pipe $(16)$ | Outside diameter (ft) |
| :---: | :---: | :---: | :---: | :---: |
| 1 | 2 | 3 | 4 | 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 |
| 3/8 | . 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 |
| $8 / 4$ | . 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 |

[^34]| Common pipe gize (in.) | $\underset{\substack{\text { Actual } \\ \text { inside } \\ \text { radius } \\(\mathrm{ft})}}{ }$ | Capacity in cubic feet per second at a flow (velocity) of 1 ft per bec | Weight of 100 ft of ${ }_{(10)}^{\text {pipe }}$ | Outside of pipe ( ft ) |
| :---: | :---: | :---: | :---: | :---: |
| 1 | 2 | 3 | 4 | 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 |
| 16 | . 6350 | 1.265 | 6,573 | 1.333 |

* Does not necessarily indicate the pipe is actually this size.

| $\begin{aligned} & \text { Common } \\ & \text { pipe } \\ & \text { size } \\ & \text { (in.) } \end{aligned}$ | Actual inside radius (ft) | Capacity in cubic feet per second at a flow (velocity) of 1 It per sec | Welght of 100 ft of pipe (lb) | Outside diameter of pipe ( f ) |
| :---: | :---: | :---: | :---: | :---: |
| 1 | 2 | 3 | 4 | 5 |
| 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 | . 8980 | 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 the pipe is actually this size.


### 7.28 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 elsewhere in this manual.) 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 tables below, single and/or double interpolation should be used to determine values in 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) Verical.
(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

$$
\begin{aligned}
& =\frac{(3.1416)(\text { radius of tank })^{2}(12)}{231} \\
& =\frac{(9.4248)(\text { diameter of tank })^{2}}{231} \\
& =(.0408)(\text { diameter })^{2}
\end{aligned}
$$

(b) Table. Gallons per foot of liquid depth are shown for vertical cylindrical tanks of various diameters.

| $\underset{(\text { in. })}{\text { Diameter }}$ | Gallons $\text { per } \mathrm{ft}$ | Diameter (in.) | Gallons per ft | $\underset{(\text { in. ) }}{\text { Diameter }}$ | Gallons per ft | $\underset{\text { (in.) }}{\text { Diameter }}$ | $\underset{\text { per }{ }_{\text {Gallons }}}{ }$ | $\int_{(\text {in. })}^{\text {Diameter }}$ | $\begin{gathered} \text { Gallons } \\ \text { per ft } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 0.0408 | 38 | 58.90 | 75 | 229.8 | 112 | 512.5 | 149 | 906.0 |
| 2 | 0.163 | 39 | 62.00 | 76 | 236.0 | 113 | 522.0 | 150 | 917.0 |
| 3 | 0.367 | 40 | 65.30 | 77 | 242.2 | 114 | 532.5 | 151 | 930.0 |
| 4 | 0.653 | 41 | 68.60 | 78 | 248.7 | 115 | 541.0 | 152 | 942.0 |
| 5 | 1.02 | 42 | 71.90 | 79 | 255.0 | 116 | 551.0 | 153 | 955.0 |
| 6 | 1.47 | 43 | 75.40 | 80 | 261.2 | 117 | 560.0 | 154 | 968.0 |
| 7 | 2.00 | 44 | 79.00 | 81 | 268.0 | 118 | 570.0 | 155 | 979.0 |
| 8 | 2.61 | 45 | 82.60 | 82 | 274.8 | 119 | 580.0 | 156 | 993.0 |
| 9 | 3.30 | 46 | 86.30 | 83 | 281.0 | 120 | 589.0 | 157 | 1,005 |
| 10 | 4.08 | 47 | 90.10 | 84 | 288.0 | 121 | 597.0 | 158 | 1,018 |
| 11 | 4.93 | 48 | 93.90 | 85 | 295.3 | 122 | 607.0 | 159 | 1,031 |
| 12 | 5.87 | 49 | 97.90 | 86 | 302.0 | 123 | 617.0 | 160 | 1,044 |
| 13 | 6.89 | 50 | 102.0 | 87 | 309.0 | 124 | 627.0 | 161 | 1,058 |
| 14 | 8.00 | 51 | 106.0 | 88 | 316.8 | 125 | 637.0 | 162 | 1,070 |
| 15 | 9.17 | 52 | 110.1 | 89 | 323.5 | 126 | 648.0 | 163 | 1,082 |
| 16 | 10.44 | 53 | 114.6 | 90 | 331.0 | 127 | 658.0 | 164 | 1,096 |
| 17 | 11.78 | 54 | 118.9 | 91 | 338.0 | 128 | 668.0 | 165 | 1,110 |
| 18 | 13.22 | 55 | 123.3 | 92 | 346.0 | 129 | 679.0 | 166 | 1,122 |
| 19 | 14.72 | 56 | 127.9 | 93 | 353.6 | 130 | 689.0 | 167 | 1,137 |
| 20 | 16.31 | 57 | 132.8 | 94 | 361.0 | 131 | 698.0 | 168 | 1,151 |
| 21 | 18.00 | 58 | 137.4 | 95 | 369.0 | 132 | 710.0 | 169 | 1,165 |
| 22 | 19.75 | 59 | 142.2 | 96 | 377.0 | 133 | 722.0 | 170 | 1,178 |
| 23 | 21.60 | 60 | 147.1 | 97 | 384.5 | 134 | 733.0 | 171 | 1,193 |
| 24 | 23.50 | 61 | 152.1 | 98 | 392.5 | 135 | 743.0 | 172 | 1,205 |
| 25 | 25.50 | 62 | 157.0 | 99 | 401.0 | 136 | 754.0 | 173 | 1,219 |
| 26 | 27.56 | 63 | 162.0 | 100 | 408.5 | 137 | 766.0 | 174 | 1,235 |
| 27 | 29.79 | 64 | 167.5 | 101 | 417.0 | 138 | 777.0 | 175 | 1,247 |
| 28 | 32.00 | 65 | 172.5 | 102 | 426.0 | 139 | 788.0 | 176 | 1,263 |
| 29 | 34.33 | 66 | 177.7 | 103 | 434.0 | 140 | 800.1 | 177 | 1,278 |
| 30 | 36.65 | 67 | 183.3 | 104 | 442.5 | 141 | 811.0 | 178 | 1,293 |
| 31 | 39.20 | 68 | 188.3 | 105 | 451.0 | 142 | 822.0 | 179 | 1,309 |
| 32 | 41.80 | 69 | 194.5 | 106 | 459.0 | 143 | 833.0 | 180 | 1,322 |
| 33 | 44.40 | 70 | 200.0 | 107 | 467.5 | 144 | 846.0 | 181 | 1,336 |
| 34 | 47.20 | 71 | 206.0 | 108 | 477.5 | 145 | 858.0 | 182 | 1,347 |
| 35 | 49.90 | 72 | 211.9 | 109 | 486.0 | 146 | 871.0 | 183 | 1,365 |
| 36 | 52.80 | 73 | 217.5 | 110 | 495.0 | 147 | 882.0 | 184 | 1,380 |
| 37 | 55.80 | 74 | 223.6 | 111 | 503.0 | 148 | 893.0 | 185 | 1,395 |


| $\begin{gathered} \text { Diameter } \\ \text { (in.) } \end{gathered}$ | Gallons per ft | $\begin{gathered} \text { Diameter } \\ (\text { in. }) \end{gathered}$ | Gallons per ft | $\underset{\text { (in.) }}{\text { Diameter }}$ | Gallons per ft | $\underset{\text { (in.) }}{\text { Diameter }}$ | Gallons per It | $\underset{(i n .)}{\text { Diameter }}$ | Gallons per ft |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 186 | 1,411 | 243 | 2,409 | 300 | 3,665 | 356 | 5,180 | 650 | 17,250 |
| 187 | 1,425 | 244 | 2,429 | 301 | 3,690 | 357 | 5,210 | 660 | 17,770 |
| 188 | 1,442 | 245 | 2,449 | 302 | 3,720 | 358 | 5,240 | 670 | 18,330 |
| 189 | 1,459 | 246 | 2,469 | 303 | 3,748 | 359 | 5,270 | 680 | 18,880 |
| 190 | 1,472 | 247 | 2,489 | 304 | 3,770 | 360 | 5,280 | 690 | 19,450 |
| 191 | 1,486 | 248 | 2,509 | 305 | 3,800 | 365 | 5,440 | 700 | 20,000 |
| 192 | 1,504 | 249 | 2,530 | 306 | 3,820 | 370 | 5,580 | 710 | 20,600 |
| 193 | 1,520 | 250 | 2,550 | 307 | 3,850 | 375 | 5,740 | 720 | 21,190 |
| 194 | 1,537 | 251 | 2,571 | 308 | 3,880 | 380 | 5,890 | 730 | 21,750 |
| 195 | 1,553 | 252 | 2,590 | 309 | 3,900 | 385 | 6,060 | 740 | 22,360 |
| 196 | 1,566 | 253 | 2,610 | 310 | 3,920 | 390 | 6,200 | 750 | 22,980 |
| 197 | 1,580 | 254 | 2,630 | 311 | 3,950 | 395 | 6,370 | 760 | 23,600 |
| 198 | 1,600 | 255 | 2,650 | 312 | 3,970 | 400 | 6,530 | 770 | 24,220 |
| 199 | 1,618 | 256 | 2,672 | 313 | 4,000 | 405 | 6,700 | 780 | 24,870 |
| 200 | 1,631 | 257 | 2,694 | 314 | 4,030 | 410 | 6,860 | 790 | 25,500 |
| 201 | 1,648 | 258 | 2,717 | 315 | 4,050 | 415 | 7,030 | 800 | 26,120 |
| 202 | 1,666 | 259 | 2,734 | 316 | 4,080 | 420 | 7,190 | 810 | 26,800 |
| 203 | 1,680 | 260 | 2,756 | 317 | 4,110 | 425 | 7,380 | 820 | 27,480 |
| 204 | 1,697 | 261 | 2,780 | 318 | 4,130 | 430 | 7,540 | 830 | 28,100 |
| 205 | 1,714 | 262 | 2,800 | 319 | 4,160 | 435 | 7,730 | 840 | 28,800 |
| 206 | 1,733 | 263 | 2,819 | 320 | 4,180 | 440 | 7,900 | 850 | 29,530 |
| 207 | 1,748 | 264 | 2,844 | 321 | 4,210 | 445 | 8,080 | 860 | 30,200 |
| 208 | 1,766 | 265 | 2,862 | 322 | 4,230 | 450 | 8,260 | 870 | 30,900 |
| 209 | 1,781 | 266 | 2,890 | 323 | 4,260 | 455 | 8,450 | 880 | 31,680 |
| 210 | 1,800 | 267 | 2,909 | 324 | 4,280 | 460 | 8,630 | 890 | 32,350 |
| 211 | 1,819 | 268 | 2,930 | 325 | 4,310 | 465 | 8,830 | 900 | 33,100 |
| 212 | 1,836 | 269 | 2,950 | 326 | 4,340 | 470 | 9,010 | 910 | 33,800 |
| 213 | 1,851 | 270 | 2,979 | 327 | 4,360 | 475 | 9,200 | 920 | 34,600 |
| 214 | 1,870 | 271 | 2,992 | 328 | 4,390 | 480 | 9,390 | 930 | 35,360 |
| 215 | 1,884 | 272 | 3,018 | 329 | 4,420 | - 485 | 9,600 | 940 | 36,100 |
| 216 | 1,902 | 273 | 3,039 | 330 | 4,440 | 490 | 9,790 | 950 | 36,900 |
| 217 | 1,920 | 274 | 3,061 | 331 | 4,470 | 495 | 10,000 | 960 | 37,700 |
| 218 | 1,940 | 275 | 3,085 | 332 | 4,500 | 500 | 10,200 | 970 | 38,450 |
| 219 | 1,957 | 276 | 3,110 | 333 | 4,530 | 505 | 10,400 | 980 | 39,250 |
| 220 | 1,975 | 277 | 3,125 | 334 | 4,550 | 510 | 10,600 | 990 | 40,100 |
| 221 | 1,991 | 278 | 3,150 | 335 | 4,580 | 515 | 10,810 | 1,000 | 40,850 |
| 222 | 2,010 | 279 | 3,180 | 336 | 4,610 | 520 | 11,010 | 1,010 | 41,700 |
| 223 | 2,025 | 280 | 3,200 | 337 | 4,630 | 525 | 11,240 | 1,020 | 42,600 |
| 224 | 2,050 | 281 | 3,220 | 338 | 4,670 | 530 | 11,460 | 1,030 | 43,400 |
| 225 | 2,065 | 282 | 3,244 | 339 | 4,690 | 535 | 11,670 | 1,040 | 44,250 |
| 226 | 2,083 | 283 | 3,265 | 340 | 4,720 | 540 | 11,890 | 1,050 | 45,100 |
| 227 | 2,100 | 284 | 3,288 | 341 | 4,740 | 545 | 12,100 | 1,060 | 45,900 |
| 228 | 2,120 | 285 | 3,310 | 342 | 4,770 | 550 | 12,330 | 1,070. | 46,750 |
| 229 | 2,140 | 286 | 3,335 | 343 | 4,800 | 555 | 12,560 | 1,080 | 47,750 |
| 230 | 2,160 | 287 | 3,360 | 344 | 4,830 | 560 | 12,790 | 1,090 | 48,600 |
| 231 | 2,179 | 288 | 3,382 | 345 | 4,860 | 565 | 13,090 | 1,100 | 49,500 |
| 232 | 2,193 | 289 | 3,408 | 346 | 4,890 | 570 | 13,280 | 1;110 | 50,300 |
| 233 | 2,212 | 290 | 3,433 | 347 | 4,920 | 575 | 13,500 | 1,120 | 51,250 |
| 234 | 2,233 | 291 | 3,455 | 348 | 4,950 | 580 | 13,750 | 1,130 | 52,200 |
| 235 | 2,250 | 292 | 3,475 | 349 | 4,980 | 585 | 13,980 | 1,140 | 53,250 |
| 236 | 2,270 | 293 | 3,498 | 350 | 4,990 | 590 | 14,220 | 1,150 | 54, 100 |
| 237 | 2,291 | 294 | 3,529 | 351 | 5,030 | 600 | 14,700 | 1,160 | 55,100 |
| 238 | 2,310 | 295 | 3,550 | 352 | 5,060 | 610 | 15,210 | 1,170 | 56,000 |
| 239 | 2,330 | 296 | 3,572 | 353 | 5,080 | 620 | 15,700 | 1,180 | 57,000 |
| 240 | 2,350 | 297 | 3,595 | 354 | 5,110 | 630 | 16,200 | 1,190 | 58,000 |
| 241 | 2,370 | 298 | 3,620 | 355 | 5,150 | 640 | 16,750 | 1,200 | 58,900 |
| 242 | 2,389 | 299 | 3,648 |  |  |  |  | . |  |

(2) Horizontal.
(a) When the capacity of a horizontal cylindrical tank is known, the quantity in the tank may be approximated by using the scale below.
Part of tank depth filled Part of tank capacity filled

|  | 1.000 |
| ---: | ---: |
| 0.95 | .974 |
| .90 | .948 |
| .85 | .904 |
| .80 | .860 |
| .75 | .804 |
| .70 | .740 |
| .65 | .687 |
| .60 | .626 |
| .55 | .563 |
| .50 | .500 |
| .45 | .437 |
| .40 | .374 |
| .35 | .313 |
| .30 | .252 |
| .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 8,000 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.
$\mathrm{L}=$ length of tank
$\mathrm{l}=$ depth of liquid in tank
$\mathrm{r}=$ radius of tank
$h=$ distance from top of tank to surface of liquid
$\mathrm{D}=$ 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.) $=\left[\frac{\mathrm{ar}}{2}-(r-1) \sqrt{2 \mathrm{rl}-l^{2}}\right] \times \frac{\mathrm{L}}{231}$
2. When tank is half full:

$$
\text { Volume (gal.) }=\frac{r^{2} \mathrm{~L}}{147}
$$

3. When tank is more than half full:

Volume (gal.)

$$
=\left[3.1416 \mathrm{r}^{2}-\mathrm{a}^{\prime} \mathrm{r}+(\mathrm{r}-\mathrm{h}) \sqrt{2 \mathrm{rh}-\mathrm{h}^{2}}\right] \times \frac{\mathrm{L}}{231}
$$

(c) When it is not practical to measure $a$ and $a^{\prime}$ in the formulas above (due to buried tanks, etc.), the lengths of these arcs can be computed by determining $1 / D$ and $h / D$ ratios, and using the table below.

| Tank less than half full |  |  |  | Tank more than half full |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1/D | Quantity to multiply D by to ob$\operatorname{tain} a$ | 1/D | Quantity to multiply D by to obtain a | h/D | Quantity to multiply D by to obtain $a^{\prime}$ |  | Quantity to multiply $\mathbf{D}$ by to ob$\operatorname{tain} a^{\prime}$ |
| . 01 | 0.200 | . 26 | 1.070 | . 01 | 0.200 | . 26 | 1.070 |
| . 02 | 0.284 | . 27 | 1.093 | . 02 | 0.284 | . 27 | 1.093 |
| . 03 | 0.348 | . 28 | 1.115 | . 03 | 0.348 | . 28 | 1.115 |
| . 04 | 0.403 | . 29 | 1.137 | . 04 | 0.403 | . 29 | 1.137 |
| . 05 | 0.451 | . 30 | 1.159 | . 05 | 0.451 | . 30 | 1.159 |
| . 06 | 0.495 | . 31 | 1.181 | . 06 | 0.495 | . 31 | 1.181 |
| . 07 | 0.536 | . 32 | 1.203 | . 07 | 0.536 | . 32 | 1.203 |
| . 08 | 0.574 | . 33 | 1.224 | . 08 | 0.574 | . 33 | 1.224 |
| . 09 | 0.609 | . 34 | 1.245 | . 09 | 0.609 | . 34 | 1.245 |
| . 10 | 0.644 | . 35 | 1.266 | . 10 | 0.644 | . 35 | 1.266 |
| . 11 | 0.676 | . 36 | $1.287^{\circ}$ | . 11 | 0.676 | . 36 | $1^{1} .287$ |
| . 12 | 0.708 | . 37 | 1.308 | . 12 | 0.708 | . 37 | 1.308 |
| . 13 | 0.738 | . 38 . | 1.328 | . 13 | 0.738 | . 38 | 1.328 |
| . 14 | 0.767 | . 39 - | 1.349 | . 14 | 0.767 | . 39 | 1.349 |
| . 15 | 0.795 | . 40 | 1.369 | . 15 | 0.795 | . 40 | 1.369 |
| . 16 | 0.823 | . 41 | 1.390 | . 16 | 0.823 | . 41 | 1.390 |
| . 17 | 0.850 | . 42 | 1.410 | . 17 | 0.850 | . 42 | 1.410 |
| . 18 | 0.876 | . 43 | 1.430 | . 18 | 0.876 | . 43 | 1.430 |
| . 19 | 0.902 | . 44 | 1.451 | . 19 | 0.902 | . 44 | 1.451 |
| . 20 | 0.927 | . 45 | 1.471 | . 20 | 0.927 | . 45 | 1.471 |
| . 21 | 0.952 | . 46 | 1.491 | . 21 | 0.952 | . 46 | 1.491 |
| . 22 | 0.976 | . 47 | 1.511 | . 22 | 0.976 | . 47 | 1.511 |
| . 23 | 1.000 | . 48 | 1.531 | . 23 | 1.000 | . 48 | 1.531 |
| . 24 | 1.024 | . 49 | 1.551 | . 24 | 1.024 | . 49 | 1.551 |
| . 25 | 1.047 | . 50 | 1.571 | . 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 length. Therefore, in the formulas shown in (b) above, the ratio $\mathrm{L} / 231$ becomes a constant of 0.0519 . To obtain liquid volume, multiply the figure from the table by the tank length (feet and fractions).

Depth of liquid in tank (in.)


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 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 54 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 57 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 63 | 162.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 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 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| E 81 | 223.2 | 233.4 | 242.7 | 251.1 | 258.2 | 263.5 | 268.0 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 过 84 | 231.6 | 242.7 | 253.1 | 262.7 | 271.3 | 278.8 | 284.6 | 287.9 |  |  |  |  |  |  |  |  |  |  |  |  |
| 蔞 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 |  |  |  |  |  |  |  |  |  |
| 奇 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 |  |  |  |  |  |  |  |  |
| F－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. |

c．Rectangular Tanks．The table 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 table were obtained from the following formula：

$$
\text { Volume (gal.) }=\frac{\mathrm{Lwl}}{231}
$$

Where

$$
\begin{aligned}
\mathrm{L} & =\text { length of tank in inches } \\
\mathrm{w} & =\text { width of tank in inches } \\
\mathrm{l} & =\text { depth of liquid in inches }
\end{aligned}
$$

Length of tank（in．）

|  |  | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 38 | 36 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |
| E | 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 |
| 号 | 42 | 26.19 | 32.70 | 39.24 | 45.80 | 52.30 | 58.90 | 65.50 | 72.00 | 78.50 |
| $\stackrel{5}{7}$ | 45 | 28.05 | 35.10 | 42.10 | 49.10 | 56.10 | 63.10 | 70.20 | 77.20 | 84.20 |
| $\stackrel{\square}{0}$ | 48 | 29.93 | 37.40 | 44.90 | 52.30 | 59.80 | 67.30 | 74.80 | 82.30 | 89.80 |
| 喜 | 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 |

Length of tank (in.)

|  |  | 12 | 15 | 18 | 21 | 24 | 27 | 80 | 33 | 36 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 81 | 50.50 | 63.10 | 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 |
| $\bigcirc$ | 90 | 56.10 | 70.20 | 84.20 | 98.20 | 112.20 | 126.10 | 140.30 | 154.50 | 168.30 |
| E | 93 | 58.00 | 72.45 | 86.90 | 101.40 | 115.70 | 130.40 | 145.00 | 159.50 | 174.00 |
| 当 | 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 |
| $B$ | 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.)

|  | 89 | 42 | 45 | 43 | 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 |
| $\stackrel{\text { ¢ }}{ }$ | 133.90 | 144.00 | 154.10 | 164.60 | 174.60 | 185.10 | 195.50 | 205.50 | 215.80 |
| 눙 69 | 139.80 | 150.50 | 161.20 | 172.00 | 182.60 | 193.50 | 204.50 | 215.00 | 225.30 |
| 完 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 |
| d | 57 | 195.50 | 204.50 | 213.00 | 222.00 | 231.00 | 239.90 | 249.00 | 257.80 | 266.90 |
| c | 60 | 205.50 | 215.00 | 224.30 | 233.30 | 243.00 | 252.30 | 261.60 | 271.00 | 280.50 |
| 号 | 63 | 215.80 | 225.30 | 235.20 | 245.00 | 255.00 | 264.90 | 274.90 | 284.60 | 294.10 |
| $\pm$ | 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 |
| 矴 | 72 | 247.00 | 258.00 | 269.30 | 280.40 | 291.60 | 302.90 | 314.20 | 325.00 | 36．50 |
| B | 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．）

|  |  | 93 | 96 | 99 | 102 | 105 | 108 | 111 | 114 | 117 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 12 | 58.00 | 59.80 | 61.70 | 63.60 | 65.40 | 67.30 | 69.20 | － 71.00 | 72.80 |
|  | 15 | 72.45 | 74.80 | 77.20 | 79.60 | 81.90 | 84.20 | 86.60 | 88.90 | 91.30 |
|  | 18 | 86.90 | 89.80 | 92.60 | 95.50 | 98.30 | 101.20 | 103.90 | 106.70 | 109.50 |
|  | 21 | 101.40 | 104.50 | 108.00 | 111.20 | 114.50 | 117.80 | 121.00 | 124.40 | 127.50 |
|  | 24 | 115.70 | 119.60 | 123.50 | 127.20 | 131.00 | 134.60 | 138.30 | 142.10 | 145.90 |
|  | 27 | 130.40 | 134.50 | 138.90 | 143.00 | 147.30 | 151.50 | 155.50 | 159.80 | 164.00 |
| E | 30 | 145.00 | 149.60 | 154.40 | 158.90 | 163.60 | 168.30 | 173.00 | 177.70 | 182.40 |
|  | 33 | 159.50 | 164.50 | 169.70 | 174.50 | 179.60 | 184.90 | 190.00 | 195.00 | 200.50 |
| 号 | 36 | 174.00 | 179.50 | 185.20 | 190.70 | 196.40 | 202.00 | 205.20 | 213.20 | 219.00 |
|  | 39 | 188.50 | 194.40 | 200.50 | 206.50 | 212.50 | 218.60 | 224.80 | 230.90 | 237.00 |
| － | 42 | 203.00 | 209.50 | 216.00 | 222.50 | 229.00 | 235.60 | 242.00 | 248.70 | 255.00 |
| 球 | 45 | 217.20 | 224.40 | 231.50 | 238.50 | 245.30 | 252.70 | 259.80 | 266.90 | 273.90 |
| 3 | 48 | 231.90 | 239.40 | 247.00 | 254.30 | 261.50 | 269.30 | 276.60 | 284.20 | 291.50 |
|  | 51 | 246.10 | 254.10 | 262.10 | 270.00 | 278.00 | 286.00 | 294.00 | 302.00 | 310.00 |
|  | 54 | 261.00 | 269.30 | 277.80 | 286.00 | 294.50 | 303.00 | 311.00 | 319.80 | 328.20 |
|  | 57 | 275.20 | 284.00 | 293.00 | 302.00 | 311.00 | 319.80 | 328.80 | 337.80 | 346.50 |
|  | 60 | 289.80 | 299.30 | 308.80 | 318.00 | 327.20 | 336.60 | 346.00 | 355.30 | 365.00 |
|  | 63 | 304.00 | 314.00 | 324.00 | 333.20 | 343.20 | 353.00 | 362.90 | 372.90 | 382.90 |
|  | 66 | 319.00 | 329.00 | 339.30 | 349.60 | 360.00 | 370.30 | 380.60 | 391.00 | 401.70 |

Length of tank (in.)


Length of tank (in.)


## 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.

$$
\text { Volume (gal.) }=\frac{.7854 a b L}{231}
$$

where
$\mathrm{a}=$ long axis of elliptical cross-section
b = short axis of elliptical cross-section
$\mathrm{L}=$ 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 $\operatorname{tank}$ filled | Part of tank capacity filled | $\begin{gathered} \text { Part of } \\ \text { tank depth } \\ \text { filled } \end{gathered}$ | Part of tank capacity filled | $\begin{gathered} \text { Part of } \\ \text { tank depth } \\ \text { filled } \end{gathered}$ | Part of tank capacity filled |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0.01 | 0.0020 | 0.35 | 0.3119 | 0.68 | 0.7234 |
| 0.02 | 0.0050 | 0.36 | 0.3244 | 0.69 | 0.7352 |
| 0.03 | 0.0090 | 0.37 | 0.3366 | 0.70 | 0.7469 |
| 0.04 | 0.0134 | 0.38 | 0.3490 | 0.71 | 0.7593 |
| 0.05 | 0.0187 | 0.39 | 0.3614 | 0.72 | 0.7700 |
| 0.06 | 0.0245 | 0.40 | 0.3739 | 0.73 | 0.7814 |
| 0.07 | 0.0307 | 0.41 | 0.3864 | 0.74 | 0.7927 |
| 0.08 | 0.0374 | 0.42 | 0.3989 | 0.75 | 0.8039 |
| 0.09 | 0.0445 | 0.43 | 0.4114 | 0.76 | 0.8150 |
| 0.10 | 0.0520 | 0.44 | 0.4240 | 0.77 | 0.8260 |
| 0.11 | 0.0598 | 0.45 | 0.4366 | 0.78 | 0.8368 |
| 0.12 | 0.0680 | 0.46 | 0.4492 | 0.79 | 0.8474 |
| 0.13 | 0.0764 | 0.47 | 0.4619 | 0.80 | 0.8577 |
| 0.14 | 0.0850 | 0.48 | 0.4745 | 0.81 | 0.8677 |
| 0.15 | 0.0940 | 0.49 | 0.4873 | 0.82 | 0.8776 |
| 0.16 | 0.1032 | 0.50 | 0.5000 | 0.83 | 0.8873 |
| 0.17 | 0.1127 | 0.51 | 0.5127 | 0.84 | 0.8968 |
| 0.18 | 0.1224 | 0.52 | 0.5255 | 0.85 | 0.9060 |
| 0.19 | 0.1323 | 0.53 | 0.5381 | 0.86 | 0.9150 |
| 0.20 | 0.1423 | 0.54 | 0.5508 | 0.87 | 0.9236 |
| 0.21 | 0.1526 | 0.55 | 0.5634 | 0.88 | 0.9320 |
| 0.22 | 0.1632 | 0.56 | 0.5760 | 0.89 | 0.9402 |
| 0.23 | 0.1740 | 0.57 | 0.5886 | 0.90 | 0.9480 |
| 0.24 | 0.1850 | 0.58 | 0.6011 | 0.91 | 0.9555 |
| 0.25 | 0.1961 | 0.59 | 0.6136 | 0.92 | 0.9626 |
| 0.26 | 0.2073 | 0.60 | 0.6261 | 0.93 | 0.9693 |
| 0.27 | 0.2186 | 0.61 | 0.6386 | 0.94 | 0.9755 |
| 0.28 | 0.2300 | 0.62 | 0.6510 | 0.95 | 0.9813 |
| 0.29 | 0.2407 | 0.63 | 0.6634 | 0.96 | 0.9866 |
| 0.30 | 0.2531 | 0.64 | 0.6756 | 0.97 | 0.9910 |
| 0.31 | 0.2648 | 0.65 | 0.6881 | 0.98 | 0.9950 |
| 0.32 | 0.2766 | 0.66 | 0.6997 | 0.99 | 0.9980 |
| 0.33 | 0.2884 | 0.67 | 0.7116 | 1.00 | 1.0000 |
| 0.34 | 0.3003 |  |  |  |  |

e. Spherical Tanks. The table ((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 table. 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:
$\mathrm{d}=$ depth of liquid or height of segment of sphere formed by liquid (when tank is less than half full)
$=$ distance from top of sphere to surface of liquid (when tank is more than half full)
$C=a$ value for different $d / D$ relationships which represents the volume of the sphere segment divided by the cube of the sphere's diameter
$\mathrm{D}=$ diameter of tank
(1) When tank is less than half full:
(a) To find the volume of the liquid, form the ratio $\mathrm{d} / \mathrm{D}$ and find the value of C in the table. Then Volume of liquid $=\mathrm{D}^{3} \mathrm{C}$
(b) Alternate method: (table not required) Volume of liquid $=.5236 \mathrm{~d}^{2}(3 \mathrm{D}-2 \mathrm{~d})$
(2) When tank is half full:

Volume of liquid $=.2618 \mathrm{D}^{3}$ (table not required)
(3) When tank is more than half full:
(a) Since the ratio $\mathrm{d} / \mathrm{D}$ (if d is considered the depth of liquid) becomes greater than 0.50 , the table no longer applies. Therefore, the table should be used to determine the volume of the unfilled portion. Subtract this from the total volume of the tank $\left(.5236 \mathrm{D}^{3}\right)$ 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 table. The unfilled portion is then $D^{3} \mathrm{C}$, and the volume of the filled portion can be determined as follows:
Volume of liquid $=.5236 \mathrm{D}^{3}-\mathrm{D}^{3} \mathrm{C}$ $=\mathrm{D}^{3}(.5236-\mathrm{C})$
(b) Alternate method: (table not required)

Volume of liquid $=.5236 \mathrm{D}^{3}$

$$
-\left[.5236 \mathrm{~d}^{2}(3 \mathrm{D}-2 \mathrm{~d})\right]
$$

(4) Table.

| d/D | c | 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 | 0.41 | 0.1919 |
| 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 | 0.2305 |
| 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.

| Product | Coefficient of expansion or contraction (base of $60^{\circ} \mathrm{F}$.)* |
| :---: | :---: |
| Aviation gasoline_ | 0.00070 |
| Motor gasoline and naptha (other than cleaning solvent) | 0.00060 |
| Light crude oil (above $35^{\circ}$ API gravity), jet fuel, cleaning solvent, kerosene, distillate fue oil, and fog oil. $\qquad$ | l $\begin{aligned} & \\ & 0.00050\end{aligned}$ |
| Medium crude oil ( $15^{\circ}$ to $35^{\circ}$ API gravity), and lubricating oil | 0.00040 |
| Heavy crude oil (up to $15^{\circ}$ API gravity) residual oil, and asphalt | , 0.00035 |

[^35]
### 7.30. Bulk Capacities

| Carrer | Galiona | Short tons |  |
| :---: | :---: | :---: | :---: |
|  |  | $\underset{\text { (bulk) }}{\text { Gasoline }} 91 \mathbf{A}$ | Lube oil (bulk) |
| Barge, coastwisel | 200, 000 to 400,000 | 614 to 1,228 | 761 to 1,522 |
| Barge, harbor and canal ${ }^{2}$ | 15,000 to 30,000 | 45.9 to 91.8 | 57 to 114 |
| Barge, Navy ponton ${ }^{\text {a }}$ - | 84,000 | 257 | 320 |
| Pipeline: ${ }^{4}$ |  |  |  |
| 4-inch | 304,000 per day | 930 | 1,150 |
| 6 -inch | 655,000 per day ${ }^{5}$ | 2,000 | 2,500 |
| 8 -inch | 1, 135,000 per day | 3,500 | 4,350 |
| Railroad tank car | 8,000; 10,$000 ; 12,000$ | 24.1; $30.6 ; 36.8$ | 30.4; 38.1; 45.7 |
| Semitrailer, 12-ton 4W. | 5,000 | 15.3 | 19 |
| Ship, large tanker ${ }^{\text {d }}$ | 2.5 to 11 million | 7,620 to 33,500 | 9,480 to 43,800 |
| Ship, small tanker? | 600,000 to 2 million | 1,830 to 6,140 | 2,280 to 7,610 |
| Tank, bolted-steel | 10,500; 42, 000 ; 420, 000 | 32.2; 128; 1,280 | 39.9; 160; 1,600 |
| Tank, portable fabric ${ }^{8}$. | 10,000 | 30.6 | 38.1 |
| Tank truck, F-3, fuel or oil | 750 | 2.3 | 2.9 |
| Tank truck, L-2, oil service.----------- | 600 | 1.8 | 2.3 |
| Trailer, fuel servicing - | 600 | 1.8 | 2.3 |
| Transporter, liquid, rolling-wheel type (RLT), $1,000 \mathrm{gal}$. T3 ${ }^{9}$ | 1,000 | 3.0 | 3.7 |

See footnotes on page 324.

| Carrier | Gallons | Short tons |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | $\underset{\text { (bulk) }}{\text { Gasoline }} 91 \mathrm{~A}$ | Lube oil (bulk) |  |
| Truck tractor and trailer, F-1 | 4,000 | 12.2 | 15.2 |  |
| Truck tractor and 2 trailers, F-1A | 8,000 | 24.4 | 30.4 |  |
| Truck tractor and trailer, F-2 | 2,000 | 6.1 | 7.6 | = |
| Truck tractor and 2 trailers, F-2A. | 4,000 | 12.2 | 15.2 |  |

${ }^{1}$ Molded hulls.
${ }^{2}$ Rectangular hulls.
${ }^{3} 6 \times 18$ ponton barge carrying three 42,000 -gallon tanks loaded to two-thirds capacity.

- In maintaining the same volumetric pipeline capacity for gasoline and oil, more pressure is required for the heavier liquid.
© Based on 32,500 gallons per hour for $\mathbf{2 0}$ hours of operation. In an emergency it can deliver $\mathbf{3 0 , 0 0 0}$ gallons per hour for $\mathbf{2 4}$ hours of operation, or $\mathbf{7 2 0 , 0 0 0}$ gallons per day.
- The ship tanker most commonly used is the T2-SE-A1, a $5,922,000$-gallon tanker. It is 425 feet long and draws 31 feet. Has three 8-flanged discharge outlets and four discharge pumps rated $1,000 \mathrm{gpm}$ at 100 pai.

7 Draft loaded, 12 to 20 feet.
B 40 feet long, 12 feet wide, 3 feet high when filled. When empty, it can be rolled to 20 inches by 12 feet; 10 can be carried in a $6 \times 6$ truck.

- A pair of removable synthetic-rubber containers (fuel cells) mounted on an axle and towing unit. Each cell has a capacity of 500 gal.


## Section VIII. SUPPLY

### 7.31 Classes of Supply

| Class | Definition | How obtained |
| :---: | :---: | :---: |
| I | Articles consumed at an approximately uniform rate, such as rations. | From QM class I distributing points. Basis of issue is the daily report of personnel strength and-equipment status submitted through channels. |
| II | Articles authorized by established allowances, such as TOE's, TA's, or special authorizations. | By requisition. Often submitted through channels to Army or section special staff officer of the supplying technical service. |
| III | Fuels, lubricants, fuel oils, coal and | Directly from Army or logistical command distribution points. |
| III(A) | Aviation fuels and lubricants | Obtained on credit basis or by exchange of empty for filled containers. |
| 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. |

### 7.32 Shipping Data on Commonly Transported Items

## a. Rations.

| Type | Package or case |  |  | Ration or packet including packaging |  | Avg calories |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Contents | $\begin{aligned} & \text { Weight } \\ & (\mathrm{lb}) \end{aligned}$ | Cuft | $\begin{aligned} & \text { Avg weight } \\ & (\mathrm{lb}) \end{aligned}$ | $\underset{(\mathrm{cu} f \mathrm{f})}{\mathrm{Avg}} \mathbf{v o l}$ |  |
| Field $\mathrm{A}^{1}$. |  |  |  | 6.0 | 0.183 | 4,200 |
| Operational $\mathrm{B}^{2}$ |  |  |  | 6.0 | 0.127 | 4,400 |
| Small detachment, 5 persons ${ }^{3}$. | 5 rations | 28.5 | 1.1 | 5.8 | 0.2 | 3,600 |
| Combat, indiv4. | 6 rations | 38 | 1.2 | 6.5 | 0.2 | 3,600 |
| Trail, frigid, indiv ${ }^{5}$ | 8 rations | 34 | 1.6 | 4.0 | 0.2 | 4,400 |
| Supplement, sundries pack (1 pack per 100 men$)^{6}$ |  | 47 | 1.9 |  |  |  |


| Type | Package or cabe |  |  | Ratlon or packet including packaging |  | Avg calories |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Contents | $\underset{(\mathrm{lb})}{\text { Weight }}$ | Cu ft | Avg weight | Avg vol (cu ft) |  |
| Indiv, combat, meal type . .-.-...- | 4 rations | 24 |  | 4.8 | 0.85 | 3,600 |
| Supplement, aid station (205 8-02 drinks) ${ }^{7}$ |  | 20 | 1.1 |  |  |  |
| Food packet, assault, indiv ${ }^{8}$. $\ldots$. | 24 packets | 29 | 1.1 | 1.1 |  | 800 |
| Survival: |  |  |  |  |  |  |
| Arctic, SA ${ }^{\text {9 }}$ - | 24 packets | 34 | 0.7 | 1.5 |  | 2,000 |
| Tropic, ST ${ }^{10}$ | 24 packets | 36 | 0.7 | 1.5 | - | 1,700 |

1 Basic field ration of approximately 200 items, including such perishables as fresh and frozen meata, vegetables, and fruit. For use primarily under stable conditions and during atatic phases of military operations when there are normal cooking and refrigeration facilities. Should be issued in preference to any otber ty pe of ration whenever circumstances permit its use. Components, weight, and volume vary.
${ }^{2}$ Canned or dry items and 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, consist of assorted spices, condimenta, and leavening agents to supplement 1,000 operatlonal rations $B$. Tbe apice pack varies in weight and volume, being tailormade for differentsituations and acaled to the $B$ ratlon.
' Nonperisbable precooked food whlch may be eaten hot when organized messing is impossible but feeding in small groups is possible.

- Nonperisbable precooked food whicb may be eaten hot or cold, carried and prepared by the individual soldier. For use when the tactical situation is so unstable tbat messing in amall groups is not possible and kitchen facilitics are not available.
- For use in extremely cold climates by small patrols or trail teams when resupply is impossiblc.
- Comfort items such as toilet articles, tobacco and candy as a supplement to ration B, for issuc before the establishment of adequate sales facilities.
${ }^{7}$ Speclal nourisbment in the form of hot atimulating beverages for combat zone casualties at aid and clearing stations.
- Ligbtwelght, highly palatable food conveniently carried by the individual in tbe initial assault phase of combat. Not for use for longer periods than $\mathbf{3 0}$ hours.
- For survival kits aboard aircraft operating over arctic regions, in tbe emergency kit forming a part of the ejection seat in combat aircraft, and in emergency kits for passengers aboard transport aircralt.
${ }^{10}$ Palatable food of higb caloric density carried in survival kits of aircraft operating over the tropics.


## b. Ammunition.

| Nomenclature | Numberper unit | Weight (b) |  | Cubic feet |  | Stowage factor |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Crated | Uncrated | Crated | Uncrated | Crated | Uncrated |
| Canister, $\mathrm{N} 2,37 \mathrm{~mm}, \mathrm{G}$ | 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 |  |
| Cart, AP, 7.62 mm , in cartons, grade $\mathrm{R}_{-}$ | 960 | 72 |  | . 91 |  | 28 |  |
| Cart, AP, 7.62 mm , in cartons, grade $\mathrm{R}_{-}$ | 1,040 | 78 |  | 1.28 |  | 37 |  |
| Cart, AP, 7.62 mm , in cartons, grade $\mathrm{R}^{-}$ | 1,200 | 86 |  | 1.28 |  | 33 |  |
| Cart, AP, 7.62 mm , in cartons, grade MG | 1,200 | 86 |  | 1.28 |  | 33 |  |
| Cart, AP, I\&T, cal $.301 / \mathrm{b}$ | 1,200 | 101 |  | 1.5 |  | 33 |  |
| Cart, AP, I\&T, cal .50, $1 / \mathrm{b}$. | 265 | 103 |  | 1.5 |  | 33 |  |
| Cart, AP\&T, cal .30, w/b (100 rds).-- | 1,200 | 92 |  | 1.5 |  | 37 |  |
| Cart, AP\&T, cal .30, w/b. | 1,240 | 98 |  | 1.5 |  | 34 |  |
| Cart, AP\&T, cal .30, w/b. | 1,250 | 100 |  | 1.5 |  | 34 |  |
| Cart, AP\&T, cal . $30,1 / \mathrm{b}$. | 1,200 | 107 |  | 1.5 |  | 31 |  |
| Cart, AP\&T, w/b, 250 rd mg, chest .- | 1,000 | 77 |  | . 9 |  | 26 |  |
| Cart, API, 7.62 mm , in cartons, grade R. $\qquad$ | 1,200 | 86 |  | 1.28 |  | 33 |  |
| 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, cal .30, w/b. | 1,200 | 93 |  | 1.5 |  | 36 |  |
| 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, 7.62mm, 220 rd belt $\ldots$. - | 880 |  |  | . 92 |  |  |  |
| Cart, ball, cal 30 carbine - ---------- | 3,000 | 100 |  | . 85 |  | 19 |  |
| Cart, ball, cal . 30 carbine.--.--------- | 3,450 | 107 |  | . 9 |  | 19 |  |


| Nomenclature | Numberper unit | Weight (lb) |  | Cubic feet |  | Stowage factor |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Crated | Uncrated | Crated | Uncrated | Crated | Uncrated |
| Cart, ball, cal .30, 8 rd clip | 1,344 | 110 |  | 1.5 |  | 31 |  |
| 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, in cartons. | 1,500 | 111 |  | 1.5 |  | 30 |  |
| 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, cal .50, in cartons. | 350 | 107 |  | 1.5 |  | 31 |  |
| Cart, ball, 7.62 mm , linked, grade MG_ | 880 | 78 |  | . 92 |  | 26 |  |
| Cart, ball, 7.62 mm , in cartons, grade $\mathrm{R}_{\text {- }}$ | 960 | 72 |  | . 91 |  | 28 |  |
| Cart, ball, 7.62 mm , in cartons, grade $\mathrm{R}_{\text {- }}$ | 1,200 | 86 |  | 1.28 |  | 33 |  |
| Cart, grenade, cal .30, M3-.-.-.-.-- | 2,000 | 90 |  | 1.5 |  | 37 |  |
| Cart, inc, cal .50, in cartons. | 350 | 108 |  | 1.5 |  | 31 |  |
| Cart, tracer, cal .30, in cartons. | 1,500 | 108 |  | 1.5 |  | 31 |  |
| Cart, tracer, cal 30, 5 rd clip. | 1,500 | 114 |  | 1.5 |  | 29 |  |
| Cart, tracer, cal .30, 8 rd clip. | 1,440 | 117 |  | 1.5 |  | 29 |  |
| Cart, tracer, cal .50, in cartons.-.---- | 350 | 111 |  | 1.5 |  | 30 |  |
| Cart, tracer, 7.62 mm , in cartons, grade R. | 1,200 | 86 |  | 1.28 |  | 33 |  |
| Cart, tracer, 7.62 mm , M62 in cartons, grade $\mathrm{R}_{\text {. }}$ | 400 | 28 |  | 54 |  | 43 |  |
| Cart, tracer, $7.62 \mathrm{~mm}, \mathrm{M} 62$ in cartons, grade R | 960 | 72 |  | . 91 |  | 28 |  |
| Cart, tracer, 7.62 mm , M62 in cartons, grade R | 1,040 | 78 |  | 1.28 |  | 37 |  |
| Cart, 12 ga , No. 00 buckshot $\ldots-\ldots$. | 500 | 62 |  | . 768 |  | 28 |  |
| Cart, 12 ga , No. $71 / 2$ - | 500 | 58 |  | . 768 |  | 30 |  |
| Cbg, prop, M1 A1 (green bag) 155 H . | 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) 155 H -- | 6 | 82 | 73 | 3.26 | 2.63 | 89 | 81 |
| Cbg, prop, M4 (white bag) 155 H | 3 | 79 | 58 | 3.92 | 2.5 | 111 | 97 |
| Chg, prop, 155G, 1917-17A1-18M1--- | 1 | 87 |  | 3.0 |  | 77 |  |
| Chg, prop, 155G, M1917-17A1-18M1- | 3 | 131 | 105 | 4.96 | 4.19 | 85 | 89 |
| Chg, prop, 155G, M1917-17A1-18M1. | 4 | 191 |  | 7.08 |  | 83 |  |
| Ch, prop, 155G, M1 \& M1A1 | 3 | 161 | 127 | 7.44 | 5.15 | 104 | 91 |
| 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, M.T., M67. | 25 | 78 |  | 1.46 | ------ | 42 | --- |
| Fuze, det, M6A2 | 200 | 64 |  | 2.50 |  | 88 |  |
| Fuze, ing, M10A2 | 200 | 64 |  | 2.7 |  | 95 |  |
| Grenade, AT, M11A1, pret | 50 | 87 |  | 3.3 |  | 85 |  |
| Grenade, hand, frg, Mk II | 25 | 50 |  | 1.26 |  | 57 |  |
| Grenade, band, off (unfuzed) | 50 | 50 |  | 1.37 | ------- | 62 | ---- |
| Grenade, hand, tug, Mk, 1 A1 | 24 | 47 |  | . 97 |  | 46 |  |
| Grenade, rifle, M9 and M9A1. | 10 | 32 |  | 1.2 | ------ | 83 | ---- |
| Grenade, rifle, prct, M11 | 50 | 108 |  | 2.8 |  | 58 |  |
| Mine, AP, M2, M2A1-------------- | 10 | 93.4 |  | 2.33 | ------ | 56 |  |
| Mine, AP, M3 | 6 | 75 |  | . 80 | ------- | 24 |  |
| Mine, AT, M1, prct | 5 | 68 |  | 1.45 |  | 48 |  |
| Mine, AT, M1A1. | 5 | 73 |  | 1.45 |  | 45 |  |
| Primer, DTE, M14, 1 -sec delay .-..-- | 100 | 67 |  | 1.01 |  | 34 |  |
| Primer, perc, Mk 11, Mk 11A, Mk $11 \mathrm{Al}$ | 2,400 | 96 |  | 1.56 |  | 36 |  |
| Shell, AP, M112B1, 155 G | 1 | 117 |  | 1.34 |  | 26 |  |
| Shell, all other 155 mm . | 1 |  | 96 |  | . 83 |  | 19 |
| Shell, HE, M1, w/f M48, 105 mm H.-- | 3 | 172 | 154 | 2.37 | 2.06 | 31 | 30 |
| Shell, HE, M43A1 (lt) 81 mm , M | 6 | 72 | 58 | 1.65 | 1.08 | 51 | 42 |
| Shell, HE, M48, w/f M48, 75 GNC - - | 3 | 82 | 68 | 1.84 | 1.03 | 50 | 34 |
| Shell, HE, M48, w/f M48, 75 GNC | 3 | 84 | 70 | 1.84 | 1.03 | 50 | 33 |


| Nomenclature | $\underset{\text { per }}{\text { Number }}$ unit | Weight (b) |  | Cubic feet |  | Stowage factor |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Crated | Uncrated | Crated | Uncrated | Crated | Uncrated |
| Shell, HE, M48, w/f M48, 75 H. | 3 | 80 | 69 | 1.35 | . 92 | 38 | 30 |
| Shell, HE, M48, w/f M54, 75 GNC. | 3 | 82 | 68 | 1.84 | 1.03 | 50 | 34 |
| Shell, HE, M48, w/f M54, 75 GNC. | 3 | 84 | 70 | 1.84 | 1.03 | 50 | 33 |
| Shell, HE, M48, w/f M54, 75 H. | 3 | 80 | 69 | 1.35 | . 92 | 38 | 30 |
| Shell, HE, M49A2, 60mm, M. | 18 | 103 | 82 | 3.23 | 2.51 | 70 | 69 |
| Shell, HE, M56 (hv), $81 \mathrm{~mm}, \mathrm{M}_{\text {- }}$ | 3 | 55 | 42 | 1.33 | . 91 | 54 | 49 |
| Shell, HE, M63, 37mm, G | 20 | 91 |  | 2.04 |  | 50 |  |
| Shell, HE, M71, 90 mm , G | 4 | 237 |  | 4.43 |  | 42 |  |
| Shell, HE, N54, 37 mm , G_ | 25 | 99 |  | 2.03 |  | 46 |  |
| Shell, HE, Mk 1 (Navy), 40mm, G | 16 | 115 |  | 1.80 |  | 35 |  |
| Shell, HE, Mk 11, 37 mm , G | 60 | 114 |  | 1.60 |  | 31 |  |
| Shell, HE, w/f, M54, 105 H | 3 | 172 | 154 | 2.37 | 2.06 | 31 | 30 |
| Shell, HE, $3^{\prime \prime}$ AA G. | 4 | 153 |  | 3.22 |  | 47 |  |
| Shell, QF, Mk II, 40 mm , G | 24 | 161 |  | 3.13 |  | 44 |  |
| Shell, pret, Mk II, 37 mm , G. | 40 | 90 |  | 1.38 |  | 34 |  |
| Shell, pret, M50A2, 60 mm , M | 18 | 103 | 82 | 2.23 | 2.51 | 70 | 69 |
| Shell, Mk I, unfuzed, 75 G | 3 | 72 | 57 | 1.72 | . 96 | 54 | 38 |
| Shell, $8^{\prime \prime}$, G... | 1 |  | 386 |  |  |  |  |
| Shell, $8^{\prime \prime}$, how_ | 1 |  | 163 |  |  |  |  |
| Shell, 280 mm , G | 1 |  | 770 |  |  |  |  |
| Shot, AP, M78, ${ }^{\prime \prime}$, AA G | 4 | 153 |  | 3.22 |  | 47 |  |
| Shot, AP, M51, 37mm, G | 20 | 104 |  | 2.01 |  | 43 |  |
| Shot, AP, M74, 37 mm , G | 20 | 91 |  | 1.01 |  | 50 |  |
| Shot, AP, M72, 75 G_ | 3 | 80 | 66 | 1.51 | . 83 | 28 | 28 |
| Shot, AP, M77, 90 mm , G | 4 | 237 |  | 4.43 |  | 42 |  |
| Shot, APC, M59, 37 mm , G | 25 | 99 |  | 2.03 |  | 46 |  |
| Shot, APC, M61, 75 mm , G.S.C. | 3 | 83 | 70 | 1.84 | 1.03 | 50 | 33 |
| Shot, LE, Mk I, 37 mm , G- | 60 | 105 |  | 1.38 |  | 29 |  |
| Signal, ground, M17 to M22. | 61 |  |  | 1.85 |  |  |  |
| Signal, Very, red \& white, Mk II- | 31 |  |  | . 92 |  |  |  |
| Signal, Very, red \& green star, Mk II | 103 |  |  | 2.57 |  |  |  |
| Smoke, WP, M60 105 H | 3 | 172 | 159 | 2.37 | 2.06 | 31 | 29 |
| Smoke, WP, M64, 75H | 3 | 82 | 70 | 1.66 | . 92 | 45 | 29 |
| Smoke, WP, M57, $81 \mathrm{~mm}, \mathrm{M}_{\text {-- }}$ | 3 | 55 | 45 | 1.65 | . 91 | 67 | 45 |
| Smoke, WP, Mk II, unfuzed, 75 G | 3 | 72 | 57 | 1.72 | . 96 | 54 | 38 |

## c. Petroleum Products.

|  | Container | No. per unit | Weight <br> (lb) | $\begin{gathered} \text { Cubic } \\ \text { feet } \end{gathered}$ | Stowage factor |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Aviation gasoline. | 55-gal. drum, 18-gage steel. | 1 | 373 | 9.03 | 54 |
|  | 55-gal. drum, 16-gage steel. | 1 | 389 | 8.8 | 51 |
|  | 55-gal. drum, 18-gage 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 | 200 | 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 |


|  | Container | No. per unit | Weight <br> (lb) | $\begin{aligned} & \text { Cubic } \\ & \text { Ceet } \end{aligned}$ | Stowage factor |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Kerosene. | 55-gal. drum, 18-gage steel. | 1 | 421 | 9.03 | 48.1 |
|  | 55-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-gal. can, 11-lb 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 |
|  | 5-gal. can, 11-lb can. | 1 | 46 | . 81 | 39.5 |
| Lubricating oils. | 55-gal. drum, 18-gage steel. | 1 | 472 | 9.03 | 42.8 |
|  | 55-gal. drum, 16-gage steel. | 1 | 488 | 8.8 | 40.5 |
|  | 55-gal. drum, 18-gage light steel. | 1 | 462 | 9.2 | 44.6 |
|  | 5-gal. can, 11-1b can. | 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. | 25-lb pails. | 1 | 29 | . 95 | 73.6 |
|  | 5-lb cans, 6 per case (crated). | 6 | 44 | 1.1 | 56 |

### 7.33 Annealed Wire

| Gage No. | Diameter <br> (in.) | Tensile strength <br> $(\mathrm{lb})$ |
| :---: | :---: | :---: |
| 7 | $3 / 16$ | 1,100 |
| 8 | $11 / 64$ | 950 |
| 9 | $\frac{5}{12}$ | 800 |
| 11 | $1 / 8$ | 500 |

7.34 Rods and Bolts

| Diameter (in.) | Tensile strength* (lb) |
| :---: | :---: |
| $1 / 2$ | 5,200 |
| $5 / 8$ | 8,100 |
| $3 / 4$ | 11,700 |
| 1 | 21,100 |
| $11 / 8$ | 25,800 |
| $11 / 4$ | 32,800 |
| $18 / 8$ | 38,600 |
| $11 / 2$ | 46,900 |

* At root of thread.


### 7.35 Common Nails

| Type | (Length (in.) |
| :---: | :---: |
| 8-penny | 21/2 |
| 9-penny | 23/4 |
| 10-penny | 3 |
| 12-penny | 31/4 |
| 16-penný. | $31 / 2$ |
| 20-penny-- | 4 |
| 30-penny | 41/2 |
| 40-penny | 5 |
| 50-penny.- | 51/2 |
| 60-penny-.- | 6 |

7.36 High-Tension Bands

| Width and thickness (in) | Tensile strength (b) |
| :---: | :---: |
| $8 / 8 \times 0.050 \ldots$ | 2,000 |
| $3 / 4 \times .028$. | 2,000 |
| $3 / 4 \times .030$ | 2,000 |
| $3 / 4 \times .035$ | 2,500 |
| $3 / 4 \times .037$ | 2,500 |
| $3 / 4 \times .050$ | 3,500 |


| Width and thicknegs (in.) | Tensile strength (lb) |
| :---: | :---: |
| 11/4 $\times .035 \ldots$ | 4,000 |
| $11 / 4 \times .037$ | 4,000 |
| $11 / 4 \times .050$ | 6,000 |
| $2 \times .050$ | 9,500 |

### 7.37 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.

## Section IX. STORAGE AND MAINTENANCE SPACE

### 7.38 Storage

a. Gross Storage Area: Average Ratio of Open to Covered by Classes of Supply.

b. Average Stack Height. Figures given are for use of all technical 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 ${ }^{1}$------------------------1, 000 short tons
Ammunition storage per square mile ${ }^{1} \ldots 5,000$ short tons Minimum hardstand for 2,500 vehicles $^{2}$-. 110,000 square feet Solid footing for vehicle park for 2,500
vehicles.---.--------------------4, $000,000 \mathrm{sq} \mathrm{ft}$
Minimum hardstand for artillery and combat vehicles, per item.
${ }^{1}$ 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.

### 7.39 Covered Shop Floor Space

| Sqm | $S q$ ft |
| :---: | :---: |
| Ordnance: |  |
| Armament rebuild battalion_.-....-9, 290 | 100,000 |
| Automotive rebuild battalion...-. - 9,290 | 100,000 |
| Direct automotive maintenance com-pany------------------------2, 323 | 25,000 |
| Direct support company $-\ldots-\ldots-{ }^{\text {- }}$ - 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 |
| Heavy automotive maintenance company $\qquad$ | 40,000 |
| Heavy maintenance company, field <br>  | 30,000 |
| Motor vehicle assembly company - - 1,858 | 20,000 |
| 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 |

## Section X. FIELD ESTABLISHMENTS AND EXPEDIENTS

### 7.40 Bivouacs and Camps

 (fig. 7.7).a. Definitions. Bivouacs are occupied less than 1 week and have temporary sanitation facilities. Camps are occupied more than 1 week and provide better bathing, sanitation, administration, security, and recreational facilities.
b. Size. Fifty square yards are allowed per man; 100 square yards per vehicle. If air attack is probable, at least 100 yards ( 91 meters) is maintained between dispersed vehicles; no extra
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 replaced during a given period of time.
d. Slice. An average logistical planning factor used to obtain estimates of requirements for personnel and materiel.
allowance is made for personnel. Dispersion of 50 yards ( 46 meters) between vehicles requires 2,500 square yards per vehicle; 100 yards between vehicles requires 10,000 square yards per vehicle. (To obtain meters, multiply feet given below by .3048.)
c. Location.
(1) Desirable.
(a) Concealment from air observation.
(b) Shade trees for sun protection.
(c) Protected slope or trees for windbreaks in cold weather.
(d) Firm, grass-covered turf.
(e) Firm ground for vehicles.
(f) Good road net.
(g) Elevated, well-drained site.
(h) Access to sufficient amount of good water.
(i) Sandy loam or gravel soil, favorable to waste disposal.
(j) Sufficient space to avoid crowding and to permit wide space between kitchens and latrines.
(2) Undèsirable.
(a) Dry beds of rivers, ravines, or depressed areas in rainy country.
(b) Clay or loose, dusty soil.
(c) Marshy ground or areas near water which may be infested by mosquitoes and subject to mist or heavy dew.
(d) Ground water level less than 4 feet from the surface of the ground.
(e) Steep slopes.
( $f$ ) Within a mile of native villages in tropical or subtropical climates.
(g) Low areas during periods of extreme cold.
d. Latrines. Locate on side of camp opposite prevailing wind, at least 100 yards from kitchen and water supply, 30 yards from nearest tents, and place to drain away from water supply.
(1) Straddle trench. Used for bivouacs only. Dig 1 foot wide by $21 / 2$ feet deep by 8 feet long for use of 50 men . Individuals cover refuse immediately. Oil daily. Close when refuse is within 1 foot of surface or when abandoned.
(2) Deep pit. Used for temporary camps. Dig 2 feet wide by 8 feet long by 3 to 10 feet deep. Depth should be 2 feet plus 1 foot for each week of occupation. Should be equipped with fly-proof latrine box.
(3) Pail latrine. Used where soil characteristics prevent digging latrine convenient to camp or bivouac.
(4) Urinal soakage pit. Used throughout camps and work areas. A pit 4 feet square by 4 feet deep filled with broken rock or brick serves 200 men indefinitely. Provide funnels on basis of 1 per 20 men.
e. Washing Facilities. Locate between tents and latrines. Ten feet of wash bench should be provided per 100 men. Showers should be provided where practicable, on basis of 1 shower head
per 25 men; in tropics and in temperature zones during summer, the ratio should be 1 shower head per 20 men. See FM 21-10 for methods of constructing expedient showers.
f. Kitchens. Locate at opposite end of area from latrines. One soakage pit with barrel or baffel grease trap should be provided for each 200 men. If area is occupied more than 2 weeks, a second pit should be installed (FM 21-10).
g. Water Supply.

\begin{tabular}{|c|c|c|}
\hline Condition \& Gallons per man
per day \& Remarks \\
\hline Temperate zones: \({ }^{2}\) Combat \& \[
1 / 2
\]
\[
1
\] \& \begin{tabular}{l}
Minimum for no longer than 3 days. Used for drinking. \\
Some allowance for cooking and personal hygiene.
\end{tabular} \\
\hline March or bivouac.-- \& \[
2
\] \& \begin{tabular}{l}
Minimum. Enough for drinking and cooking, washing mess and kitchen utensils, washing hands and face. \\
Should be supplied if possible; permits laundry and possibly some bathing.
\end{tabular} \\
\hline Camp.- \& \begin{tabular}{l}
5 \\
15 \\
30
\end{tabular} \& \begin{tabular}{l}
Minimum. Does not include bathing or sewerage facilities. \\
Includes conservative bathing. \\
Permits waterborne sewerage.
\end{tabular} \\
\hline \begin{tabular}{l}
Desert areas: \\
Emergency (traveling at night and resting in shade during day).
\end{tabular} \& 1/2 \& Such a ration should not continue for more than 5 days. Used for drinking only. \\
\hline Normal march or combat (day and night operations). \& \(3 / 4\)

$11 / 4$ \& | Ration is considered minimum for day and night conditions for not more than 5 days. Used for drinking only. |
| :--- |
| This ration permits drinking, limited cooking, careful washing of mess gear, shaving, brushing teeth. | <br>

\hline
\end{tabular}

[^36]h. Closing Camp and Bivouac. Before leaving and soakage pits, erect markers indicating site, close all sanitary installations, fill in latrines CLOSED LATRINE, etc.


Figure 7.7. Administrative company bivouac area.
7.41 Tentage



- If used as a field billet.
b A verage for normal conditions.
- Six equal sides of 105 inchcs cach
d Tent also ventilated by lifting sidewalls.
- Arched top.
${ }^{1}$ The two measurements shown are the longest dimensions, including vestibulc (trapczoid measuring $120^{*} \times 48^{*} \times 89.5^{\prime \prime} \times 89.5^{\prime \prime}$ )
E Liner does not cover vestibulc.
${ }^{6}$ Liner weighs additional 155 pounds.
Includes tent, liner, pins, and polcs.
Liner weighs additional 90 pounds and occupies a stored cubage of 8 cubic feet.
$k$ Does not include vestibulcs at cach end, which measure $48^{\prime \prime} \times 90^{\prime \prime}$.
1 Bed patients on cots.
${ }^{\text {m }}$ Height shown is for stack section. Service section is 108 inches high.
- Ventilator screcns on all sides of the serviee and stack sections, to be used as required

Plus one large opening ( $120^{\prime \prime} \times 120^{\prime \prime}$ ) in roof

- Tubular tunnel entrance, 24 inches long
- Either of the ventilator openings may be used as stovepipe opening.
- Dimensions shown for flys and paulins are length and width.
screen has a 3 -foot overlap on one side for an entrance.
Bottom edge of screcn normally 9 inches off ground.
One for a verage company-size unit.


### 7.42 Water Purification

a. Distillation. Stills can be built to produce drinkable water from impure water by using a source of heat, a method of forming and collecting steam, and some kind of condenser. (The still in figure 7.8 has a water-cooled condenser.) The efficiency of an expedient still depends on the materials available and the ingenuity of the designer. In expedient distillation, sufficient vaporseparating space must be provided to prevent the carryover of salt in the distillate with the steam. To avoid endangering personnel by the building up of excessive steam pressure, a valve must never be put in the distillate line.
b. Chlorination. The purification of water with chemicals is known as chlorination. Halazone tablets or iodine water purification tablets, chemicals in the Army supply system, may be used as directed on containers. Calcium hypochlorite, with 70 percent available chlorine, may also be used. One ounce per 1,000 gallons of water, allowed to stand for 2 hours, will purify most waters.
c. Filtration. Much of the pollution in water can be removed by filtration through sand or anthracite coal. The depth of beds for both materials is usually 24 to 30 inches. Dry sand
weighs approximately 92 pounds per cubic foot. Wet anthracite coal weighs approximately 60 pounds per cubic foot. Average yield of a sand filter is 2 gallons per minute per square foot of filter surface. Water should be tested for bacteria content after filtration.
d. Boiling. In low altitudes, practically all of the bacteria in water can be destroyed by boiling for 10 minutes; at high altitudes, where water boils at a reduced temperature, boiling time should be doubled.
e. Aeration.
(1) Many natural waters are improved by aeration, which is a process whereby the water is broken up and brought into intimate contact, with air. This process accomplishes the following:
(a) Removes or reduces undesirable gases, such as carbon dioxide, hydrogen sulphide, excess chlorine, and marsh gas.
(b) Adds oxygen.
(c) Removes odors, such as those caused by decomposition, microscopic organisms, organic matter, and trade wastes.
(d) Aids in other water purification processes, such as coagulating, mixing chemicals, removing iron and manga-


Figure 7.8. Expedient still, water-cooled condenser.


Figure 7.9. Expedient rigging for hoisting.
nese, freshening stagnant water, breaking up microscopic organisms.
(2) Aeration methods in order of effectiveness are:
(a) Fine spray from nozzles.
(b) Cascades over steps, riffles, or weirs.
(c) Trickling devices (coke or stone beds).
(d) Use of mechanical means to draw air into the water or inject air under pressure.
f. Sedimentation. Still water, such as that found in ponds and lakes or in reservoirs, becomes partly clarified and purified by the settling of suspended solids and the bleaching and germkilling action of sunlight. Time and stillness are the important factors. Surface and internal currents must be avoided; the retention period must be long enough for the water to become purified.

### 7.43 Hoists

## (fig. 7.9)

An expedient hoist, such as a windlass or the twisting of an endless rope, can be readily as-
sembled from equipment usually available in the field. Figure 7.9 shows how to move loads a short distance vertically and horizontally. In 1, figure 7.9, the upright post is not anchored because it must turn when rotary power in a horizontal plane is applied to the rod. In 2, figure 7.9 , as rotary power in a vertical plane is applied to the rod, only sufficient tension need be applied at the "under strain" point to cause static friction; therefore, there is no slippage between the rope and the pipe. A method of moving heavy loads a short distance horizontally is illustrated in 3 , figure 7.9.

### 7.44 Shears

(fig. 7.10)
Shears serve the same purpose as an A-frame, and can be used to support a block and tackle arrangement as illustrated in figure 7.12.

### 7.45 Gin Poles <br> (fig. 7.11)

A gin pole serves the same purpose as an A-


Figure 7.10. Shears.
frame. It is an inclined pole that has a sufficient number of guys to hold it in a stationary position. Figure 7.11 illustrates this type of mechanical arrangement in use.

### 7.46 Cableways

(fig. 7.12)
An expedient cableway can be used to transport supplies across a small canyon or stream or to the top of a ridge. It can be made by using two shears, two pulleys, a cargo hook, a vehicle, ropes, and stakes. Figure 7.12 illustrates one method of
erecting an expedient cableway using a $1 / 4$-ton truck as the power source. To construct a cableway:
$a$. Jack up one wheel of a $1 / 4$-ton truck and remove the tire.
b. Take a rope about 10 percent longer than twice the straightline distance between the summit of the ridge and the truck.
$c$. Run the rope through pulleys anchored at both the top and bottom of the ridge, and around the rim of the wheel.
$d$. Splice the ends of the rope together and suspend a cargo hook from it.


Figure 7.11. Gin pole.


Figure 7.12. Expedient cableway, powered by a $1 / 4$-ton truck.

## Section XI. CONVERSION FACTORS

### 7.47 Conversion Factors

a. Linear Measure.

| Meters* | Inches | Feet | Yards | Rods | Chains | Miles |  | Kilometers | Cables' lengths | Fathoms |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Statute | Nautical** |  |  |  |
| 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 | . 0.5439 |
| . 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 |

* 1 meter $=10$ decimeters $=100$ centimeters $=1,000$ millimeters
 number of minutes in a circle ( $360 \times 60=21,600$ ).


## b. Surface Measure.

| Square meters | Square inches | Square feet | Square yarda | Square rods | Acres | Hectares | $\begin{gathered} \text { Square miles } \\ \text { (statute) } \end{gathered}$ | Square kilometers |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1.0 | 1,550.0 | 10.764 | 1.196 | 0.03954 | 0.000247 | 0.0001 | 0.000000386 | 0.000001 |
| . 00065 | 1.0 | . 0069 | . 00077 | . 00000026 | . 00000016 | . 000000065 | . 00000000025 | . 00000000065 |
| . 0929 | 144.0 | 1.0 | . 1111 | . 00367 | . 00002296 | . 00000929 | . 0000000359 | . 0000000929 |
| . 8361 | 1,296.0 | 9.0 | 1.0 | . 0331 | . 0002066 | . 0000836 | . 000000323 | . 000000836 |
| 25.293 | 39,204.0 | 272.25 | 30.25 | 1.0 | . 00625 | . 000253 | . 00000977 | . 0000253 |
| 4,046.8 | 6,272,640.0 | 43,560.0 | 4,840.0 | 160.0 | 1.0 | . 4047 | . 00156 | . 00405 |
| 10,000.0 | 15,499, 969.0 | 107,639.0 | 11,960.0 | 395.37 | 2.471 | 1.0 | . 00386 | . 01 |
| 2,589,999.0 | $\mathrm{Sq} \mathrm{ft} \times 144$ | 27,878,400.0 | 3,097,600.0 | 102,400.0 | 640.0 | 259.0 | 1.0 | 2.59 |
| 1,000,000.0 | Sq ft $\times 144$ | 10,763, 867.0 | 1,195,985.0 | 39,537.0 | 247.1 | 100.0 | . 3861 | 1.0 |

c. Cubic Measure.
[ U. S. dry measure: 1 bushel $=4$ pecks $=8$ gallons $=32$ quarts $=64$ pints
U. S. liquid measure: 1 gallon $=4$ quarts $=8$ pints $=32$ gills $=128$ fluid ounces $=.83268$ imperial gallon $]$

| Cuble centimeters | $\begin{gathered} \text { Cubic } \\ \text { decimeters } \\ \text { or liters } \end{gathered}$ | Cubic inches | Cubic feet ${ }^{1}$ | Cubic yards | U. S. quarts |  | U. S. gallong |  | U. S. bushels | $\begin{gathered} \text { Measurement } \\ \text { tons } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | Lequid | 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 |
| 946.4 | . 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 $12 " \times 12^{\prime \prime} \times 1$. 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 | . 0000925 |
| . 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 per вec | Foot-pounds per sec | Horsepower |  | Poncelets | Kilowatts | Watts | Thermal units per sec |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | U. S. | Metric |  |  |  | Btu's | Kilocalories |
| $\begin{aligned} & 1.0 \\ & .13826 \\ & 76.0404 \end{aligned}$ | $\begin{gathered} 7.233 \\ 1.0 \\ 550.0 \end{gathered}$ | $\begin{aligned} & 0.01315 \\ & .001818 \\ & 1.0 \end{aligned}$ | $\begin{gathered} 0.01333 \\ .001843 \\ 1.01387 \end{gathered}$ | $\begin{aligned} & 0.01 \\ & .001383 \\ & .7604 \end{aligned}$ | $\begin{aligned} & 0.00981 \\ & .001356 \\ & .74565 \end{aligned}$ | $\begin{aligned} & 9.80597 \\ & 1.35573 \\ & 745.65 \end{aligned}$ | $\begin{gathered} 0.009296 \\ .001285 \\ .70865 \end{gathered}$ | $\begin{aligned} & 0.002342 \\ & .0003237 \\ & .17812 \end{aligned}$ |


| 8 | 75.0 | 542.475 | . 98632 | 1.0 | . 75 | . 73545 | 735.448 | . 69718 | . 17569 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\bigcirc$ | 100.0 | 723.3 | 1.31509 | 1.33333 | 1.0 | . 9806 | 980.597 | . 92957 | . 23425 |
| $\stackrel{\rightharpoonup}{0}$ | 101.979 | 737.612 | 1.3411 | 1.35972 | 1.0198 | 1.0 | 1.000 .0 | . 94796 | . 23888 |
| $\stackrel{\circ}{\square}$ | . 10198 | . 73761 | . 001341 | . 001360 | . 00102 | . 001 | 1.0 | . 000948 | . 0002389 |
|  | 107.577 | 778.104 | 1.41474 | 1.43436 | 1.07577 | 1.0549 | 1,054.9 | 1.0 | . 252 |
|  | 426.9 | 3,087.77 | 5.61412 | 5.692 | 4.269 | 4.1862 | 4,186.17 | 3.9683 | 1.0 |

f. Weight.

| $\underset{(\mathrm{kg})}{\substack{\text { Kilograms }}}$ | $\underset{(\mathrm{gr})}{\text { Grains }}$ | Ounces |  | Pounds |  | Tons |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Troy | Avoirdupois (avdp) | Troy | $\underset{(\mathrm{avdp})}{\text { Avoirdupois }}$ | $\begin{aligned} & \text { Short } \\ & (2,000 \mathrm{lb}) \end{aligned}$ | $(2,240 \text { Ib })$ | $\begin{gathered} \text { Metric } \\ (1,000 \mathrm{~kg}) \end{gathered}$ |
| 1.0 | 15,432.4 | 32.1507 | 35.274 | 2.67923 | 2.20462 | 0.001102 | 0.0009842 | 0.001 |
| . 0000648 | 1.0 | . 002083 | . 0002286 | . 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:

## Avoirdupois

1 ounce $=16$ drams
1 stone $=14$ pounds
1 dram $=1.772$ grams

Troy
1 carat $=0.2$ gram $=3.086$ grains
1 pennyweight $=1.555$ grams $=24$ grains
1 ounce $=20$ pennyweights


Troy.--.-................................................................... 1
Apothecaries

Grain
1
1

Ounce
437.5 grains

480 grains
480 grains

A pothecaries
1 scruple $=20$ grains
1 ounce $=8$ drams
1 dram $=3$ scruples
Pound
7,000 grains
5,760 grains
5,760 grains
g. Speed.

| Meters <br> per <br> second | Meters <br> per <br> minute | Feet <br> per <br> second | Feet <br> per <br> minute | Miles <br> per <br> heur | Knots <br> per <br> hour | Kilo- <br> meters <br> per hour |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | 16.7 | .91134 | 54.7 | .62137 | .53959 | 1.0 |

h. Temperature. The table below shows re-

| ${ }^{\circ} \mathrm{F}$. | ${ }^{\circ} \mathrm{C}$. | ${ }^{\circ} \mathrm{F} . \quad{ }^{\circ} \mathrm{C}$. | ${ }^{\circ} \mathrm{F} . \quad{ }^{\circ} \mathrm{C}$. | ${ }^{\circ} \mathrm{F}$. | ${ }^{\circ} \mathrm{C}$. | ${ }^{\circ} \mathrm{F}$. | ${ }^{\circ} \mathrm{C}$. | ${ }^{\circ} \mathrm{F}$. | ${ }^{\circ} \mathrm{C}$. | ${ }^{\circ} \mathrm{F}$. | ${ }^{\circ} \mathrm{C}$. | ${ }^{\circ} \mathrm{F}$. | ${ }^{\circ} \mathrm{C}$. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| -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 | -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 |  |  |  |  |  | Density equivalents |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Kilogramb per sq cm atmospheres) | Pounds per $s q$ in. | Short tons per sq ft | Atmos- | Columns of mercury <br> ( $0^{\circ} \mathrm{C}$. st sea level) |  | $\underset{\text { per cu cm }}{\text { Grams }}$ | $\stackrel{\text { Lbs }}{\text { per cuin. }}$ | $\underset{\text { per } \mathrm{cu} \mathrm{ft}_{\mathrm{t}}}{\mathrm{Lbs}}$ | Short tons per cu yd | Lbs per U.S. gal |
|  |  |  |  | Meters | Inches |  |  |  |  |  |
| 1 | 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 | 0.05171 | 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 of Weight or Masses per Unit Lengths. The table shown below may be used for wires, pipes, rails, etc.

| $\underset{\text { per centimeter }}{\text { Grams }}$ | Kilogrsms per kilometer | Kilograms per meter | Grains per inch | Pounds per foot | Pounds per ysrd | Pounds per mile |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1.0 | 100.0 | 0.1 | 39.1983 | 0.067197 | 0.201591 | 354.80 |
| 0.61 | 1.0 | 0.001 | 0.391983 | 0.00067197 | 0.00201591 | 3.5480 |
| 10.0 | 1,000.0 | 1.0 | 391.983 | 0.67197 | 2.01591 | 3,548.00 |
| 0.025511 | 2.5511 | 0.0025511 | 1.0 | 0.00171429 | 0.00514286 | 9.0514 |
| 14.8816 | 1,488.16 | 1.48815 | 583.333 | 1.0 | 3.0 | 5,280.0 |
| 4.96054 | 496.054 | 0.49605 | 194.444 | 0.33333 | 1.0 | 1,760.0 |
| 0.0028185 | 0.28185 | 0.00028185 | 0.11048 | 0.00018939 | 0.00056818 | 1.0 |

l. Simplified Conversion Factors (Feet and Inches). The table 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
table, 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.

| INCHES | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 | 220 | 230 | 240 | 250 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 |  | 1-8 | 2-6 | 3-4 | 4-2 | 5 | 5-10 | 6-8 | 7-6 | 8-4 | 9-2 | 10 | 10-10 1 | 11-8 | 12-6 | 13-4 | 14-2 | 15 | 15-10 | 16-8 1 | 17-6 1 | 18-4 | 19-2 | 20 | 20-10 |
| 1 |  | 1-9 | 2-7 | 3-5 | 4-3 | 5-1 | 5-11 | 6-9 | 7-7 | 8-5 | 9-3 | 10-1 | 10-11 | 11-9 | 12-7 | 13-5 | 14-3 | 15-1 | 15-11 | 16-9 1 | 17-7 | 18-5 | 19-3 | 20-1 | 20-11 |
| 2 | 1-0 | 1-10 | 2-8 | 3-6 | 4-4 | 5-2 | 6 | 6-10 | 7-8 | 8-6 | 9-4 | 10-2 | 11 | 11-10 | 12-8 | 13-6 | 14-4 | 15-2 | 16 | 16-10 1 | 17-8 | 18-6 | 19-4 | 20-2 | 21 |
| 3 | 1-1 | 1-11 | 2-9 | 3-7 | 4-5 | 5-3 | 6-1 | 6-11 | 7-9 | 8-7 | 9-5 | 10-3 | 11-1 | 11-11 | 12-9 | 13-7 | 14-5 | 15-3 | 16-1 | 16-11 1 | 17-9 | 18-7 | 19-5 | 20-3 | 21-1 |
| 4 | 1-2 | 2 | 2-10 | 3-8 | 4-6 | 5-4 | 6-2 | 7 | 7-10 | 8-8 | 9-6 | 10-4 | 11-2 | 12 | 12-10 | 13-8 | 14-6 | 15-4 | 16-2 | $17 \quad 1$ | 17-10 | 18-8 | 19-6 | 20-4 | 21-2 |
| 5 | 1-3 | 2-1 | 2-11 | 3-9 | 4-7 | 5-5 | 6-3 | 7-1 | 7-11 | 8-9 | -9-7 | 10-5 | 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 |
| 6 | 1-4 | 2-2 | 3 | 3-10 | 4-8 | 5-6 | 6-4 | 7-2 | 8 | 8-10 | 9-8 | 10-6 | 11-4 | 12-2 | 13 | 13-10 | 14-8 | 15-6 | 16-4 | 17-2 | 18 | 18-10 | 19-8 | 20-6 | 21-4 |
| 7 | 1-5 | 2-3 | 3-1 | 3-11 | 4-9 | 5-7 | 6-5 | 7-3 | 8-1 | 8-11 | 9-9 | 10-7 | 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 |
| 8 | 1-6 | 2-4 | 3-2 | 4 | 4-10 | 5-8 | 6-6 | 7-4 | 8-2 | 9 | 9-10 | 10-8 | 11-6 | 12-4 | 13-2 | 14 | 14-10 | 15-8 | 16-6 | 17-4 | 18-2 | 19 | 19-10 | 20-8 | 21-6 |
| 9 | 1-7 | 2-5 | 3-3 | 4-1 | 4-11 | 5-9 | 6-7 | 7-5 | 8-3 | 9-1 | 9-11 | 10-9 | 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 |
|  | 260 | 270 | 280 | 290 | 300 | 310 | 320 | 330 | 340 | 350 | 360 | 370 | 380 | 390 | 400 | 410 | 420 | 430 | 440 | 450 | 460 | 470 | 480 | 490 | 500 |
| 0 | 21-8 | 22-6 | 23-4 | 24-2 | 25 | 25-10 | 26-8 | 27-6 | 28-4 | 29-2 | 30 | 30-10 | 31-8 | 32-6 | 33-4 | 34-2 | 35 | 35-10 | 36-8 | 37-6 | 38-4 | 39-2 | 40 | 40-10 | 41-8 |
| 1 | 21-9 | 22-7 | 23-5 | 24-3 | 25-1 | 25-11 | 26-9 | 27-7 | 28-5 | 29-3 | 30-1 | 30-11 | 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 |
| 2 | 21-10 | 22-8 | 23-6 | 24-4 | 25-2 | 26 | 26-10 | 27-8 | 28-6 | 29-4 | 30-2 | 31 | 31-10 | 32-8 | 33-6 | 34-4 | 35-2 | 36 | 36-10 | 37-8 | 38-6 | 39-4 | 40-2 | 41 | 41-10 |
| 3 | 21-11 | 22-9 | 23-7 | 24-5 | 25-3 | 26-1 | 26-11 | 27-9 | 28-7 | 29-5 | 30-3 | 31-1 | 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 |
| 4 | 22 | 22-10 | 23-8 | 24-6 | 25-4 | 26-2 | 27 | 27-10 | 28-8 | 29-6 | 30-4 | 31-2 | 32 | 32-10 | 33-8 | 34-6 | 35-4 | 36-2 | 37 | 37-10 | 0-38-8 | 39-6 | 40-4 | 41-2 | 42 |
| 5 | 22-1 | 22-11 | 23-9 | 24-7 | 25-5 | 26-3 | 27-1 | 27-11 | 28-9 | 29-7 | 30-5 | 31-3 | 32-1 | 32-11 | 33-9 | 34-7 | 35-5 | 36-3 | 37-1 | 37-11 | 1 38-9 | 39-7 | 40-5 | 41-3 | 42-1 |
| 6 | 22-2 | 23 | 23-10 | 24-8 | 25-6 | 26-4 | 27-2 | 28 | 28-10 | 29-8 | 30-6 | 31-4 | 32-2 | 33 | 33-10 | 34-8 | 35-6 | 36-4 | 37-2 | 38 | 38-10 | 39-8 | 40-6 | 41-4 | 42-2 |
| 7 | 22-3 | 23-1 | 23-11 | 24-9 | 25-7 | 26-5 | 27-3 | 28-1 | 28-11 | 29-9 | 30-7 | 31-5 | 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 |
| 8 | 22-4 | 23-2 | 24 | 24-10 | 25-8 | 26-6 | 27-4 | 28-2 | 29 | 29-10 | 30-8 | 31-6 | 32-4 | 33-2 | 34 | 34-10 | 1035-8 | 36-6 | 37-4 | 38-2 | 39 | 39-10 | 40-8 | 41-6 | 42-4 |
| 9 | 22-5 | 23-3 | 24-1 | 24-11 | 25-9 | 26-7 | 27-5 | 28-3 | 29-1 | 29-11 | 30-9 | 31-7 | 32-5 | 33-3 | 34-1 | 34-11 | $135-9$ | 36-7 | 37-5 | 38-3 | 39-1 | 39-11 | 40-9 | 41-7 | 42-5 |



### 7.48 Conversion of Fuel and Lubricants From Gallons to Tons

The scale in figure 7.13 is approximate and should be used only for rapid computation. For this reason, weights given per unit of volume are slightly heavier than average.


Figure 7.18. Scale for converting gallons of fuel and lubricants to tons.

### 7.49 Petroleum Conversion Factors

(Conversion factors give averages, not exact figures.)

| Multiply | By | 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. |

### 7.50 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 |
|  | Feet | 2,083 | 4,167 | 6,250 | 8,333 | 16,667 | 20,833 | 41,667 | 83,333 |
|  | Yards | 694 | 1,389 | 2,083 | 2,778 | 5,555 | 6,944 | 13,888 | 27,776 |
|  | Kilometers | . 635 | 1.27 | 1.91 | 2.54 | 5.08 | 6.35 | 12.7 | 25.4 |
|  | Miles. | . 393 | . 790 | 1.19 | 1.58 | 3.15 | 3.94 | 7.9 | 15.76 |
|  | Meters | 635 | 1,270 | 1,910 | 2,540 | 5,080 | 6,350 | 12,700 | 25,400 |
| One centimeter-- | Inches. | 9,843 | 19,685 | 29,528 | 39,370 | 78,740 | 98,425 | 196,850 | 393,700 |
|  | Feet. | 820 | 1,640 | 2,460 | 3,281 | 6,562 | 8,202 | 16,404 | 32,808 |
|  | Yards. | 273 | 547 | 820 | 1,094 | 2,187 | 2,734 | 5,468 | 10,936 |
|  | Kilometer | . 250 | . 500 | . 750 | 1.0 | 2.0 | 2.5 | 5.0 | 10.0 |
|  | Miles.------ | $.154$ | .31 | $.465$ | $\text { . } 62$ | $1.24$ | 1.55 | 3.1 | 6.2 |
|  | Meters------ | 250 | $500$ | 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 equivalent 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 $1 / 25,000$.
7.51 Speed Conversion Table, Approximate

| $\begin{aligned} & \text { Miles } \\ & \text { per hour } \end{aligned}$ | Knota | $\underset{\text { per Beecond }}{\text { Fet }}$ | Kilometers per hour | Meters per second |
| :---: | :---: | :---: | :---: | :---: |
| 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 |
| 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 |
| 65 | \$7.50 | 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 |


| Miles <br> per hour | Knots | Feet <br> per second | Kilometers <br> per howr | Meters <br> per second |
| :---: | :---: | :---: | :---: | :---: |
| 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 |
|  |  |  |  |  |

7.52 Conversion of Foreign Measures to United States Measures

| Country | Weight or measure | U. S. equivalent |
| :---: | :---: | :---: |
| Argentina | Arroba | 25.32 lb |
|  | Baril | 20.077 gal . |
|  | Cuadra | 4.2 acres |
|  | Frasco (liq) | 2.509 qt (liq) |
|  | Last. | 58.4 bu |
|  | Libra | 1.013 lb |
|  | Pie_ | 0.947 ft |
|  | Quintal | 101.28 lb |
|  | Vara_- | 34:094 in. |
| Australiar- | Same as United Kingdom |  |
| Austria | Joch.. | 1.422 acres |
|  | Klafter. | 2.074 yd |
| Belgium. | Last. | 85.134 bu |
| Bolivia. | Marc. | 0.507 lb |
| Borneo. | Picul. | 135.64 lb |
| Brazil | Arroba | 32.379 lb |
|  | Quintal | 120.54 lb |
| Canada | Same as United Kingdom |  |
| Celebes | Picul. | 135.64 lb |
| Central America | Centore. | 4.263 gal |
|  | Fanega | 1.574 bu |
|  | Libra. | 1.014 lb |
|  | Manzama | 1.727 acres |
|  | Vara. | 32.913 in. |
| Chile | Fanega | 2.753 bu |
|  | Libra. | 1.014 lb |
|  | Quintal. | 101.41 lb |
|  | Vara. | 32.918 in. |
| Chins | Catty | 1.333 lb |
|  | Ch'ih. | 12.6 in. |
|  | Li | 1,890 ft |
|  | Picul. | 183.338 lb |
|  | Trel Kuping .-. | $\begin{aligned} & 575.64 \text { grains } \\ & \text { (troy) } \end{aligned}$ |
|  | Chun | 1.26 in. |



| Country | Weight or measure | U. S. equivalent |
| :---: | :---: | :---: |
| Sweden-Continued | Last_ | 9,371.3 lb |
|  | Skalpund | 0.937 lb |
|  | Tunna | 4.5 bu |
|  | Tunnland | 1.22 acres |
| Thailand.-.-....--- | Catty, standard. | 1.333 lb |
|  | Catty | 2.667 lb |
|  | Coyan. | 2,645.5 lb |
| Turkey---..-....-- | Cantar | 124.45 lb |
|  | Oke | 2.828 lb |
|  | Pik | 27.9 in. |
| U.S.S.R.-.-------- | Arshin (lin) | 28 in . |
|  | Arshin (sq) - | 5.44 sq ft |
|  | Berkovets. | 361.128 lb |
|  | Chetvert. | 5.957 bu |
|  | Dessiatine | 2.699 acres |
|  | Food | 36.113 lb |
|  | Funt | 0.9 lb |
|  | Last_ | 80.0 cu ft |
|  | Sajene_ | 7 ft |
|  | Vedro | 2.707 gal . |
|  | Verst. | 0.633 mile |
|  | Duim | 1 in . |
|  | Foute | 1 ft |
|  | Garnetz | 2.98 qt |
|  | Milya. | 4.64 miles |
|  | Pfund. | 0.903 lb |
|  | Pood or poud. | 36.11 lb |
|  | Pound. | 0.903 lb |
|  | Zak | 2.368 bu |
| United Kingdom --- | Comb | 4.128 bu |
|  | Gallon. | 1.2 gal . |
|  | Last. | 82.56 bu |
|  | Load (timber). | 50 cu ft |
|  | Cwt (hundred wt).- | 112.0 lb |
|  | Quart (liq) .....-.- | 1.2 qt (liq) |
|  | Quart (dry)----.-. | 1.3 qt (liq) |
|  | Quarter -----.---- | 8.256 bu |
|  | Sack (flour)-------- | 280 lb |
|  | Stone. | 14 lb |
|  | Wey--- | 41.282 bu |
| Uruguay--------- | Cuadra | 1.82 acres |
|  | Fanega | 3.888 bu |
|  | Libra | 1.014 lb |
| Venezuela-------- | Fanega.----------- | 3.334 bu |
|  | Libra. | 1.014 lb |
| Yugoslavia - .-.--- | Wagon- | 10 metric tons |
| Zanzibar--------- | Frasila. | 35 lb |

7.53 Miscellaneous Conversion Factors for U.S. and British Measures

| Multiply | By | 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 horsepow | 33,475.0 | Btu per hour |


| Multiply | By | To obtain |
| :---: | :---: | :---: |
| 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. | . 1782 | 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 (surveyors)...- | 7.92 | Inches |
| Liters. | . 2642 | Gallons (U.S.) |
| Liters. | 1.76 | Pint (imperial) |
| Liters..-------..---- | 2.1134 | Pint (U.S.) |


| Multiply | By | To obtain |
| :---: | :---: | :---: |
| Liters. | 1.057 | Quart (iquid) |
| Meters | 100.0 | Centimeters |
| Millimeters. | . 0393 | Inches |
| Mils | . 001 | Inches |
| Ounces | 20 | Pennyweights |
| Ounces_ | 28.349 | Grams |
| Ounces (fluid) | 1.805 | Cubic inches |
| Pennyweight. | 24 | Grains |
| Pounds. | 453.6 | Grams |
| Pounds of water. | . 01603 | Cubic feet |
| Pounds of water. | . 1198 | Gallons (U.S.) |
| Pounds per square inch | 2.307 | Feet of water |
| Pounds per square inch | 2.036 | Inches of mercury |
| Quintals.- | 1.97 | Hundredweights |
| Quires | 25.0 | Sheets (of paper, etc.) |


| Multiply | By | To obtain |
| :---: | :---: | :---: |
| Reams | 500.0 | Sheets (of paper, etc.) |
| Short ton-miles-.-- | 1.45968 | Metric ton-kilometers |
| Square centimeters.-- | . 1550 | Square inches |
| Square feet | 929.0 | Square centimeters |
| Square feet. | 144.0 | Square inches |
| Square inches.-.---- | 6.452 | Square centimeters |
| Stones. | 14.0 | Pounds |
| $\begin{gathered} \text { Temp }\left({ }^{\circ} \mathrm{C}\right. \text {.) plus } \\ 17.8 \end{gathered}$ | 1.8 | Temp ( ${ }^{\circ} \mathrm{F}$.) |
| $\begin{aligned} & \text { Temp ( }{ }^{\circ} \text { F.) minus } \\ & \hline 2 \end{aligned}$ | . 5556 | Temp ( $\left.{ }^{\circ} \mathrm{C}.\right)$ |
| Tons (measurement) | 40.0 | Cubic feet |
| Tons (register).-.-.- | 100.0 | Cubic feet |
| Weeks------------ | 168.0 | Hours |

## Section XII. STOWAGE FACTORS

### 7.54 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 )

$$
=\frac{\text { cube of cargo }(\mathrm{cu} \mathrm{ft}) \times 2,240}{\text { weight in pounds }}
$$

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 ${ }^{1}$ | Conversion factor (ST to MT) | Stowage factor |
| :---: | :---: | :---: |
| Class I: Rations | 2.1 | 94 |
| Class II: |  |  |
| Chemical_ | 2.3 | 103 |
| Engineer | 3.3 | 147 |
| Medical (including Class I and IV). | 2.5 | 112 |
| Ordnance | 1.8 | 80 |
| Ordnance vehicle replacement.-- | 2.2 | 99 |
| QM clothing and equipage.----- | 2.0 | 89 |
| QM general supplies | 2.8 | 125 |
| Signal (including Class IV)-.--- | 3.8 | 170 |
| Class III: |  |  |
| Aviation fuel and lubricants (Class III A). | 1.5 | 67 |
| Fuel for temperate zone.-...--- | 2.0 | 89 |
| Gas, oil, grease ${ }^{2}$ (less aviation). | 1.5 | 67 |


| Item ${ }^{1}$ | $\begin{aligned} & \text { Conversion } \\ & \text { (factor } \\ & \text { (ST to MT) } \end{aligned}$ | Stowage factor |
| :---: | :---: | :---: |
| Class IV: |  |  |
| Aviation, supply and replacement | 4.0 | 179 |
| Chemical (negligible). |  |  |
| Engineer construction material | 1.5 | 67 |
| Medical (included in Class II) |  |  |
| Ordnance motor maintenance..- | 1.0 | 45 |
| QM sales items.--- | 1.7 | 76 |
| Signal (included in Class II).---- |  |  |
| Transportation. | 2.4 | 108 |
| Class V: |  |  |
| Ammunition (less aviation) --- -- | . 9 | 40 |
| Aviation ammunition. | . 9 | 40 |
| Chemical ammunition. | 1.2 | 54 |


7.56 Average Densifies of Common Materials and Specified Supply Ifems
Figures shown below will aid transportation planners and operators when making loading plans
for any mode of transportation. The information given is for specific items. When planning loads for the general classes of supply, see paragraphs 7.4, 7.32, 7.54, and 7.55.

## a. Common Materials.

## Material

Weight (lb
per ers ft)

## Acid:

Muriatic, 40\% ..... 75
Nitric, $91 \%$ ..... 94
Sulphuric, $87 \%$ ..... 112
Alcohol, $100 \%$Ethyl49
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
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 ..... 57Chemical plant
Clay:
Damp, plastic ..... 110
Dry ..... 63
Marl (mineral) ..... 137
Wet ..... 80
With gravel, dry ..... 100
Coal:Anthracite97
Bituminous ..... 84
Charcoal, oak ..... 33
Charcoal, pine
Weipht (b Material ..... per cu fl)
Coke ..... 75
Lignite ..... 78
Peat, turf, dry ..... 47
Coal and coke, piled: ..... 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
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
Material
Weight (lb
Ice.57
Indigo ..... 63
Irdium ..... 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 ..... 465
Leather ..... 59
Lime, gypsum, loose ..... 53-64
Limestone:
Marble, quartz (solid) ..... 155
Marble, quartz (quarried, piled) ..... 95
Locust timber ..... 45
Logwood, dry (average) ..... 57
Lumber, structural (average) ..... 42
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
Weight (b)
Materiaper cu fl)
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 ..... 67353
Material ..... Weight (lb
Rubber:
Caoutchoue ..... 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
Slate ..... 172
Silver
Cast-hammered ..... 656
German ..... 536
Sisal ..... 24
Slags:
Bank67-72
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:
489
Cold-drawn
487
Machine
481
Tool
65
Stone riprap, wet
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
Material
weight (b)
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) Periskables and bulk staples.
Material
Wright (bbDairy 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 (Honey Dew) ..... 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
MaterialWetght (lb
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:
Chicken, dressed:
Fryer ..... 31.5
Hen ..... 40.2
Chicken, cut-up ..... 29.6
Turkey ..... 29.3
Sausage:
Bologna ..... 32.5
Frankfurter ..... 35.2
Liver ..... 36.5
Luncheon meat ..... 37.3
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
MaterialWeight (bbper cuft)
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
Onions:
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 (lb
Material
Material ..... per cu fl)
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. 21/2 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 ( $100-\mathrm{lb}$ sack) ..... 39.2
Beans, string (No. 10 can) ..... 41.6
(No. 21/2 can) ..... 40.0
(No. 2 can) ..... 39.5
Beef, canned (6-lb can) ..... 62.0
Beef, roast (No. 10 can) ..... 42.5
Beets ..... 42.5
(No. $21 / 2$ can) ..... 40.0
(No. 2 can) ..... 41.0

| Material | Weight (lb per cu fi) | Material |
| :---: | :---: | :---: |
| Biscuits, Types C (2-lb pack) | 28.8 | Salmon (1-lb container) |
| Bouillon cubes ( 100 per pack) | 37.3 | Salt (100-lb bag) |
| Butter (5-lb pack) | 45.6 | Sauerkraut (No. 10 can) |
| Cabbage, dehy (5-lb pack) | 13.8 | (No. $21 / 2$ can) |
| Candy, hard (15-lb pack) | 33.1 | (No. 2 can) |
| Carrots (No. 10 can) | 42.5 | Sausage (2-lb pack) |
| (No. 21/2 can) | 40.0 | Sausage, Vienna (1 1/2-lb pack). |
| (No. 2 can) | 41.0 | Soup, dehy (5-lb pack) |
| Catsup (No. 10 can ) | 45.0 | Spaghetti (No. 10 can) |
| (No. $21 / 2$ can) | 42.1 | (No. 21/2 can) |
| (No. 2 can) | 41.0 | (No. 2 can) |
| Cereal, uncooked (22 oz) | 32.7 | Spinach (No. 10 can) |
| Cereal, individual | 8.7 | (No. $21 / 2$ can) |
| Cheese, processed (6-lb pack) | 54.4 | (No. 2 can) |
| Chile con carne (No. 10 can) | 42.5 | Stew, meat \& veg (28-0z pack) |
| (No. $21 / 2$ can) | 40.0 | (30-oz pack) |
| (No. 2 can) | 41.0 | Sugar, granulated: |
| Cocoa (5-lb pack) | 25.0 | (10-lb pack) |
| Coffee (16-lb bag) | 30.0 | (100-lb pack) |
| Corn (No. 10 can) | 43.2 | Syrup (No. 10 can) |
| (No. 21/2 can) | 41.1 | (1-1b container) |
| (No. 2 can) | 41.0 | Tea (5-lb box) |
| Crackers, Graham (2-lb pack) | 30.0 | Tomatoes (No. 10 can) |
| Eggs, dehy (No. 10 can) | 25.0 | (No. $21 / 2$ can) |
| Figs (No. 10 can) | 45.0 | (No. 2 can) |
| (No. $21 / 2$ can) | 42.1 | Tomato Juice (No. 10 can) |
| (No. 2 can) | 42.5 | (No. $21 / 2$ can) |
| Flour (98-lb sack) | 36.1 | (No. 2 can) |
| Grapefruit (No. 10 can) | 41.6 | Vegetables, mixed: |
| (No. $21 / 2$ can) | 40.0 | (No. 10 can) |
| (No. 2 can) | 39.5 | (No. 2 can) |
| Hash, corned beef ( $51 / 2-\mathrm{lb}$ pack) | 33.1 | Vinegar (1-gal. jar) |
| Hash, meat \& veg (No. 10 can) | 43.8 |  |
| Jam, assorted (No. 10 can) | 52.5 | c. Clothing and Individua |
| (No. $21 / 2$ can) | 41.0 |  |
| (No. 2 can) | 47.0 | Material |
| Lard (37-lb container) | 46.8 | Axe, chopping |
| Luncheon meat (6-lb pack) | 49.5 | Bag, barracks |
| Mackerel (14-oz can). | 26.7 | Bag, duffel. |
| Milk, powdered (5-lb container) | 31.3 | Bag, sleeping |
| Milk, evaporated (141/2-oz pack) | 42.3 | Bar, mosquito |
| Oats, rolled (48-oz pack) | 20.9 | Belt, cartridge |
| Peaches and/or pears: |  | Belt, pistol. |
| (No. 10 can) | 43.8 | Blanket, wool, OD |
| (No. $21 / 2$ can) | 41.1 | Boots, service, combat |
| (No. 2 can) | 42.5 | Bunting, wool. |
| Peanut butter (No. 10 can) | 43.8 | Can, meat, aluminum |
| (No. $21 / 2$ can) | 41.1 | Canteen, aluminum- |
| (No. 2 can). | 41.0 | Cap, garrison, AG 44 |
| Peas (No. 10 can) | 42.8 | Cap, service, wool |
| (No. 2 can) | 41.0 | Carrier, pack |
| Pickles (1-gallon jar) | 48.5 | Case, canvas, dispatch |
| Pineapple, sliced: |  | Coat, wool. |
| (No. 10 can) | 43.8 | Comforter, wool |
| (No. $21 / 2$ can) | 42.1 | Cover, canteen |
| (No. 2 can) | 41.0 | Cup, canteen, aluminum. |
| Pineapple juice (No. 10 can) | 41.7 | Drawers, cotton- |
| (No. 2 can) | 41.0 | Drawers, winter |
| Potatoes, dehy (No. 16-lb pack) | 33.0 | Gloves, cotton. |
| (10-lb pack). | 24.7 | Gloves, leather |
| Prunes, dry ( $25-\mathrm{lb}$ bag). | 60.0 | Gloves, wool - |
| (5-lb bag). | 44.4 | Handkerchief |


aterial ..... cu fi)Container, water, 5 -gal11.6Cover, mattress24.0
Desk, field, empty, fiber ..... 9.0Fly, tent, wal30.0
Kit, barber .....
Mattress, cotton ..... 4.0
Paulin canvas,43.0
Pillow, feather21.0
Pin, tent, $16^{\prime \prime}$ ..... 36.3
Pient27.0
Range, field ..... 22.7
Seen, latrine.9.2
Table, mess ..... 1.823.9
*Tent, storage ..... 36.3Tent, wall, large25.0
7.57 Rapid Computation of Weight of a Unif 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

### 7.58 Measurement of Surfaces and Solids

| Figure | Formula |
| :---: | :---: |
| a. Area of: Circle $\qquad$ <br> Sector of |  |
|  | Square of the diameter times |
|  | .7854, or square of the |
|  | radius times 3.1416. |
|  | Length of the arc times the |
|  | radius divided by 2 , or |



| Figure | Formula |
| :---: | :---: |
| Frustrum of....- | Slant height times sum of circumferences of bases divided by 2 plus sum of the areas of both bases. |
| 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. |
| 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. |
| Square | 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 | Sum of all sides. |
| Polygon. <br> c. Volume of: |  |
| Cone.-------------- | Height times area of base divided by 3. |
| Frustrum of cone.-- | Height times $\left(\mathbf{B}+\mathbf{B}^{\prime}+\sqrt{\left.\mathbf{B} \times \mathbf{B}^{\prime}\right)}\right.$ |
| 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 $\left(\mathbf{B}+\mathbf{B}^{\prime}+\sqrt{\left.\mathbf{B} \times \mathbf{B}^{\prime}\right)}\right.$ |
| 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. |

## Note

Apothem-perpendicular from center of polygon to any side.
$B$ and $B^{\prime}$-area of upper and lower hases, reapectively, of frustrum of cone or pyramid.

Frustrum-that part of a pyramid or cone included between the base and a section of the pyramid or cone parallel to the base.
Polygon-closed, straight-lined figure having more than 4 sides
Quadrilateral-closed, atraight-lined figure having 4 sides.
Regular polygon-closed, atraight-lined figure having equal sides and equal angles.
Trapezoid-quadrilateral figure having one pair of parallel sides

### 7.59 Functions of Numbers

Quantities in the table 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 10 is the power to which 10 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 $\overline{2} .00000$, 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 $1 / 3 \times \overline{1} .00000$, it should be expressed as $1 / 3 \times(2.00000-3)$, which equals $0.66666-1$, or $\overline{1} .66666$. An example of the use of logarithms is presented by the problem of raising 44 to the 0.36 power.

$$
\begin{aligned}
& \text { Let } x=(44)^{0.36} \\
& \text { Then } \begin{aligned}
\log x & =0.36 \times \log 44 \\
& =0.36 \times 1.64345 \\
& =0.59164
\end{aligned}
\end{aligned}
$$

$$
\text { and } x=\text { antilog of } 0.59164 \text {, or } 3.905
$$

| 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 | 841 | 5.3852 | 24389 | 3.072 | 1.46240 |
| 30 | 900 | 5.4772 | 27000 | 3.107 | 1.47712 |
| 31 | 961 | 5.5678 | 29791 | 3.141 | 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 | 1.63347 |
| 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 |
| 60 | 3600 | 7.7460 | 216000 | 3.915 | 1.77815 |
| 61 | 3721 | 7.8102 | 226981 | 3.936 | 1.78533 |


| Number | Square | Square root | Cube | Cube root | Loga- rithm |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |

7:60 Decimal Equivalents

| Inches |  |  |  |  | Inches | Millimeters |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\cdots$ |  |  |  | $1 / 4$ | 0.015625 | 0.397 |
|  |  |  | $1 / 62$ | , | . 03125 | . 794 |
|  |  |  |  | $8 / 6$ | . 046875 | 1.191 |
|  |  | 1/4 |  | --- | . 0625 | 1.588 |
|  |  |  |  | $5 / 6$ | . 078125 | 1.984 |
|  |  |  | $8 / 62$ | --- | . 09375 | 2.381 |
|  |  |  |  | 7\% | . 109375 | 2.778 |
|  | 1/8 |  |  | --- | . 125 | 3.175 |
|  |  |  |  | 9/4 | . 140625 | 3.572 |
|  |  |  | 5/62 | --- | . 15625 | 3.969 |
|  |  |  |  | 11/64 | . 171875 | 4.366 |
|  |  | $8 / 16$ |  | ---- | . 1875 | 4.763 |
|  |  |  |  | 13/4 | . 203125 | 5.159 |



| Inches |  |  |  |  |  | Inches | Millumeters |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | 29\% | . 609375 | 15.478 |
|  |  | 5/8 | ---- | ---- | ---- | . 625 | 15.875 |
|  |  |  |  |  | 434 | . 640625 | 16.272 |
|  |  |  |  | 21/2 | --- | . 65625 | 16.669 |
|  |  |  |  |  | 48/4 | . 671875 | 17.066 |
|  |  |  | 11/18 |  | - | . 6875 | 17.463 |
|  |  |  |  |  | 45 | . 703125 | 17.859 |
|  |  |  |  | $23 / 2$ | ---- | . 71875 | 18.256 |
|  |  |  |  |  | 47/4 | . 734375 | 18.653 |
|  | $3 / 4$ |  |  |  | ---- | . 75 | 19.050 |
|  |  |  |  |  | 49\% | . 765625 | 19.447 |
|  |  |  |  | 25/62 | ---- | . 78125 | 19.844 |
|  |  |  |  |  | 51/64 | . 796875 | 20.241 |
|  |  |  | 1918 |  | -- | . 8125 | 20.638 |
|  |  |  |  |  | 53/64 | . 828125 | 21.034 |
|  |  |  |  | 87/2 | --- | . 84375 | 21.431 |
|  |  |  |  |  | 56/4 | . 859375 | 21.828 |
|  |  | 7/8 | -- |  |  | . 875 | 22.225 |
|  |  |  |  |  | 57/64 | . 890625 | 22.622 |
|  |  |  |  | 29/82 | ---- | . 90625 | 23.019 |
|  |  |  |  |  | 59/64 | . 921875 | 23.416 |
|  |  |  | 15/66 |  | -- | . 9375 | 23.813 |
|  |  |  |  |  | ${ }^{61} 64$ | . 953125 | 24.209 |
|  |  |  |  | 31/2 | ---- | . 96875 | 24.606 |
|  |  |  |  |  | 63/64 | . 984375 | 25.003 |
| 1 |  |  |  |  |  | 1.0 | 25.400 |

### 7.61 Trigonometric Solution of Triangles


$\operatorname{Sin} A=\frac{a}{c}$
$\operatorname{Cos} A=\frac{\mathrm{b}}{\mathrm{e}}$
$\operatorname{Tan} A=\frac{a}{\bar{b}}$
$\operatorname{Cot} A=\frac{b}{a}$
$\operatorname{Sec} A=\frac{c}{b}$
$\operatorname{Csc} A=\frac{\mathrm{c}}{\mathrm{a}}$

$$
\begin{aligned}
\text { Area } & =\frac{a b}{2}=\frac{a}{2} \sqrt{c^{2}-a^{2}}=\frac{a^{2} \operatorname{Cot} A}{2} \\
& =\frac{b^{2} \operatorname{Tan} A}{2}=\frac{c^{2} \operatorname{Sin} 2 A}{4}
\end{aligned}
$$


$a^{2}=b^{2}+c^{2}-2 b c \operatorname{Cos} A$
$b^{2}=a^{2}+c^{2}-2 a c \operatorname{Cos} B$
$c^{2}=a^{2}+b^{2}-2 a b \operatorname{Cos} C$
Area $=\sqrt{s(s-a)(s-b)(s-c)}$

## Where

$s=\frac{\mathrm{a}+\mathrm{b}+\mathrm{c}}{2}$

### 7.62 Natural Trigonometric Functions.

| Angto ${ }^{\circ}$ | Stn | Cosee | Tan | Cotan | Sec | Cos | Angto |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |
| 24 | . 407 | 2.459 | . 445 | 2.246 | 1.095 | . 914 | 66 |
| 25 | . 423 | 2.366 | . 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 |


| Angle | Sin | Cosec | Tan | Cotan | Sec | Cos | Angle ${ }^{\circ}$ |
| :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 |
| 38 | .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 |
| Angle ${ }^{\circ}$ | Sin | Cosec | Tan | Cotan | Sec | Cos | Angle ${ }^{\circ}$ |

### 7.63 Computing Guy Stress

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 7.14; 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.


TENSION $\quad t=\frac{w d}{y}$
WHERE
$y=$ PERPENDICULAR DISTANCE FROM BASE OF POLE TO REAR GUY $w=$ WEIGHT OF LOAD + $1 / 2$ WEIGHT OF POLE
$d=$ DISTANCE FROM GUY ANCHOR TO BASE OF POLE


Figure 7.14. Computing guy stress.

## Section XIV. TIME, TIDE, AND LIGHT

### 7.64 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, $190225 Z$.
(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. 7.15).
(1) The earth averages one rotation on its axis every 24 hours. This causes in the same period an apparent travel of the sun 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 $712^{\circ}$ east of Greenwich and $712^{\circ}$ 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. It does not designate location on the earth's surface (fig. 7.15). 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 7.16.

### 7.65 Tides, Sunlight, and Moonlight

a. Chart. Figure 7.17 shows the type of chart which is issued for each major operation or


| TIMEZONE | hours of day in local mean time |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | previous day |  |  |  |  |  |  |  |  |  |  |  |  |  | same dar |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | next oay |  |  |  |  |  |  |  |  |  |  |  |
| $\left(\begin{array}{ll}-2 & (8) \\ -3 & (0)\end{array}\right.$ | 12 | 13 |  | 14 | 13 | 16 | 17 | 18 | 19 | 92 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 304 | 4.03 | 306 | 0 | 7 | - | 091 | 10 | 11 | 12 | 13 | 14 | 13 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 010 | 020 | 030 | 04 | 05 | 060 | 07 | 080 | 0810 | 10 |  |
|  | 13 | 4 | 4 | 15 | 16 | 17 | 18 | 19 | 120 | 20 | 212 | 22 | 25 | 00 | 01 | 02 | 03 | 04 | $4{ }^{0}$ | 30 | 6 or |  |  | 09 | 10 | 11 | 12 | 15 | 14 | 15 | 16 | 17 | 16 | 19 | 20 | 21 | 22 | 25 | 00 | 01 | 02 | 05 | 040 | 050 | 06 | 070 | 080 | 09 | 10.11 | 1112 | 12 |
|  | 14 | 3 | 3 | 16 | 17 | 18 | 19 | 20 | $0 \cdot 21$ | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 03 | O6 | 6 | 70 | 0 | os | 10 | 1 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 050 | 06 | 07 | Of 09 | 09 | 10 | 12 | 12 |  |
|  | 13 | 6 | 6 | 17 | 18 | 19 | 20 | 21 | 22 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 405 | 06 | 6.07 | 7 Oe | ${ }^{6}$ Of | 810 | 0 | 1 | 12 | 15 | 14 | 15 | 16 | 17 | 16 | 19 | 20 | 21 | 22 | 25 | 00 | 01 | 02 | 03 | 04 | 0506 | 0607 | 0708 | - | O8 10 | 101 | 11 | 1213 | 13 | 4 |
| -4 (0) | 16 | 7 | 7 | 18 | 19 | 20 | 21 | 22 |  | $23 \bigcirc$ | 00 | 01 | 02 | 03 | 04 | 03 | 06 | ) 07 | 70 | $\bigcirc$ | 910 | 1 | 1 | 12 | 13 | 14 | 13 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 040 | 03 | 0607 | 07 00 | 08 | 09 | 10 | 111 | 121 | 1314 | 14 | 5 |
| -5 (E) | 17 | - | $\theta$ | 19 | 20 | 21 | 22 | 23 | 00 | $00 \cdot$ | 01 | 02 | 03 | 04 | 08 | 08 | 07 | 08 | 88 | 910 | 0 | 12 | 2 | 13 | 14 | 13 | 16 | 17 | 18 | 19 | 29 | 21 | 22 | 25 | 00 | 01 | 02 | 05 | 04 | 05 | 06 | 0700 | 0809 | 0910 | 10 | 111 | 12 | 15 | 14.15 | 15 |  |
| $\left\|\begin{array}{ll} -6 & (f) \\ -7 & (G) \end{array}\right\|$ |  | 19 | 9 | 20 | 21 | 22 | 23 | 00 |  | 010 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 910 | 011 | 12 | 12 | 3 | 14 | 13 | 18 | 17 | 16 | 19 | 20 | 212 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 03 | 06 | 07 | 0809 | 0910 | 10 | 1112 | 12 | 14 | 14.13 | 1318 | 18 |  |
|  |  | 20 | 02 | 21 | 22 | 25 | 00 | 01 |  | 22 | 03 | 04 | 03 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 |  |  | 15 | 16 | 17 | 18 | 18 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 05 | 04 | 05 | 06 | 07 | 06 | 09 | 1 | 11 | 12 | 15 | 14 15 | 15 | 16.17 | 17 |  |
|  | 20 | 21 | 2 | 22 | 23 | 00 | 01 | 02 |  | 030 | 04 | 03 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 215 | 14 |  | 5 | - | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00. | 01 | 02 | 03 | 04 | 03 | 06 | 07 | $0 \cdot$ | 08 | 10.11 | 1112 | 1213 | 13 | 14 | 18 | 18 17 | 17.18 | 18 |  |
|  | 21 | 22 | 22 | 25 | 00 | 01 | 02 | 03 |  | 040 | 05 | 06 | 07 | 08 | $\bigcirc 9$ | 10 | 11 | 12 | 213 | 13 | 13 | 18 | - | 7 | 181 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 03 | 06 | 07 | 06 | 09 | 10 | 1112 | 12 13 | 1314 | 4 | 13 | 18 19 | 171 | 1810 | 19 | 0 |
|  | 22 | 25 | 50 | 00 | 01 | 02 | 03 | 04 |  | 030 | 06 | 07 | 08 | 09 | 10 | 1 | 12 | 15 | 14 | 415 | 18 |  |  | 16 | 19 | 20 | 21 | 22 | 25 | 00 | 01 | 02 | 05 | 04 | 05 | 08 | 07 | 06 | 09 | 10 | 11 | 1215 | 1514 | 1415 | 5 | 16 | 1716 | 18 | 1920 | 20 |  |
|  | 23 | $\bigcirc$ | 0 | O | 02 | 05 | 04 | 05 |  | $0 \cdot 1$ | Ot | 08 | 09 | 10 | 11 | 12 | 15 | 14 | 15 | 518 | 17 | 16 |  | 16 | 20 | 21 | 22 | 23 | 00.0 | 01 | 02 | 03 | 04 | 05 | O日 | 07 | 06 | 09 | 10 | 11 | 12 1 | 13 14 | 14.15 | 15.16 | 16 | 7 | 19 | 19.2 | 2021 | 21 |  |
| -12 (m) | 00 | 01 |  | 02 | 03 | 04 | 03 | 06 | OT | 71 | 06 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 18 | 17 | 16 | 16 |  | 20 | 21 | 22 | 230 | 00 | 01 | 02 | 05 | 04 | 05 | 08 | 07 | 08 | 09 | 10 | 11 | 12 is | is | 14.15 | 1516 | 16 | 1716 | 1819 | 1920 | 202 | 2122 | 22 |  |
|  |  | 12 |  | 15 | 14 | 13 | 16 | 17 | 18 | 1819 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 304 | 03 | 0 |  | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 13 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 0102 | 0203 | 0304 | 0403 | 03 O6 | 0607 | 070 | 0809 | 09 |  |
|  |  | 11 | 1 | 12 | 13 | 14 | 15 | 1516 |  | 17 | 18 | 19 | 20 | 21 | 22 | 25 | 00 | 01 | 02 | 2 O | 5 |  | 05 | - | 07 | -8 | 09 | 10 | 11 | 12 | 15 | 14 | 15 | 16 | 17 | 16 | 19 | 20 | 21 | 22. | 2 | 0001 | 102 | 0203 | 03 | 0403 | 0306 | 06 | 07 O8 | 06 | 9 |
|  |  | 10 | 1 | 1 | 12 | 13 | 14 | 13 | 16 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 0 O1 | 102 | 05 | ${ }^{2}$ | 4 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 13 | 18 | 17 | 18 | 19 | 20 | 212 | 22 | 23.00 | 0001 | 010 | 020 | 030 | 0403 | 03 | 0607 | 07 | - |
|  | 06 | 09 | 9 | 10 | 11 |  | 13 | 14 | 13 | 1316 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | $\bigcirc 01$ | 02 |  | 3 | 4 | 03 | 06 | 07 | -8 | 09 | 10 | 11 | 12 | 13 | 14 | 13 | 16 | 17 | 18 | 19 | 20.2 | 21 | 2225 | 25.00 | 0001 | 1 | 0203 | 0304 | 040 | 05 O8 | 08 | 7 |
| +5 (R) ${ }_{+}$ |  | 06 | 6 | 09 | 10 | 11 | 12 | 13 | 14 | 4 | 15 16 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 30 | 01 | 0 | 203 | 3 | 04 | 03 | 06 | 07 | OB | 09 | 10 | 11 | 12 | 13 | 14 | 13 | 16 | 17 | 18 | 1920 | 202 | 2122 | 22.23 | 2300 | $\bigcirc 0$ | 010 | 0203 | 030 | 0405 | 05 |  |
| +6 (s) ${ }^{+5}$ |  | 07 | 7 | $\bigcirc 0$ | 09 | 10 | 1 | 12 | 13 | 31 | 14 | 13 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 0 |  | 02 | 03 | 04 | OS | 06 | 07 | 08 | 09 | 10 | $1{ }^{11}$ | 12 | 13 | 14 | 13 | 16 | 17 | 1819 | 1920 | 2021 | 2122 | 22.23 | 23. | 0001 | 0102 | 020 | 0304 | 04 |  |
| +7 (T) | 03 | 06 | ${ }^{\circ} \mathrm{O}$ | 07 | 08 | 09 | 10 | 11 |  | 12 15 | 15 | 14 | 13 | 16 | 17 | 18 | 19 | 20 | 21 | 122 | 23 | 00 |  | 1 | 02 | 03 | 04 | 03 | 06 | 07 | 08 | 09 | 10 | " | 12 | 13 | 14 | 13 | 16 | 17 18 | 18 | 1920 | 20.21 | 2122 | 22 | 23 | $\infty$ | 010 | 0203 | 3 | 4 |
| +6 (0) | 04 | 05 |  | 06 | 07 | 08 | 09 | 09 |  | 111 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 021 | 22 | 23 |  | 00 | $\bigcirc$ | 02 | 05 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 15 | 14 | 13 | 16 | 17 | 19 | 19 20 | 2021 | 212 | 222 | 2300 | 00 0 | 0102 | 02 | 3 |
|  | Os | 04 |  | 05 | 06 | 07 | 08 | 09 |  | 10 | 111 | 12 | 15 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |  | 23 | 0 | 01 | 02 | 03 | 04 | 03 | 06 | 07 | OB | 09 | 10 | 11 | 12 | 13 | 14 | 13 16 | 16 | 1718 | 19 | 920 | 2021 | 2122 | 2823 | 2310 | 00 01 | 1 | 2 |
| $\left\|\begin{array}{l} +10(w) \\ +11(x) \\ +12(y) \end{array}\right\|$ | 02 | 03 |  | 04 | 03 | 06 | 07 | 08 | 09 | 9 10 | 10 | 11 | 12 | 13 | 14 | 13 | 16 | 17 | 18 | 19 | 20 | 2 |  | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 03 | $\infty$ | 07 | -8 | 09 | 10 | 11 | 12.13 | 13 | 15 | 15 | 17 | 17.18 | 19 | 9 | 2021 | 21 | 23 | 2300 | 0 |  |
|  | 01 | 02 |  | 03 | 04 | 05 | 06 | O7 | 08 | 06 | 09 | 10 | 11 | 12 | 15 | 14 | 15 | 16 | 17 | 178 | 19 | 20 |  | 21 | 22 | 23 | 00 | 01 | 02 | 05 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 111 | 12 | 1314 | 1415 | 1516 | 17 | 718 | 18 | 1920 | 20.21 | 2122 | 2223 | 2300 |  |
|  | 00 | 01 |  | 02 | 03 | 04 | 05 | 06 |  | ${ }^{7}$ | ${ }_{06}{ }^{\circ}$ | 09 | 10 | 11 |  | 15 | 14 | 15 | 16 | 17 | 16 | 19 |  | 20 | 21 | 22 | 25 | 00 | 01 | 02 | 05 | 04 | 05 | 08 | 07 | 08 | 09 | 10 | 11 | 12 15 | 1514 | $14{ }^{13}$ | 1316 | 1617 | 17 18 | 18.19 | 1920 | 20.2 | 2122 | 22.25 |  |
|  | previous day |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ame | DAY |  |  |  |  |  |  |  |  |  |  |  |  |

KAGOSHIMA - WAN, KYUSHU *
LAT $31^{\circ} 30^{\circ} \mathrm{N}$., LONG $130^{\circ} 40^{\circ} \mathrm{E}$.

DECEMBER 1945
TIME MERIDIAN: $135^{\circ} \mathrm{E}$. SUNLIGHT AND MOONLGHT DATA COMPUTED FOR LAT $311^{\circ} 30^{\circ} \mathrm{N}$, LONG $130^{\circ} 40^{\prime} E$.


* TMIS GIAGRAM, mith THE CHAWGES IMDIGATED, IS ALSO APPLIGABLE TO TME FOLLOMIMG PLACES: TOMARI URA -adD IO MEUTES TD TIMES OF HIGN AMD LOT TIDES SUBTRAGT $1 / 2$ FOOT FROM HEIGHTS OF HIGH TIDES. ODOMARI-WAN _ SUETRAGT 25 MINUTES FROM TIMES OF HIGH ANO LOW TIOES. SUBTRACT \& FOOT FROM HESGHTS OF HIGH TIDES

Figure 7.17. Sample diagram of tides, sunlight, and moonlight.
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


NOTE-Degrees refer to center of sun below horizon.
Figure 7.18. Twilight factors.
in a zone number east of the one shown on the diagram, the number is increased by 1 hour for each $15^{\circ}$; if west, the number is decreased by 1 hour for each $15^{\circ}$.
d. Dates. In the upper diagram of figure 7.17, 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. 7.18).
(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.
(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 7.17. 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 7.17 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 complied in the area and from meteorological forecasts for the area.

### 7.66 Hours of Daylight

[Time between sunrise and sunset. It is light for approximately 30 minutes] Lbefore sunrise and after sunset. For latitude south, subtract figure given from 24.]

| Latitude north | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dee |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $0^{\circ}$ | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| $10^{\circ}$ | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 12 | 12 | 12 | 12 | 12 |
| $20^{\circ}$ | 11 | 12 | 12 | 13 | 13 | 13 | 13 | 13 | 12 | 12 | 11 | 11 |
| $30^{\circ}$ | 10 | 11 | 12 | 13 | 14 | 14 | 14 | 13 | 12 | 11 | 11 | 10 |
| $40^{\circ}$ | 10 | 11 | 12 | 13 | 14 | 15 | 15 | 14 | 12 | 11 | 10 | 9 |
| $50^{\circ}$ | 9 | 10 | 12 | 14 | 15 | 16 | 16 | 14 | 12 | 11 | 9 | 8 |
| $60^{\circ}$ | 7 | 9 | 12 | 15 | 17 | 19 | 18 | 16 | 12 | 10 | 9 | 6 |
| $70^{\circ}$ | 0 | 7 | 12 | 16 | 23 | 24 | 24 | 18 | 12 | 9 | 4 | 0 |
| $80^{\circ}$ | 0 | 0 | 12 | 24 | 24 | 24 | 24 | 24 | 12 | 5 | 0 | 0 |

### 7.67 Calendar 1900-1999

## a. Calendar.

| Key letter ${ }^{\text {d }}$ | 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 |


| Koy letter ${ }^{1}$ |  |  |  |  |  | Year |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| T |  |  |  |  |  | 1906 |  | 1934 | 1962 |  | 1990 |
|  |  |  |  |  |  | 1907 |  | 1935 | 1963 |  | 1991 |
|  |  |  |  |  |  | 1908 |  | 1936 | 1964 |  | 1992 |
| X |  |  |  |  |  | 1909 |  | 1937 | 1965 |  | 1993 |
| Y |  |  |  |  |  | 1910 |  | 1938 | 1966 |  | 1994 |
| Z |  |  |  |  |  | 1911 |  | 1939 | 1967 |  | 1995 |
|  |  |  |  |  |  | 1912 |  | 1940 | 1968 |  | 1996 |
|  |  |  |  |  |  | 1913 |  | 1941 | 1969 |  | 1997 |
|  |  |  |  |  |  | 1914 |  | 1942 | 1970 |  | 1998 |
|  |  |  |  |  |  | 1915 |  | 1943 | 1971 |  | 1999 |
|  |  |  |  |  |  | 1916 |  | 1944 | 1972 |  |  |
|  |  |  |  |  |  | 1917 |  | 1945 | 1973 |  |  |
|  |  |  |  |  |  | 1918 |  | 1946 | 1974 |  |  |
|  |  |  |  |  |  | 1919 |  | 1947 | 1975 |  |  |
|  |  |  |  |  |  | 1920 |  | 1948 | 1976 |  |  |
|  |  |  |  |  |  | 1921 |  | 1949 | 1977 |  |  |
| Z |  |  |  |  |  | 1922 |  | 1950 | 1978 |  |  |
|  |  |  |  |  |  | 1923 |  | 1951 | 1979 |  |  |
|  |  |  |  |  |  | 1924 |  | 1952 | 1980 |  |  |
|  |  |  |  |  |  | 1925 |  | 1953 | 1981 |  |  |
|  |  |  |  |  |  | 1926 |  | 1954 | 1982 |  |  |
|  |  |  |  |  |  | 1927 |  | 1955 | 1983 |  |  |
|  |  |  |  |  |  | 1928 |  | 1956 | 1984 |  |  |
| Morih |  |  |  |  |  | Key later |  |  |  |  |  |
|  | Octo |  |  |  | Z | Y | X | W | V | U | T |
|  | Ma | vem |  |  | W | V | U | T | 2 | Y | X |
|  |  |  |  |  | T | Z | Y | X | W | V | U |
| Ma |  |  |  |  | Y | X | W | V | U | T | Z |
| Jun |  |  |  |  | V | U | T | Z | Y | X | W |
|  |  |  |  |  | X | W | V | U | T | Z | Y |
|  | r, D |  |  |  | U | T | Z | Y | X | W | V |
| Day |  |  |  |  | Day of meek |  |  |  |  |  |  |
| 1 | 8 | 15 | 22 | 29 | Sun | Sat | Fri | Thurs | Wed | Tues | Mon |
| 2 | 9 | 16 | 23 | 30 | Mon | Sun | Sat | Fri | Thurs | Wed | Tues |
| 3 | 10 | 17 | 24 | 31 | Tues | Mon | Sun | Sat | Fri | Thurs | Wed |
| 4 | 11 | 18 | 25 |  | Wed | Tues | Mon | Sun | Sat | Fri | Thurs |
| 5 | 12 | 19 | 26 |  | Thurs | Wed | Tues | Mon | Sun | Sat | Fri |
| 6 | 13 | 20 | 27 |  | Fri | Thurs | Wed | Tues | Mon | Sun | Sat |
| 9 | 14 | 21 | 28 | --- | Sat | Fri | Thurs | Wed | Tues | Mon | Sun |

[^37]
## 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,__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 this 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 a 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

### 7.68 Gradient

Gradient, or slope percentage, is the ratio between the vertical rise and the horizontal distance traveled. This information is sometimes needed by operators in the field, and can be determined from observation on the spot or from maps, by using one of the two methods shown below. The first method, when properly employed with accurate instruments, can give an exact gradient. If accurate instruments are not available or if the accuracy of the first method is in doubt, a workable gradient can be obtained from a map by using the second method. When possible, both methods should be used, so that each can serve as a check upon the other.
a. First Method. With the horizontal bubble leveled in a transit, artillery compass, or similar instrument, sight through the instrument to a point on the terrain; mark the terrain where line of sight intersects. Measure the ground distance in feet to this point and the height in feet (to line of sight) of the instrument. Use the following formula to obtain gradient in percent.

$$
\frac{a}{\sqrt{b^{2}-a^{2}}} \times 100=\text { gradient in percent }
$$

Where

$$
\begin{aligned}
\mathrm{a}= & \text { height of instrument (to line of sight) } \\
& \text { in feet } \\
\mathrm{b}= & \text { ground distance in feet between point } \\
& \text { of sighting and mark on terrain }
\end{aligned}
$$

b. Second Method. Measure the horizontal distance in feet on a map between the two designated points, per map scale. Then measure the change in elevation between the two points by using the map's contour lines. Use the following formula to obtain gradient in percent.

$$
\frac{\mathrm{a}}{\mathrm{c}} \times 100=\text { gradient in percent }
$$

Where

$$
\begin{aligned}
a= & \text { change in elevation in feet } \\
c= & \text { horizontal distance in feet between the } \\
& \text { two designated points }
\end{aligned}
$$

### 7.69 Maps

This paragraph is a brief summary of the essential elements needed for the intelligent and practical use of a relatively large-scale military map. No attempt is made to cover detailed techniques pertaining to orientation, direction, distance, and elevation. The reader should refer to FM 21-26, FM 21-30, and FM 21-31 for more detailed information on map reading.
a. Orienting the Map. A map is oriented when directions on it are parallel with the represented ground directions. In each method outlined below, the map is held in a horizontal position.
(1) Inspection. A straight road, railroad track, or similar feature on the map is made parallel with the same feature on the ground. Care is required to insure that the map is not $180^{\circ}$ out of phase.
(2) Compass. The map, with a compass placed upon it, is turned until the compass needle is parallel to the magnetic north arrow on the map.
(3) Distant point. The observer lines up his own position on the map and a distant point on the map with the same distant point on the ground.
b. Recognizing Ground Objects and Places That Also Appear on the Map. The ability of the observer to accomplish this depends upon his experience and the proper use of military map symbols. Natural and manmade shapes. and the color scheme of the map must also be understood. On a military map, black represents cultural or manmade features; blue, water; green, vegetation; brown, relief features (contour lines are brown); and red, main roads. Other colors may also be used, such as yellow for contaminated areas.
c. Determination of Horizbntal Direction. Horizontal direction is expressed as a clockwise angle (called an azimuth) from true, magnetic, or grid north.
(1) The three kinds of north are defined below. Marginal information on all military maps should indicate these directions.
(a) True north. The direction that points to the north pole is true north. All lines of longitude (meridians) run true north. These lines are not parallel but intersect at the north and south poles.
(b) Magnetic north. The northern direction indicated by a compass needle is magnetic north. It is affected by many magnetic influences in the earth, chief of which is the magnetic north pole in the vicinity of Melville Island, northern Canada. It may vary considerably with changes in location on the earth's surface and may even show slight variations with changes in time. Therefore, for accurate work, it is mandatory that up-to-date data be used, and that compass readings be as free as possible from surrounding artificial magnetic influences such as those produced by electricity and masses of metal.
(c) Grid north. Grid north is the northern direction that coincides with or is parallel to the vertical lines in a grid system that has been superimposed on a map. These vertical lines are always parallel to each other and should not be confused with true north.
(2) If magnetic north cannot be determined with a compass, and/or the magnetic declination from true north is not known, an approximate direction of true north can be found by one of the following methods.
(a) Use of stars (night).

1. Northern hemisphere. 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.
2. Southern hemisphere. The horizontal axis of the constellation known as the Southern Cross (composed of four stars) is used for this determination. A point above the South Pole is to the right of the horizontal axis at an approximate distance of four
and a half times the length of the axis. The North Pole (true north) is $180^{\circ}$ from the South Pole.
(b) Use of a watch set on standard time (day).
3. Northern hemisphere. The hour hand on the watch should be pointed at a direction on the horizon which is directly below the sun. A line bisecting the largest angle between the hour hand and 12 o'clock points north.
4. 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.

## d. Horizontal Distance and Elevation.

(1) Horizontal distance. This distance may be expressed in miles, kilometers, feet, yards, meters, or any other approved unit of linear measure (par. 7.47a). To properly apply ground distance to a map, or map distances to the ground, the map's scale must be known. This is usually expressed as a representative fraction (RF). The representative fraction indicates the number of horizontal units (denominator) on the ground that are represented by one horizontal unit (numerator) on the map (par. 7.50). If the map scale is not shown, it can be determined by comparing the map distance between two known points with the measured horizontal ground distance.
(2) Elevation. This is the vertical distance above or below sea level. On military maps, elevation is usually shown by contour lines, which are lines joining points of equal elevation. The difference in elevation between contour lines is known as the contour interval. This interval should be stated in the margin of a military map and must remain constant for any one map. The amount of the interval depends upon the nature of the surface (a mountainous area has a larger interval than relatively flat terrain). If the contour interval is not indicated, it
can be approximated by using the scale of the map and the following formula:
Contour interval
60
$=\overline{\text { Number of map inches to the mile }}$
e. Point Location in General. On a military map, point location is generally accomplished through the use of polar coordinates or grid coordinates.
(1) Polar coordinates. A direction is determined from the appropriate north discussed in $c$ above. A distance along this direction from a base point then gives the point location.
(2) Grid coordinates. A grid system of horizontal and vertical lines (making equal squares) is superimposed upon a map. Point locations are then defined as
horizontal and vertical distance from specified intersections of the grid.
f. Location of Unknown Point from Two Known Positions. Determine a direction to the unknown point from a known position that is occupied. Draw a line on the oriented map along this direction. Move to a new known position to the left or right of the one last occupied, and determine a new direction to the unknown point. Draw another line on the oriented map along this new direction. The intersection of the two lines locates the unknown point on the map.
g. Location of One's Own Position on a Map. Determine directions to two known points that can be seen on the ground and can also be located on the map. Draw lines on the oriented map along both of these directions. The intersection of these lines represents the observer's location on the map.

| $\begin{aligned} & \text { Line } \\ & \text { No. } \end{aligned}$ | TOE No. (8ee par. 7.72 for nomenclature) | 55-11 | 55-12 | 6S-16 | 55-17 | $\begin{gathered} \text { (Cargo } \\ (\text { Cargo } \end{gathered}$ | $\begin{gathered} 55-18 \\ (\mathrm{Pet}) \end{gathered}$ | $\begin{gathered} 55-18 \\ \text { (Refrig) } \end{gathered}$ | 55-19 | 55-27 | 55-46 | 55-47 | 65-56 | 65-57 | Ss-75 | 55-76 | 55-77 | 55-78 | 55-79 | 55-111 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 2 | TOE Equipment \& Bupplies: <br> $\mathrm{Cu} f\left(\right.$ (full atr) ${ }^{1}$ <br> ST (full adr) ${ }^{1}$ | $\begin{array}{r} 1,463.0 \\ 9.6 \end{array}$ | $\left\lvert\, \begin{array}{r} 1,118.0 \\ 0.4 \end{array}\right.$ | $\begin{array}{r} 774.0 \\ 7.0 \end{array}$ | $\begin{array}{r} 2,661: 0 \\ 18.9 \end{array}$ | $\begin{array}{r} 2,131.0 \\ 15.1 \end{array}$ | $\begin{array}{r} 2,143.0 \\ 15.3 \end{array}$ | $\begin{array}{\|r} 2,245.0 \\ 17.5 \end{array}$ | $\begin{array}{\|c} 1,730.0 \\ 11.7 \end{array}$ | $\begin{array}{r} 2,062.0 \\ \quad 14.7 \end{array}$ | $\begin{array}{r} 1,289.0 \\ 10.5 \end{array}$ | $\begin{array}{r} 4,171.0 \\ \begin{array}{r} 25.7 \end{array} \end{array}$ | $\begin{array}{r} 1,585.0 \\ \quad 13.0 \end{array}$ | $\begin{array}{r} 1,885.0 \\ 11.6 \end{array}$ | $\begin{array}{r} 7,812.0 \\ 52.5 \end{array}$ | $\begin{array}{\|c} 2,390.0 \\ 20.5 \end{array}$ | $\left.\begin{array}{r} 1,083.0 \\ 9.5 \end{array} \right\rvert\,$ | $\left.\begin{array}{\|r} 1,676.0 \\ 8.9 \end{array} \right\rvert\,$ | $\begin{array}{\|r\|} \hline 1,293.0 \\ 9.2 \end{array}$ | $\begin{array}{\|c} 2,727.0 \\ \begin{array}{r} 28.2 \end{array} \end{array}$ |
| 3 | TOE Vehicles \& Trailers: ST (full atr)! | 32.0 | 31.4 | 36.2 | 658.0 | 1,030.7 | 1,089.7 | 828.3 | 177.2 | 123.3 | 43.0 | 1,187.9 | 50.8 | 85.2 | 3,017.8 | 114.7 | 818.0 | 1,112.2 | 62.5 | 9.1 |
| 4 | Troose ${ }^{1}$. | 124 | 01 | 47 | 168 | 181 | 187 | 200 | 111 | 184 | 55 | 180 | 72 | 147 | 521 | 122 | 158 | 92 | 59 | 303 |
| 5 | TOE personnel add individual equipment, assuroing average reight of 240 lb per man: ${ }^{1}$ ET (full str)2 | 14.9 | 7.3 | 5.6 | 20.1 | 21.7 | 22.4 | 24.0 | 13.3 | 22.1 | 6.6 | 21.6 | 8.6 | 17.7 | 62.5 | 14.7 | 18.7 | 11.0 | 7.1 | 36.4 |
| 7 | Cleat I necesesary for 3 days, assąuing 0.0 lb per ration per man per day: <br> Cu ft (full str) ${ }^{3}$ <br> ST (full str) | $\begin{gathered} 103.0 \\ 1.23 \end{gathered}$ | 50.3 .6 | 39.4 <br> .47 | 139.0 1.86 | 150.0 1.79 | $\begin{gathered} 155.0 \\ 1.85 \end{gathered}$ | $\begin{gathered} 166.0 \\ 1.88 \end{gathered}$ | 92.2 1.1 | $\begin{gathered} 152.5 \\ 1.82 \end{gathered}$ | 46.1 <br> .55 | $\begin{gathered} 149.0 \\ 1.78 \end{gathered}$ | 59.5 <br> .71 | $\begin{gathered} 122.5 \\ 1.46 \end{gathered}$ | 43.8 .58 | $\begin{gathered} 101.5 \\ 1.21 \end{gathered}$ | 129.0 1.54 | 76.3 .91 | $\begin{gathered} 49.5 \\ .59 \end{gathered}$ | $\begin{gathered} 250.0 \\ 2.88 \end{gathered}$ |
| $0$ | Class III necessary unit vehicles 300 miles from deatingtion' point after arrival, if sutborised in shipment: <br>  <br> ST (full stz) | $\begin{gathered} 28.9 \\ 1.15 \end{gathered}$ | $\begin{gathered} 28.4 \\ 1.13 \end{gathered}$ | $\begin{gathered} 22.3 \\ .89 \end{gathered}$ | $\begin{gathered} 490.0 \\ 19.53 \end{gathered}$ | $\begin{gathered} 555.0 \\ 22.11 \end{gathered}$ | $\begin{aligned} & 555.0 \\ & 22.11 \end{aligned}$ | $\begin{aligned} & 555.0 \\ & 22.11 \end{aligned}$ | $\begin{gathered} 180.5 \\ 8.63 \end{gathered}$ | $\begin{gathered} 590.0 \\ 23.48 \end{gathered}$ | $\begin{gathered} 31.4 \\ 1.25 \end{gathered}$ | $\left\|\begin{array}{c} 1,820.0 \\ 72.44 \end{array}\right\|$ | $\begin{gathered} 40.7 \\ 1.62 \end{gathered}$ | $\begin{gathered} 78.2 \\ 3.11 \end{gathered}$ | $\begin{gathered} \text { 4. } 100.0 \\ 162.68 \end{gathered}$ | $\begin{gathered} 169.0 \\ 6.74 \end{gathered}$ | $\begin{gathered} 428.0 \\ 17.05 \end{gathered}$ | $\left\|\begin{array}{c} 1,740.0 \\ 69.44 \end{array}\right\|$ | $\begin{gathered} 14.8 \\ .59 \end{gathered}$ | 8.05 .32 |
| $\begin{aligned} & 10 \\ & 11 \end{aligned}$ | Basic load of Class V . $\mathrm{Cu} \mathrm{ft}(\mathrm{full} \text { str) })^{\circ}$ ST (full str) ${ }^{\text { }}$ | $\begin{gathered} 6.58 \\ .184 \end{gathered}$ | $\begin{gathered} 3.64 \\ .104 \end{gathered}$ | $\begin{gathered} 2.75 \\ .077 \end{gathered}$ | $\begin{aligned} & 55.5 \\ & 1.555 \end{aligned}$ | $\begin{gathered} 7.78 \\ .246 \end{gathered}$ | $\begin{gathered} 9.0 \\ .252 \end{gathered}$ | 9.5 <br> .288 | $\begin{gathered} 7.71 \\ .216 \end{gathered}$ | $\begin{gathered} 20.2 \\ .565 \end{gathered}$ | $\begin{gathered} 12.75 \\ .357 \end{gathered}$ | $\begin{gathered} 30.8 \\ .865 \end{gathered}$ | $\begin{gathered} 7.36 \\ .206 \end{gathered}$ | $\begin{gathered} 18.0 \\ .504 \end{gathered}$ | $\begin{gathered} 553.0 \\ 15.52 \end{gathered}$ | 19.15 <br> .538 | $\begin{gathered} 7.7 \\ 2.01 \end{gathered}$ | $\begin{gathered} 223.0 \\ 6.26 \end{gathered}$ | $\begin{gathered} 9.53 \\ .267 \end{gathered}$ | $\begin{array}{r} 15.35 \\ .43 \end{array}$ |
| 12 | Total ST ${ }^{3}$ | 59.1 | 49.9 | 50.2 | 719.7 | 1,091.8 | 1,131.6 | 894.1 | 210.1 | 185.9 | 62.3 | 1,290.3 | 74.9 | 119.6 | 3,311.3 | 158.4 | 684.8 | 1,208.7 | 80.2 | 67.4 |
| 13 | Cube of equipment, supplies, and classes I, III \& Vo | 1,602.0 | 1,200.0 | 839.0 | 3,346.0 | 2,844.0 | 2,882.0 | 2,976.0 | 1,998.0 | 2,825.0 | 1,379 0 | 6, 171.0 | 1.693 .0 | 2,084.0 | 12,509.0 | 2,880.0 | 1,712.0 | 3,715.0 | 1,387.0 | 3,000.0 |
| 14 | Density of TOE equipment and supplies, and classes I, III, and Vio Cu ft per ST | 139.7 | 113.7 | 106.2 | 112.0 | 109.5 | 109.1 | 104.2 | 127.5 | 108.8 | 115.5 | 107.6 | 116.3 | 140.5 | 93.6 | 107.2 | 86.2 | 84.8 | 132.5 | 138.0 |

See footnotea on page 374.

| $\begin{aligned} & \text { Line } \\ & \text { No. } \end{aligned}$ | TOE No. (See par. 7.72 for nomenclature) | 55-116 | 58-117 | 65-121 | 55-131 | 65-137 | 65-147 | 65-201 | 55-202 | 55-225 | 55-226 | 55-227 | 55-226 | 56-229 | 55-236 | 55-260 | 85-302 | 65-456 | 55-457 | 65-456 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & 1 \\ & 2 \end{aligned}$ | TOE Equipment \& Supplise: <br> Cu ft (full str) ${ }^{1}$ <br> ST (full str) ${ }^{1}$ | $\begin{array}{r} 644.0 \\ 7.7 \end{array}$ | $\begin{array}{r} 30,224.0 \\ 245.0 \end{array}$ | $\begin{array}{\|r\|} 2,050.0 \\ 13.7 \end{array}$ | $\begin{array}{\|r\|} \mathbf{1}, 702.0 \\ 11.7 \end{array}$ | $\begin{array}{r} 1,976.0 \\ \quad 17.5 \end{array}$ | $\begin{array}{r} 6,179.0 \\ 27.4 \end{array}$ | $\begin{array}{r} 2,217.0 \\ 15.7 \end{array}$ | $\begin{array}{r} 1,230.0 \\ 9.6 \end{array}$ | $\begin{array}{r} 23,921.0 \\ 176.6 \end{array}$ | $\begin{array}{\|r} 617.0 \\ 5.6 \end{array}$ | $\begin{array}{\|r} 13,056.0 \\ 106.2 \end{array}$ | $\begin{array}{r} 2,850.0 \\ 36.2 \end{array}$ | $\begin{array}{r} 5.750 .0 \\ 27.6 \end{array}$ | $\begin{array}{r} 2,663.0 \\ \quad 13.1 \end{array}$ | $\begin{array}{r} 9,172.0 \\ 65.1 \end{array}$ | $\begin{array}{r} 1,283.0 \\ 6.1 \end{array}$ |  | $\begin{array}{r} 2,221.0 \\ 14.6 \end{array}$ | $\begin{array}{r} 2,962.0 \\ 19.1 \end{array}$ |
| 3 | TOE Vehicles \& Trailers: <br> ST (full etr) ${ }^{1}$ | 25.1 | 149.9 | 17.6 | 16.3 | 341.5 | 45.0 | 54.2 | 22.9 | 260.9 | 24.6 | 216.9 | 26.6 | 6.7 | 20.4 | 12.6 | 40.9 | 30.6 | 195.9 | 122.5 |
| 4 | Troops ${ }^{1}$ | 56 | 329 | 167 | 131 | 194 | 91 | 201 | 101 | 823 | 124 | 251 | 142 | 306 | 102 | 117 | 139 | 33 | 129 | 168 |
| 5 | TOE peraonnel and individual equipment, assuming average weigbt of 240 lb per $\operatorname{man}^{1}$ <br> ST (full str)' | 6.7 | 39.5 | 22.4 | 15.7 | 23.3 | 10.9 | 24.1 | 12.1 | 98.8 | 14.9 | 30.2 | 17.1 | 36.7 | 12.1 | 14.1 | 16.7 | 4.0 | 15.6 | 20.4 |
| 6 7 | Class 1 necessary for 3 days, assuming 6.6 lb per ration per man per day: <br> $\mathrm{Cuft}(\mathrm{full} \mathrm{str}) \mathrm{s}$ <br> ST (full str) | $\begin{aligned} & 46.9 \\ & .56 \end{aligned}$ | $\begin{array}{r} 273.0 \\ 3.26 \end{array}$ | $\begin{gathered} 155.0 \\ 1.85 \end{gathered}$ | $\begin{array}{r} 109.0 \\ 1.3 \end{array}$ | $\begin{gathered} 161.0 \\ 1.92 \end{gathered}$ | $\begin{array}{r} 75.5 \\ .9 \end{array}$ | $\begin{gathered} 166.0 \\ 1.96 \end{gathered}$ | $\begin{array}{r} 83.6 \\ 1.0 \end{array}$ | $\begin{gathered} 683.0 \\ 6.16 \end{gathered}$ | $\begin{array}{\|c\|} 103.0 \\ 1.23 \end{array}$ | $\begin{gathered} 209.0 \\ 2.49 \end{gathered}$ | $\begin{array}{r} 118.0 \\ 1.41 \end{array}$ | $\begin{array}{r} 254.0 \\ 3.03 \end{array}$ | $\begin{gathered} 64.7 \\ 1.01 \end{gathered}$ | $\begin{gathered} 97.2 \\ 1.16 \end{gathered}$ | $\begin{gathered} 115.5 \\ 1.38 \end{gathered}$ | $\begin{array}{r} 27.7 \\ .33 \end{array}$ | $\begin{gathered} 146.5 \\ 1.77 \end{gathered}$ | $\begin{gathered} 139.0 \\ 1.68 \end{gathered}$ |
| $\begin{aligned} & 8 \\ & 9 \end{aligned}$ | Class 111 necessary to move unit vebicles 300 miles from destination point after arrival, if autborized in shipment: $\begin{aligned} & \text { Cu ft (full str) })^{4} \\ & \text { ST } \quad(\text { full } \mathrm{str})^{3} \end{aligned}$ | $\begin{array}{r} 20.3 \\ .81 \end{array}$ | $\begin{gathered} 77.6 \\ 3.09 \end{gathered}$ | $\begin{array}{r} 7.27 \\ .29 \end{array}$ | $\begin{array}{r} 7.27 \\ .29 \end{array}$ | $\begin{array}{r} 229.5 \\ 9.15 \end{array}$ | $\begin{array}{r} 35.1 \\ 1.4 \end{array}$ | $\begin{gathered} 48.0 \\ 1.91 \end{gathered}$ | $\begin{array}{r} 22.6 \\ .91 \end{array}$ | $\begin{gathered} 129.0 \\ 5.15 \end{gathered}$ | $\begin{gathered} 29.4 \\ 1.17 \end{gathered}$ | $\begin{gathered} 76.2 \\ 3.03 \end{gathered}$ | $\begin{array}{r} 13.05 \\ .52 \end{array}$ | $\begin{array}{r} 10.8 \\ .43 \end{array}$ | $\begin{gathered} 24.6 \\ .96 \end{gathered}$ | $\begin{aligned} & 33.4 \\ & 1.33 \end{aligned}$ | $\begin{gathered} 38.9 \\ 1.65 \end{gathered}$ | $\begin{gathered} 34.6 \\ 1.36 \end{gathered}$ | $\begin{gathered} 135.0 \\ 5.38 \end{gathered}$ | $\begin{gathered} 85.1 \\ 3.39 \end{gathered}$ |
| $\begin{aligned} & 10 \\ & 11 \end{aligned}$ | Basic load of Class $V$ : Cuft (full str) ${ }^{6}$ ST (full str) ${ }^{7}$ | $\begin{gathered} 1.62 \\ .051 \end{gathered}$ | $\begin{aligned} & 20.8 \\ & .685 \end{aligned}$ | 10.2 .268 | $\begin{gathered} 7.36 \\ .208 \end{gathered}$ | $\begin{gathered} 23.4 \\ .658 \end{gathered}$ | $\begin{gathered} 5.75 \\ .161 \end{gathered}$ | $\begin{gathered} 7.11 \\ .189 \end{gathered}$ | $\begin{gathered} 5.66 \\ .159 \end{gathered}$ | $\begin{aligned} & 40.9 \\ & 1.145 \end{aligned}$ | $\begin{gathered} 7.72 \\ .216 \end{gathered}$ | $\begin{aligned} & 15.9 \\ & .445 \end{aligned}$ | $\begin{array}{r} 9.26 \\ .26 \end{array}$ | $\begin{array}{r} 8.05 \\ .225 \end{array}$ | $\begin{gathered} 6.36 \\ .178 \end{gathered}$ | $\begin{gathered} 7.36 \\ .208 \end{gathered}$ | $\begin{gathered} 7.79 \\ .218 \end{gathered}$ | $\begin{gathered} 3.64 \\ .104 \end{gathered}$ | $\begin{aligned} & 29.7 \\ & .833 \end{aligned}$ | $\begin{aligned} & 25.9 \\ & .726 \end{aligned}$ |
| 12 | Total ST | 40.9 | 441.3 | 56.1 | 47.5 | 394.0 | 85.7 | 88.1 | 46.7 | 570.7 | 47.8 | 363.3 | 84.1 | 76.9 | 47.8 | 94.7 | 66.6 | 39.1 | 234.0 | 167.6 |
| 13 | Cube of equipment, supplies, * Classes I, II1, \& V | 913.0 | 30,596.0 | 2,223.0 | 1,826.0 | 2,380.0 | 6,295.0 | 2,438.0 | 1,342.0 | 24,774.0 | 957.0 | 13,357.0 | 2,890.0 | 6,023.0 | 2,879.0 | 9,310.0 | 1,445.0 | 361.0 | 2,534.0 | 3,212.0 |
| 14 | Density of TOE equipment and supplises, Classes I, III, and $V^{\circ}$ <br> Cu ft per ST | 105.7 | 124.7 | 139.4 | 137.0 | 100.7 | 217.0 | 131.0 | 121.0 | 131.6 | 127.5 | 118.7 | 76.6 | 193.0 | 207.0 | 136.5 | 140.0 | 96.7 | 131.0 | 140.5 |

 autharised; this will not appreciably affect tbe aircraft requirement.
${ }^{2} \mathrm{C}-119$ aircraft has 82 troopseats, but weight capacity limits number of personnol to 57 ; C-130 aircraft has 92 troopeests; C-124 aircraft has 200 troopseats; but weigbt capacity limita number of personnel to 168.
Computed from weight, using etowage factor of 94
${ }^{4}$ Includes only 40 percent of total POL weight (line 9) to be carried in 5 -gallon cans. The remsining 60 percent is in vehicle tanks. Factors used aro: 1.31 (conversion from bulk to gas in cans); 46.1 cans per $8 T ; 1$ cu ft per can
POL for vehicles having no roadability (crawler cranes, etc.) has boen excluded
Computed from weight, using etowage factor of 40.
Number of weapons times rounds per weapon times weight per round
Sum of lines 2, 3, 5, 7, 9, and 11

- Sum of lines $1,6,8$, and 10
is Density of equipment and supplies may be used to estimate extent to whicb vehicle cargo space and other space can be utilized in aireraft. Lines 13 and 14 are for this purpose. Line 14 is obtained by dividing line 13 by the sum of lines 2, 7, 40 percent of line 9 , and line 11. Line 14 can also be expressed as a stowage factor by multiplying quantities ahown by 1.12 .



I Yehicles for C-119 losding: (columns 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 15, 16, 27, 28, 29, 30, 31, 38, 39, 40, 41, 42, 43, 44, 45, 46 47)
Yehicles for C -130 loading: (columns 11, 13, 19, 24, 37)
Vehicles for C-124 loading: (eolumns 9, 14, 17, 18, 20, 21, 22, 23, 25. 26. 32, 33. 34, 35, 36)
${ }^{1}$ Figures sbown are useful for general planning. When loading specific vehiclea that are identifed by a model number, the actual dintiensiona and weight inusit be deterrined belorebind. It must ako bo borns in mind for all vehiclea that
assembly produces sligbt variations in aize, even for tbs asme make and model number
1 Following usable aircraft capacities apply: Length Width Height
C-119-ST capacity (6.815); cargo compt, inches ( $443 \times 110 \times$ 08); door opening, nches ( $110 \times 96$ )
C-130-ST capacity (14.750); cargo compt, inches ( $498 \times 123 \times 109$ ); doar opening, inchea ( $120 \times 110$ )
C-124-ST capacity ( 20.250 ); cargo compt, incbes ( $924 \times 136 \times 138$ ); door opening, inches ( $135 \times 139$ )

- Units indicated by asterisk (*)


### 7.72 Air Transportability

a. General. Data in the two preceding paragraphs are used in conjunction with other data to construct the air-transportability table shown in c below. The table, consisting of 43 columns, indicates to the transportation planner a logical sequence in planning the movement of transportation units by Air Force aircraft. In obtaining the figures shown in columns 39 through 42 (notes 14 through 17), any fractional portion of an aircraft in the totals is considered as a whole aircraft. Figures in parentheses show the basic aircraft requirement when 60 percent of the POL load is carried in vehicles. Only those units shown are affected. POL load for the others is negligible. See line 9 of the table in paragraph 7.70.
b. Loading. The planner should not feel bound by the loading combinations shown below. Other combinations can be used.
(1) Method 1. Method 1 utilizes C-119 and C-124 aircraft only. Maximum load in C-119's includes all equipment, supplies, personnel, and individual equipment and some of the vehicles and trailers. The remainder of the load, consisting of vehicles and trailers, is transported by C-124's. Vehicle and trailer loads in column 15 are placed in C-119 aircraft; the loads in columns 16 and 17 are placed in $\mathrm{C}-124$ 's.
(2) Method 2. Method 2 utilizes C-130 and C-124 aircraft only. The C-119 load goes in the $\mathrm{C}-130$ 's. The $\mathrm{C}-124$ load remains the same except for those units having equipment that does not fit into C-119's but does fit in C-130's. In the cases of these units ( $55-18,-56,-57$, $-117,-137,-225,-227,-457$, and -458 ), the C-130's transport some of the vehicles which were allotted to C-124's by method 1. Vehicle and trailer loads in columns 15 and 16 are placed in C - 130 aircraft; the loads in column 17 are placed in C-124's.
(3) Adjustments due to configuration. Units indicated in this subparagraph need more or less aircraft due to configuration of certain vehicles and trailers. (See note 4,
par. 7.71.) For determining the aircraft requirement change, only columns 25 through 28 in the table are used, since columns $12,13,14,36,37$, and 38 do not pertain to vehicles and trailers. The increased vehicle configuration requirement for heavy aircraft, which does not utilize their maximum tonnage capacity, may result in a decrease in the requirement for medium aircraft, since some or all of the cargo from columns 3 and 4 in the table can be loaded into the cargo space of vehicles. Increase or decrease in requirement will be as shown below, with increase denoted by " + ," and decrease denoted by " -." Any decrease in requirement cannot be greater than the actual requirement for equipment and supplies indicated by columns 12 and 13 in the table.
(4) Personnel loading. When loading personnel with their individual equipment (columns 30 through 35 in the table), either troop seat capacity or the weight of 240 pounds per man produces the limiting factors. Weight is the limiting factor for the $\mathrm{C}-119$ and the $\mathrm{C}-124$ and volume for the $\mathrm{C}-130$.
(5) Use of heavy aircraft only. Should C-124 aircraft be used exclusively, vehicle and trailer configuration assumes less importance. Therefore, a rapid and close approximation of the number of aircraft required (except for units organized under TOE 55-18) can be arrived at through use of the formula shown below. In most cases the estimate allows for a safety factor of one aircraft. (See line 12 of the table in paragraph 7.70 for values of $W$ in the formula.)

$$
\text { Aircraft required }=\frac{W}{20.25}+1
$$

In the case of TOE 55-18 units, aircraft in addition to those called for by the formula would be required as follows:

TOE 55-18 (cargo)-9
TOE 55-18 (petrl)-7
TOE 55-18 (refrig)-3

| $\begin{aligned} & \text { Unit TOE } \\ & \text { No. } \end{aligned}$ | Loading | C-119 | C-130 | C-124 | $\underbrace{}_{\substack{\text { Unit Tos } \\ \text { No. }}}$ | Loading method | C-119 | C-130 | C-124 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 55-12 | $\begin{aligned} & 1 \\ & 2 \end{aligned}$ | -1 |  | +1 +1 | 55-78 | 1 |  |  | $\begin{aligned} & +2 \\ & +2 \end{aligned}$ |
| $\begin{aligned} & \text { 55-18 } \\ & \text { (cargo) } \end{aligned}$ | 1 | -3 | +21 | +13 +11 | 55-79 | 1 | -1 |  | +2 +2 |
| $\begin{aligned} & \text { 55-18 } \\ & \text { (petrl) } \end{aligned}$ | 1 2 | -2 | +20 | +12 +8 | 55-117 | 1 | -1 |  | +1 |
| $\begin{aligned} & \text { 55-18 } \\ & \text { (refrig) } \end{aligned}$ | 1 | -3 | +21 | $\begin{aligned} & +14 \\ & +11 \end{aligned}$ | 55-137 | 1 | -3 | +16 | +5 |
| 55-19 | 1 | -1 |  | +1 +1 | 55-201 | 1 | -1 |  | +1 +1 |
| 55-27 | 1 | +8 | +1 |  | 55-225 | 1 | -3 |  | +3 +1 |
| 55-47 | 1 | -4 | -2 | +3 +3 | 55-227 | 1 | -4 |  | +4 +1 |
| 55-75 | 1 | -19 | -9 | $\begin{aligned} & +23 \\ & +23 \end{aligned}$ | 55-457 | 1 | -2 | -1 | +3 +3 |
| 55-76 | 1 | -2 | -1 | +2 +2 | 55-458 | 1 | -1 | -1 | +1 +2 |
| 55-77 | 1 | -1 | -1 | +14 +14 |  |  |  |  |  |


| UNIT | $\begin{aligned} & \text { TOE } \\ & \text { No. } \end{aligned}$ | EQUIPMENT AND SUPPLIESI |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\begin{aligned} & \text { Total } \\ & \mathrm{CuFt} \mathrm{Ft}^{2} \end{aligned}$ | Total Weight (ST) ${ }^{2}$ | Average of equip and (Cu Ft per ST) ${ }^{2}$ | Aircraft requirementa* |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Minimum required for volume loading |  |  | Minimum required for weight ioading |  |  | Number actually required by cube or weight |  |  |
|  |  |  |  |  | $\underset{\substack{\text { Method }}}{\mathrm{C}-119}$ | $\underset{\substack{\text { Method }}}{\text { C-130 }}$ | C-124 | $\underset{\substack{\text { Method } \\ \\ \text { C-119 }}}{\text { che }}$ | $\underset{2}{\mathrm{Method}}$ | C-124 | $\underset{\text { Method }}{\text { C-119 }}$ | $\underset{\substack{\text { Method }}}{\substack{\text { C-1 }}}$ | C-124 |
| 1 | 2 | 8 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Hq \& Hq Co, Trans Mtr Transport Comd | 55-11 |  |  |  |  |  |  |  |  |  |  |  |  |
| Hq \& Ha Co, Trans Trk Gp |  | 1,602 |  | 139.7 | . 59 | . 41 |  | . 1.63 | . 78 |  | 1.63 | . 78 |  |
| Hq \& Hq Co, Trans Trk Gp------- | 55-12 | 1,200 | 10.56 | 113.7 | 1.44 | . 31 |  | 1.55 | . 72 |  | 1.55 | . 72 |  |
| or COMMZ | 55-16 | 839 | 7.90 | 106.2 | . 31 | . 22 |  | 1.16 | . 54 |  | 1.16 | . 54 |  |
| Trans Lt Trk Co_ | 55-17 | 3,346 | 29.93 | 112.0 | 1.24 | . 86 |  | 4.40 | 2.03 |  | 4.40 | 2.03 |  |
| Trans Med Trk Co (Cargo) | 55-18 | 2,844 | 25.98 | 109.5 | 1.06 | . 73 |  | 3.82 | 1.76 |  | 3.82 | 1.76 |  |
| Trans Med Trk Co (Petroleum.-.--- | 55-18 | 2,862 | 26.25 | 109.1 | 1.06 | . 74 |  | 3.86 | 1.78 |  | 3.86 | 1.78 |  |
| Trans Med Trk Co (Refrigerator) .-- | 55-18 | 2,976 | 28.59 | 104.2 | 1.10 | . 77 |  | 4.20 | 1.94 |  | 4.20 | 1.94 |  |
| Trans Car Co.- | 55-19 | 1,996 | 15.67 | 127.5 | . 74 | . 52 |  | 2.30 | 1.06 |  | 2.30 | 1.06 |  |
| Trans Cargo Carrier Co (Tracked) -- | 55-27 | 2,825 | 26.47 | 106.8 | 1.05 | . 73 |  | 3.90 | 1.80 |  | 3.90 | 1.80 |  |
| Hq \& Hq Det, Trans Tactical Carrier $B n$. | 55-46 | 1,379 | 11.91 | 115.5 | . 51 | . 36 |  | 1.75 | . 81 |  | 1.75 | . 81 |  |
| Trans Tactical Carrier Co..........- | 55-47 | 6,171 | 57.32 | 107.6 | 2.29 | 1.59 |  | 8.42 | 3.89 |  | 8.42 | 3.89 |  |
| Hq \& Hq Det, Trans Transport Acft Bn | 55-56 | 1,693 | 14.56 | 116.3 | . 63 | . 44 |  | 2.14 | . 99 |  | 2.14 | . 99 |  |
| Tans Lt Helicopter Co.------.-.--- | 55-57 | 2,084 | 14.81 | 140.5 | . 77 | 54 |  | 2.18 | 1.01 |  | 2.18 | 1.01 |  |
| Inf Div Trans Bn.... | 55-75 | 12,509 | 133.61 | 93.6 | 4.63 | 3.23 |  | 19.60 | 9.06 |  | 19.60 | 9.06 |  |
| Hq \& Hq Co, Inf Div Trans Bn. | 55-76 | 2,680 | 24.94 | 107.2 | . 99 | . 69 |  | 3.66 | 1.69 |  | 3.66 | 1.69 |  |
| Trk Trans Co, Inf Div Trans Bn...- | 55-77 | 1,712 | 19.87 | 86.2 | . 63 | . 44 |  | 2.93 | 1.35 |  | 2.93 | 1.35 |  |
| Armored Carrier Co, Inf Div Trans Bn. | 55-78 | 3,715 | 43.85 | 84.8 | 1.38 | . 96 |  | 6.45 | 2.97 |  | 6.45 |  |  |
| Inf or Armored Div Trans Acft Maint Det | 55-79 | 1,367 | 10.29 | 84.8 132.5 | 1.38 .51 | .96 .35 |  | 6.45 1.51 | 2.97 70 |  | 6.45 1.51 | 2.97 70 |  |
| $\mathrm{Hq} \& \mathrm{Hq} \mathrm{Co}$, Trans Term Comd $\mathrm{C}_{-}$ | 55-111 | 3,000. | 21.74 | 138.0 | 1.11 | . 78 |  | 3.19 | 1.47 |  | 3.19 | .70 1.47 |  |
| Hq \& Hq Det, Trans Term Bn. . . - | 55-116 | 913 | 8.64 | 105.7 | . .34 | . 24 |  | 1.27 | 1.47 .59 |  | 3.19 1.27 | 1.47 .59 |  |
| Trans Term Sve Co.-.-.----...--- | 55-117 | 30,596 | 250.08 | 124.7 | 11.35 | 7.91 |  | 36.80 | 16.95 |  | 36.80 | 16.95 |  |
| Hq \& Hq Co, Trans Term Comd B.- | 55-121 | 2,223 | 15.95 | 139.4 | . 82 | . 58 |  | 2.34 | 1.08 |  | 2.34 | 1.08 |  |
| Hq \& Hq Co, Trans Term Comd A.- | 55-131 | 1,826 | 13.32 | 137.0 | . 70 | . 47 |  | 1.95 | . 90 |  | 1.95 | . 90 |  |
| Trans Amphib Trk Co.-.-.-.....-.- | 55-137 | 2.390 | 23.74 | 100.7 | . 88 | . 59 |  | 3.48 | 1.61 |  | 3.48 | 1.61 |  |
| Trans Staging Area Co. | 55-147 | 6,295 | 29.02 | 217.0 | 2.33 | 1.62 |  | 4.27 | 1.97 |  | 4.27 | 1.97 |  |


| UNIT | $\begin{gathered} \text { TOE } \\ \text { No. } \end{gathered}$ | EQUIPMENT AND SUPPLIES |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\begin{gathered} \text { Total } \\ \mathrm{CuFt} \mathrm{Ft}^{2} \end{gathered}$ | $\begin{aligned} & \text { Total } \\ & \text { Weight } \\ & \text { (STV) } \end{aligned}$ | Average <br> of equip and ${ }_{\text {cut }}$ per ST) ${ }^{2}$ | Aircraft requirementa* |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Minimum required for volume loading |  |  | Minimum required for weight loading |  |  | Number actually required by cube or welght |  |  |
|  |  |  |  |  | $\underset{\substack{\text { Method } \\ \text { C-119 }}}{\text { Cond }}$ | $\underset{\substack{\text { Method }}}{\text { C-130 }}$ | C-124 |  | $\underset{\underset{2}{\text { Method }}}{\stackrel{\text { C-180 }}{6}}$ | C-124 | $\begin{gathered} \text { C-119 } \\ \substack{\text { Method } \\ 1} \end{gathered}$ | $\underset{2}{\text { Method }}$ | C-124 |
| 1 | 2 | 8 | 4 | 5 | 6 | 7 | 8 | ¢ | 10 | 11 | 12 | 18 | 14 |
| GHQ, Trans Railway Sve. | 55-201 | 2,438 | 18.64 | 131.0 | . 90 | . 63 |  | 2.74 | 1.26 |  | 2.74 | 1.26 |  |
| Hq \& Hq Co, Trans Railway Gp.--- | 55-202 | 1,342 | 11.12 | 121.0 | . 50 | . 35 |  | 1.64 | . 75 |  | 1.64 | . 75 |  |
| Trans Railway Operating Bn.-.-.-- | 55-225 | 24,774 | 187.96 | 131.6 | 9.17 | 6.40 |  | 27.60 | 12.75 |  | 27.60 | 12.75 |  |
| $\mathrm{Hq} \& \mathrm{Hq} \mathrm{Co}$, Trans Railway Operating Bn . | 55-226 | 957 | 7.51 | 127.5 | . 36 | . 25 |  | 1.10 | . 51 |  | 1.10 | . 51 |  |
| Railway Engineering Co, Trans Railway Op Bn | 55-227 | 13,357 | 112.35 | 118.7 | 4.95 | 3.45 |  | 16.50 | 7.61 |  | 16.50 | 7.61 |  |
| Railway Equipment Co, Trans Railway Op Bn. | 55-228 | 2,990 | 38.08 | 78.6 | 1.11 | . 77 |  | 5.60 | 2.58 |  | 5.60 | 2.68 |  |
| Train Operating Co, Trans Railway $\mathrm{Op} \mathrm{Bn}^{2}$ | 55-229 | 6,023 | 31.23 | 193.0 | 2.23 | 1.56 |  | 4.58 | 2.12 |  | 4.58 | 2.12 |  |
| Hq \& Hq Co, Trans Railway Shop $\mathrm{Bn}_{-}$ | 55-236 | 2,979 | 14.68 | 207.0 | 1.10 | . 77 |  | 2.15 | . 99 |  | 2.15 | . 99 |  |
| Trans Depot Co------------------- | 55-260 | 9,310 | 66.99 | 138.5 | 3.45 | 2.40 |  | 9.84 | 4.54 |  | 9.84 | 4.54 70 |  |
| Hq \& Hq Co, Trans Railway Comd.- | 55-302 | 1,445 | 10.32 | 140.0 | . 54 | . 37 |  | 1.51 | . 70 |  | 1.51 | . 70 |  |
| $\mathrm{Hq} \& \mathrm{Hq}$ Det, Trans Army Acft Maint \& Sup Bn. | 55-456 | 361 | 3.69 | 98.7 | . 13 | . 09 |  | . 54 | . 25 |  | .54 .85 | .25 .28 |  |
| Trans Army Acft Direct Support Co.- | 55-457 | 2,534 | 19.36 | , 181.0 | . 94 | . 65 |  | 2.85 | 1.32 |  | 2.85 | 1.32 |  |
| Trans Army Acft Hv Maint \& Sup Co $\qquad$ | 55-458 | 3,212 | 22.84 | 140.5 | 1.19 | . 83 |  | 3.36 | 1.55 |  | 3.36 | 1.55 |  |

[^38] units to fly and these aircraft must be loaded in Air Force alrcraft, moe appropriate TM (- - eeries), "Proparation for Shipment of Army Aircraft" or TM $55-450$ series. Any additional Air Force aircraft required will be in addition to the requiroment ahown in this table.
 and Class V. For personnei foading, mee notes 1 and 2, paragraph 7.70. Disregard small fuctuations in number of personnei authorized; this will not appreclably affect the alrcraft requirement.

C-119: 2,700 cu ft and 6.815 ST (cargo compartment-448 $\times 110 \times 96$; door- $110 \times 96$ )
C-180: 8,870 cu ft and 14.75 ST (cargo compartment-498 $\times 128 \times 109$; door- $120 \times 110$ )
C-180: 8,870 cu ft and $10,000 \mathrm{cu} \mathrm{ft}$ and 20.25 ST (cargo compartment- $924 \times 186 \times 188$; do0r- $185 \times 189$ )

- Column 8 divided by 2,700.
- Column 9 divided by 8,870
- Column 4 divided by 6.815.
- Column 4 divided by 14.75.

I Use the larger quantities in columns 6 or 9 for column 12.

- Use the larger quantities in columan 7 or 10 for column 18.

| UNIT | VEHICLES AND TRALIERS |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Aircraft load distribution |  |  | Aircraft requirements＊ |  |  |  |  |  |  |  |  |  |  |
|  | $\begin{gathered} \mathrm{C}-119 \\ (\mathrm{ST})^{1} \end{gathered}$ | $\begin{aligned} & \text { C-180 } \\ & \text { (ST) } \end{aligned}$ | $\begin{gathered} \mathrm{C}-124 \\ (\mathrm{ST})^{9} \end{gathered}$ | Mlnlmum required for volume loading＇ |  |  | Minlmum required for weight loading |  |  |  | Number actually required by weight |  |  |  |
|  |  |  |  | $\begin{gathered} \text { C-119 } \\ \text { Method } \\ 1 \end{gathered}$ | $\underset{2}{\text { C-180 }} \underset{\substack{\text { Method }}}{ }$ | C－124 | $\underset{\substack{\text { Method } 10}}{\text { C-119 }}$ | $\underset{2}{\text { C-180 }} \underset{\substack{\text { Metho }}}{ }$ | $\underset{\substack{\text { Method } \\ \text { M } \\ \hline}}{\text { C-124 }}$ | $\underset{2}{\text { Method } 124}$ | $\underset{\substack{\text { C-119 } \\ 1}}{\substack{\text { C-10 }}}$ | $\underset{2}{\text { C-180 }} \underset{2}{\text { Method }}$ | $\underset{\substack{\text { Method } \\ \text { M } \\ \hline \\ \hline}}{\text { C-124 }}$ | $\begin{gathered} \text { C-124op } \\ \text { Meth } \\ 2 \end{gathered}$ |
|  | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 28 | 24 | 25 | 26 | 27 | 28 |
| Hq \＆Hq Co，Trans Mtr Trans－ port Comd | 25.6 |  | 6.4 |  |  |  | 3.75 | 1.73 | ． 32 | ． 32 | 3.75 | 1.73 | ． 32 | 32 |
| Hq \＆Hq Co，Trans Trk Gp．.-- | 18.6 |  | 12.8 |  |  | r | 2.73 | 1.26 | ． 63 | ． 63 | 2.73 | 1.26 | ． 63 | ． 63 |
| Hq \＆Hq Det，Trans Trk Bn， Army or COMMZ． | 29.8 |  | 6.4 |  |  |  | 4.37 | 2.02 | ． 32 | ． 32 | 4.37 | 2.02 | .63 .32 | .63 .32 |
| Trans Lt Trk Co． | 40.1 |  | 619.0 |  |  |  | 5.88 | 2.72 | 30.40 | 30.40 | 5.88 | 2.72 | 30.40 | 30.40 |
| Trans Med Trk Co（Cargo） | 13.0 | 561.0 | 457.0 |  |  |  | 1.91 | 38.90 | 50.40 | 22.60 | 1.91 | 38.90 | 50.40 | 22.60 |
| Trans Med Trk Co（Petroleum）－ | 16.0 | 561.0 | 493.0 |  |  |  | 2.35 | 39.10 | 52.10 | 24.30 | 2.35 | 39.10 | 52.10 | 24.30 |
| Trans Med Trk Co（Refrigerator）． | 14.0 | 561.0 | 254.0 |  |  |  | 2.05 | 39.00 | 40.20 | 12.50 | 2.05 | 39.00 | 40.20 | 12.50 |
| Trans Car Co－－－－－－－－－－－－－－－－－ | 157.2 |  | 20.8 |  |  |  | 23.00 | 10.70 | 1.03 | 1.03 | 23.00 | 10.70 | 1.03 | 1.03 |
| Trans Cargo Carrier Co（Tracked）． | 123.3 |  |  |  |  |  | 18.10 | 8.33 |  |  | 18.10 | 8.33 |  |  |
| Hq \＆Hq Det，Trans Tactical Carrier Bn | 30.2 |  | 12.8 |  |  |  | 4.43 | 2.05 | ． 63 | ． 63 | 4.43 | 2.05 | ． 63 | ． 63 |
| Trans Tactical Carrier Co．．． | 30.1 |  | 1137.8 |  |  |  | 4.42 | 2.04 | 56.20 | 56.20 | 4.42 | 2.04 | 56.20 | 56.20 |
| Hq \＆Hq Det，Trans Transport <br> Acft Bn． | 27.5 | 10.5 | 12.8 |  |  |  | 4.03 | 2.58 | 1.15 | .20 .63 | 4.03 | 2.04 2.58 | 5.20 1.15 | 56.20 63 |
| Trans Lt Helicopter Co． | 49.1 | 10.5 | 25.6 |  |  |  | 7.20 | 4.04 | 1.78 | 1.27 | 7.20 | 4.04 | 1.78 | 1.27 |
|  | 157.0 |  | 2860.5 |  |  |  | 23.00 | 10.65 | 141.40 | 141.40 | 23.00 | 10.65 | 141.40 | 141.40 |
| Hq \＆Hq Co，Inf Div Trans Bn－－ | 33.7 |  | 81.0 |  |  |  | 4.95 | 2.29 | 4.00 | 4.00 | 4.95 | 2.28 | 4.00 | 4.00 |
| Trk Trans Co，Inf Div Trans Bn．－ | 104.0 |  | 512.0 |  |  |  | 15.30 | 7.05 | 25.30 | 25.30 | 15.30 | 7.05 | 25.30 | 25.30 |
| Armored Carrier Co，Inf Div Trans Bn． | 6.4 |  | 1105.8 | ¢ | ¢๐ | ¢ | ． 94 | ． 43 | 54.60 | 54.60 | ． 94 | 73 | 54.60 | 54.60 |
| Inf or Armored Div Trans Acft |  |  |  | $\underset{N}{N}$ | 순 | ล |  |  |  |  | ． 94 | ． 43 | 54.60 | 54.60 |
| Maint Det－－－－－－－－－－－－－－－－－－－1 | 6.5 |  | 55.9 | 5 | 5 | 5 | ． 95 | ． 44 | 2.76 | 2.76 | ． 95 | ． 44 | 2.76 | 2.76 |
| Hq \＆Hq Co，Trans Term Comd C－ | 2.7 |  | 6.4 | 骨 | 魚 | 呂 | ． 39 | ． 18 | ． 32 | ． 32 | ． 39 | ． 18 | ． 32 | ． 32 |
| Hq \＆Hq Det，Trans Term Bn－－－ | 18.7 |  | 6.4 | 宸 | 㹂 | 監 | 2.74 | 1.27 | ． 32 | ． 32 | 2.74 | 1.27 | ． 32 | ． 32 |
| Trans Term Sve Co－－－－－－－－－－－－－ | 25.8 | 13.8 | 110.3 | $\begin{aligned} & \text { 甜 } \\ & \text {, } \end{aligned}$ | 吕 | 㪊 | 3.79 | 2.68 | 6.13 | 5.45 | 3.79 | 2.68 | 6.13 | 5.45 |
| $\mathrm{Hq} \& \mathrm{Hq}$ Co，Trans Term Comd B． | 11.2 |  | 6.4 | $\underset{\sim}{\mathbb{N}}$ | ஆ | \& | 1.64 | ． 76 | ． 32 | ． 32 | 1.64 | ． 76 | ． 32 | ． 32 |
| Hq \＆Hq Co，Trans Term Comd A． | 11.9 |  | 6.4 |  |  |  | 1.75 | ． 81 | ． 32 | ． 32 | 1.75 | ． 81 | ． 32 | ． 32 |
| Trans Amphib Trk Co ．－．－．－－－－－ | 30.6 | 281.2 | 29.6 |  |  |  | 4.49 | 21.10 | 15.40 | 1.46 | 4.49 | 21.10 | 15.40 | 1.46 |
| Trans Staging Area Co． | 19.4 |  | 25.6 |  |  |  | 2.84 | 1.32 | 1.27 | 1.27 | 2.84 | 1.32 | 1.27 | 1.27 |

See footnotes on page 382.

| UNIT | VEHICLES AND TRALLERS ${ }^{\text {a }}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Aircraft load distribution |  |  | Aircralt requirementas |  |  |  |  |  |  |  |  |  |  |
|  | $\begin{gathered} \mathrm{C}-119 \\ (\mathrm{ST})^{2} \end{gathered}$ | $\begin{gathered} \text { C-180 } \\ (\mathrm{ST})^{*} \end{gathered}$ | $\begin{gathered} \mathrm{C}-124 \\ (\mathrm{ST})^{0} \end{gathered}$ | Minimum required for volume loadlag ${ }^{9}$ |  |  | Minimum required for weight loading |  |  |  | Number actualiy required by weight |  |  |  |
|  |  |  |  | $\underset{\substack{\text { C-119 } \\ 1}}{ }$ | $\underset{2}{\text { C-180 }} \underset{\substack{\text { Method }}}{ }$ | C-124 | $\underset{1}{\text { C-119 }} \underset{1}{\text { Method } 10}$ |  | $\underset{\text { Method }}{\substack{\text { C-12 }}}$ | $\underset{2}{\text { Method }}$ | $\underset{1}{\text { Method } 10}$ | $\underset{\text { Method }}{\substack{\text { Clin }}}$ | $\underset{\substack{\text { Method } \\ \\ \text { C-12 } \\ \hline}}{\text { and }}$ | $\underset{\substack{\text { Method } \\ \\ \text { C-124 }}}{\text { and }}$ |
|  | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 28 | 24 | 25 | 26 | 27 | 28 |
| GHQ, Trans Railway Sve..----- |  |  | 19.2 |  |  |  | 5.13 | 2.37 | . 95 | . 95 | 5.13 | 2.37 | . 95 | . 95 |
| Hq \& Hq Co, Trans Railway Gp.- | 16.5 | 35.0 | 6.4 |  |  |  | 2.42 | 1.12 | . 32 | . 32 | 2.42 | 1.12 | . 32 | . 32 |
| Trans Railway Operating Bn-.--- | 127.6 | 87.3 | 66.0 |  |  |  | 18.70 | 14.60 | 7.57 | 3.26 | 18.70 | 14.60 | 7.57 | 3.26 |
| Hq \& Hq Co, Trans Railway Operating Bn. | 24.8 |  |  |  |  |  | 3.64 | 1.68 |  |  | 3.64 | 1.68 |  |  |
| Railway Engineering Co, Trans Railway Op Bn | 65.4 | 87.4 | 66.0 |  |  |  | 9.58 | 10.35 | 7.58 | 3.26 | 9.58 | 10.35 | 7.58 | 3.26 |
| Railway Equipment Co, Trans Railway Op Bn | 28.6 |  |  |  |  |  | 4.19 | 1.94 |  |  | 4.19 | 1.94 | ------- |  |
| Train Operating Co, Trans Railway Op Bn | 8.7 |  |  |  |  |  | 1.28 | . 59 |  |  | 1.28 | . 59 | ------- |  |
| Hq \& Hq Co, Trans Railway shop Bn | 20.4 |  |  |  |  |  | 2.97 | 1.39 |  | 32 | 2.97 | 1.39 |  |  |
|  | 6.4 |  | 6.4 |  |  |  | . 94 | .43 | . 32 | . 32 | . 94 | . 43 | . 32 | . 32 |
| Hq \& Hq Co, Trans Railway Comd | 28.1 |  | 12.8 |  |  |  | 4.12 | 1.90 | . 63 | . 63 | 4.12 | 1.90 | . 63 | . 63 |
| Hq \& Hq Det, Trans Army Acft Maint \& Sup Bn | 17.8 |  | 12.8 |  |  |  | 2.61 | 1.21 | . 63 | . 63 | 2.61 | 1.21 | . 63 | . 63 |
| Trans Army Acft Direct Support Co. $\qquad$ | 64.0 | 27.6 | 104.3 |  |  |  | 9.40 | 6.21 | 6.52 | 5.15 | 9.40 | 6.21 | 6.52 | 5.15 |
| Trans Army Acft Hv Maint \& Sup Co $\qquad$ | 54.6 | 9.2 | 58.8 |  |  |  | 8.00 | 4.33 | 3.37 | 2.91 | 8.00 | 4.33 | 3.37 | 2.91 |

${ }^{-}$See paragraph 7.7 for vehicles, configuration, and ioading.
${ }^{10}$ Column 15 divided by 6.815 (used with method 1).
${ }^{11}$ Column 15 plus coiumn 16 divided by 14.75 (used with method 2).
${ }^{12}$ Column 16 plus column 17 divided by 20.25 (used with method 1).
is Column 17 divided by 20.25 (used with method 2).
(Soe page 380 for footnotes 1-8.)

| UNIT | PERSONNEL AND INDIVIDUAL EQUIPMENT |  |  |  |  |  |  |  |  |  | BASIC AIRGRAFT REQUIREMENT TO LIFT UNIT |  |  |  | TOE No. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Troopg ${ }^{\text {a }}$ | Aircratt requiremento |  |  |  |  |  |  |  |  | $\underset{\substack{\text { Method } \\ 14}}{\mathrm{C}-119}$ | $\underset{2^{16}}{\text { Method }}$ | $\underset{\substack{\text { Method } \\ 1^{18}}}{\text { C-124 }}$ | $\underset{\substack{\text { Method } \\ \mathbf{C}^{?}-124}}{\text { Ced }}$ |  |
|  |  | Minimum required for volume loading (troopseats in parenthesis) seats in parenthesis) |  |  | Minimum required for weight loading (240 pounds per man) |  |  | Number act ually required by cube or weight |  |  |  |  |  |  |  |
|  |  | $\begin{gathered} \mathrm{C}-119 \\ \text { Method } \\ 1 \\ (62) \end{gathered}$ | C-180 Method (92) | $\begin{aligned} & C-124 \\ & (200) \end{aligned}$ | $\begin{gathered} \text { C-119 } \\ \text { Method } \\ 1 \end{gathered}$ | $\underset{2}{\text { C-180 }} \underset{\substack{\text { Method }}}{ }$ | C-124 | $\begin{gathered} \text { C-119 } \\ \substack{\text { Method } \\ 1} \end{gathered}$ | $\begin{array}{\|c\|} \text { C-130 } \\ \text { Method } \\ 2 \end{array}$ | C-124 |  |  |  |  |  |
|  | 29 | 80 | 31 | 32 | 83 | 34 | 85 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
| Hq \& Hq Co, Trans Mtr Transport Comd. | 124 |  | 1.35 |  | 2.18 |  |  | 2.18 | 1.35 |  | 8 | 4 |  |  |  |
| Hq \& Hq Co, Trans Trk Gp_---- | 61 |  | . 66 |  | 1.07 |  |  | 1.07 | 1.35 .66 |  | 6 | 3 | 1 | 1 | $\begin{aligned} & 55-11 \\ & 55-12 \end{aligned}$ |
| Hq \& Hq Det, Trans Trk Bn, Army or COMMZ. | 47 |  | . 51 |  | . 83 |  |  | 1.07 .83 | . 66 |  | 7 |  |  |  |  |
|  | 168 |  | 1.83 |  | 2.95 |  |  | . 2.95 | . 1.81 |  | 14 | 4 | 11 |  | 55-16 |
| Trans Med Trk Co (Cargo) | 181 |  | 1.97 |  | 3.18 |  |  | 3.95 | 1.97 |  | 14 9 | 43(44) | $\begin{aligned} & 31(32) \\ & 51(52) \end{aligned}$ | $\begin{aligned} & 31(32) \\ & 23(24) \end{aligned}$ | $\begin{aligned} & 55-17 \\ & 55-18 \text { (c) } \end{aligned}$ |
| Trans Med Trk Co (Petroleum) -- | 187 |  | 2.04 |  | 3.28 |  |  | 3.28 | 2.04 |  | 10 | 43 (44) | 53 (54) | 25 (26) | 55-18 (p) |
| Trans Med Trk Co (Refrigerator)- | 200 |  | 2.18 |  | 3.51 |  |  | 3.51 | 2.18 |  | 10 | 44 (45) | 41 (42) | 13 (14) | 55-18(r) |
| Trans Car Co ----------------- | 111 |  | 1.21 |  | 1.95 |  |  | 1.95 | 1.21 |  | 28 (29) | 13 (14) | 2 | 2 | 55-19 |
| Trans Cargo Carrier Co (Tracked)- | 184 |  | 2.00 |  | 3.23 |  |  | 3.23 | 2.00 |  | 26 (29) | 13(14) |  |  | 55-27 |
| Hq \& Hq Det, Trans Tactical Carrier Bn | 55 |  | . 60 |  | . 97 |  |  | . 97 | . 60 |  | 8 | 13 4 | 1 | 1 | 55-46 |
| Trans Tactical Carrier Co...--.-- | 180 |  | 1.96 |  | 3.16 |  |  | 3.16 | 1.96 |  | 16 | 8 | 57 (59) | 57 (59) | 55-47 |
| Hq \& Hq Det, Trans Transport Acft Bn. $\qquad$ | 72 |  | . 78 |  | 1.26 |  |  | 1.26 | 1.96 .78 |  | 16 8 | 8 5 |  | 57 (59) |  |
| Trans Lt Helicopter Co. | 147 |  | 1.60 |  | 2.58 |  |  | 2.58 | 1.60 |  | 12 | 7 | 2 | 2 | $\begin{aligned} & 55-566^{8} \\ & 55-57{ }^{18} \end{aligned}$ |
| Inf Div Trans Bn.... | 521 |  | 5.67 |  | 9.32 |  |  | 9.32 | 5.67 |  | 52 | 26 | 142 (147) | 142 (147) | $55-7518$ |
| Hq \& Hq Co, Inf Div Trans Bn..- | 122 |  | 1.33 |  | 2.14 |  |  | 2.14 | 1.33 |  | 11 | 6 | 142(147) | $4$ | $55-76$ |
| Trk Trans Co, Inf Div Trans Bn.Armored Carrier Co, Inf Div | 156 |  | 1.70 |  | 2.74 |  |  | 2.74 | 1.70 |  | 21 | 11 | 26 (27) | 26 (27) | 55-77 |
| Trans Bn. | 92 |  | 1.00 | ---- | 1.61 |  |  | 1.61 | 1.00 |  | 9 | 5 | 55 (57) | 55 (57) | 55-78 |
| Inf or Armored Div Trans Acft Maint Det $\qquad$ | 59 |  | . 64 |  | 1.04 |  |  | 1.04 | . 64 |  | 4 | 5 | 3 | 3 | 55-7918 |
| Hq \& Hq Co,Trans Term Comd C_ | 303 | --.--- | 3.30 |  | 5.36 |  |  | 5.36 | 3.30 |  | 9 | 5 | 1 | 1 | 55-111 |
| Hq \& Hq Det, Trans Term Bn - - | 56 |  | . 61 |  | . 98 |  |  | . 98 | . 61 |  | 5 | 3 | 1 | 1 | 55-116 |
| Trans Term Sve Co. | 329 |  | 3.58 |  | 5.78 |  |  | 5.78 | 3.58 |  | 47 | 24 | 7 | 6 | 55-117 |
| Hq \& Hq Co, Trans Term Comd B_ | 187 |  | 2.04 |  | 3.28 |  |  | 3.28 | 2.04 |  | 8 |  | 1 | 1 | 55-121 |
| Hq \& Hq Co, Trans Term Comd A. | 131 |  | 1.42 |  | 2.30 |  |  | 2.30 | 1.42 |  | 6 | 4 | 1 | 1 | 55-131 |
| Trans Amphib Trk Co....-......-- | 194 |  | 2.11 |  | 3.41 |  |  | 3.41 | 2.11 |  | 12 | 25 (26) | 16 | 2 | 55-137 |
| Trans Staging Area Co. | 91 |  | . 99 |  | 1.60 |  |  | 1.60 | . 99 |  | 9 | 5 | 2 | 2 | 55-147 |


| UNIT | PERSONNEL AND INDIVIDUAL EQUIPMENT |  |  |  |  |  |  |  |  |  | BASIC AIRCRAFT REQUIREMENT TOLIFT UNIT |  |  |  | TOE No. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Troops ${ }^{\text {a }}$ | Aircraft requirements ${ }^{\text {a }}$ |  |  |  |  |  |  |  |  | $\begin{gathered} \text { C-119 } \\ \text { Method } \\ 1^{14} \end{gathered}$ | $\underset{\substack{\text { Method } \\ 2^{13}}}{\text { C-180 }}$ | $\underset{\substack{\text { Method } \\ 116}}{\text { C-124 }}$ | $\begin{gathered} \text { C-124 } \\ \substack{\text { Method } \\ 2^{17}} \end{gathered}$ |  |
|  |  | Minimum required for volume loading (troep seata in parenthesis) |  |  | Minimum required for weight ioading (240 pounds per man) |  |  | Number actually required by cube or weight |  |  |  |  |  |  |  |
|  |  | (C-119 <br> Method <br> (62) <br> ( | C-130 Method (92) | $\begin{aligned} & \text { C-124 } \\ & (200) \end{aligned}$ | $\left\lvert\, \begin{gathered} \text { C-119 } \\ \text { Method } \\ 1 \end{gathered}\right.$ | $\underset{2}{\mathrm{Me}-180}$ | C-124 | $\underset{\substack{\text { Method } \\ 1}}{\text { C-119 }}$ | $\begin{gathered} \text { C-130 } \\ \text { Method } \\ 2 \end{gathered}$ | C-124 |  |  |  |  |  |
|  | 29 | 80 | 81 | 82 | 88 | 84 | 85 | 36 | 87 | 88 | 89 | 40 | 41 | 42 | 48 |
| GHQ, Trans Railway Sve......... | 201 |  | 2.19 |  | 3.54 |  |  | 3.54 | 2.19 |  |  |  |  |  |  |
| Hq \& Hq Co, Trans Railway Gp - | 101 |  | 1.10 |  | 1.77 |  |  | 1.77 | 1.10 |  | 12 6 | 6 3 |  | 1 | 55-201 |
| Trans Railway Operating Bn..... | 823 |  | 8.95 |  | 14.45 |  |  | 14.45 | 8.95 |  | 61 | 3 3 | 1 | 4 | 55-202 |
| $\mathrm{Hq} \& \mathrm{Hq} \mathrm{Co}$, Trans Railway Operating Bn . | 124 |  | 1.35 |  | 2.18 |  |  | 14.45 | 8.95 1.35 |  | 61 7 | 37 4 | 8 |  | $55-225$ |
| Railway Engineering Co, Trans Railway Op Bn. | 251 |  | 2.74 |  | 2.18 4.40 |  |  | 2.18 4.40 | 1.35 2.74 |  | 7 31 | 21 | 8 | 4 | $55-226$ $55-227$ |
| Railway Equipment Co, Trans Railway Op Bn. | 142 |  | 1.55 |  | 2.49 |  |  | 2.49 | 1.55 |  |  |  |  |  |  |
| Train Operating Co, Trans Railway Op Bn | 306 |  | 3.32 |  | 5.48 |  |  | 2.49 5.38 | 1.55 |  | 13 | 7 |  |  | 55-228 |
| $\mathrm{Hq} \& \mathrm{Hq} \mathrm{Co}$, Trans Railway Shop Bn | 102 |  | 1.11 |  |  |  |  | 5.38 | 3.32 |  | 12 | 7 |  |  | 55-229 |
| Trans Depot Co.................-. | 117 |  | 1.27 |  | 1.79 2.05 |  |  | 1.79 | 1.11 |  | 7 | 4 |  |  | 55-236 |
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| Comd. | 139 |  | 1.51 |  | 2.44 |  |  | 2.44 | 1.51 |  | 9 | 5 | 1 | 1 | 55-302 |
| Hq \& Hq Det, Trans Army Acft Maint \& Sup Bn. | 33 |  | . 36 |  | . 68 |  |  | . 58 |  |  |  |  |  |  |  |
| Trans Army Acft Direct Support Co | 129 |  |  |  | . 68 |  |  | . 58 | . 36 |  | 4 | 2 | 1 | 1 | 55-456 |
| Trans Army Acft Hv Maint \& | 129 |  | 1.40 |  | 2.27 |  |  | 2.27 | 1.40 |  | 15 | 9 | 7 | 6 | 55-45718 |
| Sup Co.. | 168 |  | 1.83 |  | 2.95 |  |  | 2.95 | 1.83 |  | 15 | 8 | 4 | 3 | 55-45818 |

${ }^{15}$ Sum of columna 18, 26, and 87 (ueed with method 2).
${ }^{10}$ Sum of columna 14, 27, and 88 (uned with method 1).
${ }^{17}$ Sum of columns 14, 28, and 88 (used with method 2).
u Figures do not include all aircraft ahop and tool seta (accurate welght and cube data not avaliable).
(See pages 880 and 382 for footnotes 1-18.)

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| 780-770 | Depot Missions; Transportation Corps. |
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| 21-5 | Military Training. |
| 21-6 | Techniques of Military Instruction. |
| 21-10 | Military Sanitation. |

## ABBREVIATIONS

(Any abbreviation marked with an asterisk is not authorized for electrically transmitted messages.)


| Abbreviations | Meaning |
| :---: | :---: |
| apers----------------antipersonnel |  |
| APMA | -advance payment of mileage authorized |
| APMALTA | -advance payment of monetary allowance in lieu of transportation is authorized |
| APO | Army Post Office; Air Post Office |
| APOD | - Aerial Port of Debarkation |
| APOE | -Aerial Port of Embarkation |
| app. | .appendix; apprehend |
| APRI------------- air priority |  |
| APTDA | _advance payment of travel per diem authorized |
| ARSR | - air route surveillance radar |
| ARTC | _ Air Route Traffic Control |
| ARTCC | - Air Route Trafflc Control Center |
| asg | _assign; assigned |
| ASOC | - Air Support Operations Center |
| ASP | -ammunition supply point |
| ASR.---------------- available supply rate |  |
| ASUPP | _air supply |
| at.-.----------------antitank |  |
| ATA --------------- actual time of arrival |  |
| ATCC | -Air Traffic Control Center; Atlantic Division Transport Control Center (Hq) |
| atch---------------attach |  |
| ATCO | - Air Traffic Coordinating Officer |
| ATCS | -Air Traffic Communications Station |
| ATD. | _ actual time of departure |
| ATERN-.----------- air terminal |  |
| ATMC | _Air Transport Movement Control Center |
| ATO | - Aircraft Transfer Order |
| ATR.-------------- Air Traffic Regulations |  |
| autmv---------------automotive |  |
| auto--------------- automatic |  |
| aux----------------- auxiliary |  |
| a val_--------------- - available |  |
| AVGAS ------------- aviation gasoline |  |
| AVIONICS_--------- aviation electronics |  |
| AVLUB------------- - a viation lubricant |  |
| avn---------------- ${ }^{\text {aviation }}$ |  |
| AVOIL------------- aviation oil |  |
| AWS----------------Air Weather Service |  |
| az_------------------azimuth |  |
| bag.---------------- baggage |  |
| BALOG_-------------base logistical command |  |
| BARC - - ----------- barge, amphibious, resupply, cargo |  |
| bdry---.----------.-. boundary |  |
| BG----.-------------beach group, battle group |  |
| bhd-----------------beachhead |  |
| BMU.--------------beachmaster unit |  |
| bn. | . battalion |




| Abbreviations | Meaning |
| :---: | :---: |
| EC | _ Emergency Capability |
| ech | _echelon |
| EDD | -estimated delivery date |
| EDP | ._equipment deadlined for parts; electronic data processing |
| EEI | -essential elements of information |
| elm | element |
| EM | _-enlisted man (men); Education Manual |
| emb | _embark; embarked; embarkation |
| en | enemy |
| eng | _engine |
| enr | en route |
| ENRFOSCOMD | _-en route this station from oversea command |
| EP | __entrucking point |
| est | _ estimate; estimated; estimation |
| ETA | estimated time of arrival |
| ETD | estimated time of departure |
| ETDP | -Emergency Traffic Disposition |
| ETE | estimated time en route |
| ETR | . estimated time of return; Export Traffic Release |
| ETS | expiration term of service |
| evac | evacuate; evacuated; evacuation |
| EXTAL | . extra time allowance |
| FAS | free alongside ship |
| FASO | . forward airfield supply organization |
| FIO. | Free In and Out |
| FLDO | field officer |
| FLDTNS | field trains |
| flt | flight |
| Fltbrg | floatbridge |
| FOA | Free of Address |
| FOB | Free on Board |
| FSO | Fuel Supply Office |
| FTD | Freight Traffic Division |
| FTRAC | full-tracked vehicle |
| fus. | fuselage |
| FW | fixed wing |
| fxd | fixed |
| gal | gallon |
| gas_ | -gasoline |
| GCA | ground controlled approach |
| GCM | general court-martial |
| GED | gas engine driven |
| gnd | -ground |
| GNP | chemical agent, nonpersistent |
| GP | -general purpose |
| gp. | -group |
| GPV | general purpose vehicle |
| gd | guard |
| GS | _ General Staff; general service |
| GTA | .graphic training aid |
| GTAV | -.general transport administrative vehicle |
| HAMD. | _ _Helicopter Ambulance Medical Detachment |
| har | -harbor |
| HARCFT | -harbor craft |
| HBS | harbor boat service |


| Abbreviations | Meaning |
| :---: | :---: |
| HD | _Honorable Discharge; harbor defense |
| HDC | _Helicopter Direction Center; harbor defense command |
| hdlg | handling |
| HE | high explosive |
| HECP | _Harbor Entrance Control Post |
| HECVES | .Harbor Entrance Control Vessel |
| hel. | _helicopter |
| HELITEAM | helicopter team |
| HF | high frequency; harassing fire |
| HHG | _household goods |
| HOA | heavy observation aircraft |
| how | howitzer |
| HRAT | Hampton Roads Army Terminal |
| HRP | holding and reconsignment point; highway regulation point |
| HS | _hardstanding; high school |
| HV | _high velocity |
| hv | heavy |
| hyd | hydraulic |
| hydro | hydrographic |
| ICC | Interstate Commerce Commission |
| ICW | _intercoastal waterway |
| IFR | Instrument Flight Rules |
| ILS | instrument landing system |
| init | initial |
| insp. | _inspect |
| instl | installation; install |
| instr | instruct; instructor; instruction; instructed |
| in | -intelligence |
| intmed | intermediate |
| intn | in transit |
| IR | instrument reading |
| IROAN | inspect and repair only as necessary |
| iss | issue |
| ITS | Intersectional Transportation Service |
| IWT | Inland Waterway Transport |
| IWW | inland waterway |
| JANAST | Joint Army-Navy-Air Force Sea Transportation Message |
| JANIS. | Joint Army-Navy Intelligence Study |
| JATO | Jet-assisted takeoff |
| JATS | Joint Air Transportation Service |
| JCCA | Joint CONEX Control Agency |
| JCS. | _Joint Chiefs of Staff |
| jct. | junction |
| JMTB | Joint Military Transportation Board |
| JOSPRO | Joint Overseas Shipping Procedure |
| JTF | Joint Task Force |
| LA | low altitude; letter of activation |
| LANCRAB | landing craft and bases |
| LARC. | _lighter, amphibious, resupply, cargo |
| LC. | line of contact; launching control |
| LCAVAT | landing craft and amphibious vehicle assignment table |
|  | launcher |


| Abbreviations | Meanino |
| :---: | :---: |
| LCL--------------- less than carload lot |  |
| LCM | landing craft, mechanized |
| LCVP | _landing craft, vehicle, personnel |
| LD------------------line of duty; line of departure |  |
| ldg-------------------landing |  |
| LE | _light equipment; low explosive |
| ln-------------------- liaison |  |
| LO | _lubrication order; letter order; liaison officer; local oscillator |
| LOA --------------light observation aircraft; leave of |  |
| loc | -locate; locating; located; location; locality |
| loco | -locomotive |
| $\log$ | _logistics; logistical |
| LOGEX | _logistical exercise |
| LOTS | -logistics over-the-shore operations |
| LSE | _landing signal, enlisted |
| LSD | _Landing Ship, Dock |
| LSO | Landing Signal Officer |
| LST | Landing Ship, Tank |
| LTD | _less than truckload |
| LTON | -long ton |
| ltr. | -letter |
| LVD | _low velocity drop |
| LVTP | -landing vehicle, tracked, personnel |
| LWB | -long wheelbase |
| LWL | _load waterline |
| MA | _marshaling area; machine accountant; military attache |
| MAAG | Military Group Assistance Advisory |
| MAC | _Mean Aerodynamic Chord; Maintenance Allocation Chart |
| mach----------------machine; machinist |  |
| MAIN | _Military Authorization Identification Number |
| MAM----------------military air movement numberman.---------manifest |  |
|  |  |
| MANDR |  |
| MAP----------------. Military Assistance Program |  |
| mat.----------------materiel; material |  |
| MATS | _Military Air Transport Service |
| mbl-----------------------mobile |  |
| MCC | Movement Control Center; Military Coordinating Committee |
| MD--------------.-. Movement Directive |  |
| MDHTSMAGEJ | _Movement of dependents and household goods to temporary station(s) not authorized at Government expense, except as prescribed in JTR, chapter 8 |
| me------------------multiengine |  |
| mech | _mechanic; mechanical; mechanized |
| MEDP-------------------medium port , |  |
| mg------------------machinegun |  |
| MHE |  |
| MM | _Motor Maintenance Aptitude |
|  | Area; Missile Master |
| MO_----------------movement orders |  |
| MOGAS--------------motor gasoline |  |
| MOS---------------military occupational specialty |  |
| MOT | month of travel |


| Abbrevations | Meaning |
| :---: | :---: |
| mov----------------- movement |  |
| MPH | - -miles per hour |
| msg | - message |
| MSR |  |
| MSTS | - Military Sea Transportation Service |
| MSTSO | Military Sea Transportation Service Office |
| MT | _motor transport; mechanical transport; megaton |
| MTCC | _MATS Transport Control Center <br> (Hq) |
| mtd | - - mounted |
| MTON | -measurement ton |
| mtr | -motor |
| mtrel | motorcycle |
| MVD | _ Army Motor Vehicle Driver Selection Battery |
| MWO | Modification Work Order |
| NA | not applicable |
| NASA | -National Aeronautics and Space Administration |
| NATO | -North Atlantic Treaty Organization |
| nav | _navigate; naval |
| NAVCM | _navigation countermeasures and deception |
| NCO | _noncommissioned officer |
| NCS | net control station |
| NFS | not on flying status |
| ni | night |
| NLF | nearest landing field |
| NLG | _nose landing gear |
| NLT | _not later than |
| NOART | New Orleans Army Terminal |
| nonptbl. | _nonportable |
| NRA. | _no repair action; National Rifle Association; nonregistered accountable |
| NTI | no travel involved |
| * 0 | -order; office |
| obs | obstacle |
| OIC | -officer-in-charge (of) |
| OL | -operation location |
| OMS | -organizational maintenance shop |
| op | _operate; operated; operational; operation; operator |
| OP | _observation post |
| ord | -ordnance |
| org | _organization; organize; organized |
| OSPE | _organizational spare parts and equipment |
| PC. | . port call; purchasing and contracting |
| PD | -per diem; full stop/period |
| plat | platoon |
| PLL | prescribed load list |
| POD | -port of debarkation |
| POE | port of embarkation |
| POL | petroleum, oil, and lubricants |
| POLIS | Petroleum Intersectional Service |
| POM | _preparation for oversea movement (units) |


| Abbretations | Meaning | Abbreviations | Meanino |
| :---: | :---: | :---: | :---: |
| POR. | _preparation of replacements for oversea movement | SHIPREQ <br> sho | . -ship to apply on requisition - _shore |
| pos. | _position | shpmt | shipment |
| pri | .priority | shpsd. | _shipside |
| proc | _ process, procure | sig | _signal; signaller, signalman |
| PSANDT.-..- | -pay, subsistence, and transportation | sit. <br> scd | _situation <br> .schedule |
| pt | point | SLA | . supply loading airfield |
| ptbl | . portable | smbl | _semimobile |
| ptl. | _patrol | SO. | _shipment order; Special Orders; |
| pty | party |  | stockage objectives |
| PW | -prisoner of war; public works; pulse width | $\begin{aligned} & \text { SOI } \\ & \text { SOP } \end{aligned}$ | . - signal operations instructions <br> . . standing operating procedures |
| RADIAC. | _radiation, detection, indication, and computation | SP | . -self-propelled; start point; shore party; shore police |
| RADLWAR | .radiological warfare | S\&P | - .stake and platform vehicle |
| RASO | _Rear Airfield Supply Organization | SPCM | .special court-martial |
| wa | _rail-water | spd | _speed |
| rawara | _rail-water-rail | SPE | .special purpose equipment |
| RB | _road bend; rigid boat | SPM | _self-propelled mount |
| rd | _road; round | spt | .support |
| RD | _readiness date; research and development; requ ired date | SPV SSI | . .special purpose vehicles |
| RDD | _ required delivery uate | sta | -station; status |
| recon | _reconnaissance; r connoiter | STANAG | _standardization agreement |
| reinf | _reinforce | std | _standard; standing |
| rep | . repair; represert; represented; re- | stfe.-- | .staff |
|  | presentative | STGAR | staging area |
| REQSI | _request shipping instructions | STGB | _staging base |
| res.-.-. | -reserve(s) | stlr | semitrailer |
| rese | _rescind | STOL | short takeoff and landing |
| RFA | _Reserve Forces Act, relieved from assigned | STON <br> stor. | short ton .storage |
| rfl | _refuel | str. | _strength |
| rhd | _railhead | subor | subordinate |
| RJ | _road junction | SUNEC | supply units, Northeast Command |
| rkt | _rocket | sup | _supply; supplied |
| nwy. | _runway | SUPPT | _supply point |
| 20AD | _Reorganization Objective Army | sve | _service; serviced; servicing |
|  | Divisions | SWB | _short wheelbase |
| ROCID | -reorganization of the current in- | swbd | .switchboard |
|  | fantry division release point | T. | -ton |
|  | (ground traffic); retained personnel | TA. | __table of allowance; target area; time and attendance |
| RS | .report of survey; road space; regulating station | TAAM | - Transportation Army Aviation Maintenance |
| rsq | rescue | TAAS | Transportation Army Aircraft |
| RTC | _replacement training center |  | Supply |
| RTO. | -rail transportation office(r); rail- | TAD | tactical air direction |
|  | way traffic officer | TADC | Tactical Air Direction Center |
| RW | -rotary wing | TAF. | Tactical Air Force |
| rwy | _railway | TAHQ | theater army headquarters |
| SCM | summary court-martial; sender's composition message | TALOG TASS | theater army logistical command Tactical Air Support Section |
| SDC | _shipment detail card | TAT | to accompany troops |
| SE | -single engine | TATSA | Transportation Aviation Test and |
|  | -section |  | Support |
| SHAPE | _Supreme Headquarters, Allied Powers Europe | TB | _technical bulletin; troop basis; tuberculosis |
| SHIPDA. | .shipping data | TBAWRBA. | -travel by military aircraft, military |
| SHIPDTO | _ship on depot transfer order |  | and/or Naval water carrier, |
| SHIPGO. | -shipping order |  | commercial rail and/or bus is |
| SHIPIM | _ship immediately |  | authorized |


| Abbrevations | Meaning |
| :---: | :---: |
| TBGAA. $\qquad$ travel by Government automobile authorized |  |
| TBMAA | travel by military aircraft authorized |
| TCC | _transportation control card; Transport Control Center; Troop Carrier Command |
| TCF----------------troop carrier forces |  |
| TCP--------------- |  |
| TCR.-...-----.-......-. Transportation Corps release <br> TCSMC.-.--.-.--.-.-.-. Transportation Corps Supply and Maintenance Command |  |
|  |  |
| TCTC...-------------Transportation Corps Technical |  |
| TCTM | - Aircraft Time Compliance Technical Manuals |
| TCV----------------troop carrying vehicle |  |
| TDHHG | -For travel of dependents authorized transportation of household goods including packing and crating, and unpacking and uncrating |
| TDN | -travel as directed is necessary in the military service |
| tfc-------------------traffic |  |
| THM | -transport helicopter maintenance |
| THQ ----------------theater headquarters |  |
| tk------------------tank |  |
| tl-.------------------truckload |  |
| tlr-------------------trailer |  |
| TMAO--------------troop movement assignment order |  |
| TMDAG | this mode of transportation has been determined to be more advantageous to the Government |
| tml----------------- terminal |  |
| TMO | -Transportation Movements Office <br> (r); Total Material Objective |
| tn-------------------train |  |
| TOE | -table of organization and equipment; term of enlistment |
| TOS - ---------------type of shipment |  |
|  ance authorized |  |
| TR ---------------- Transportation Request |  |
| ac.----------------tractor; tracer |  |
| tracdr----------------tractor-drawn |  |
| tran-----------------transient |  |
| trans----------------transport |  |
| TRC.------------------transportation railway command; type requisition code |  |
| trk----------------- -truck |  |
| trkdr----------------truck-drawn |  |
| trkhd.---------------truckhead |  |
| TROB | _transportation railway operating battalion |
| trp | -troop |
| TRS | -Transportation Railway Service |
| TRSB | -transportation railway shop battalion |
| TS | transit storage; terminal service; TOP SECRET |




## APPENDIX III

MAP SYMBOLS
a. Air. 1


1/ All symbols refer to piston engine aircraft. If a symbol having a
propeller refers specifically to Army aviation, the propeller is black.

Landing area, or heliport
b. Motor Transport.

Boundary between two sections of road


Convoy (Arrow indicates direction; point of arrow indicates position of
head of convoy; figures immediately adjacent to arrow indicate time
at that position.)
Dest Pt
Destination point $\qquad$

HRP

Highway regulating point



Light line (The line beyond which exposed lights are prohibited)_ _LL-LL-
$\qquad$

Markers:

Road, national and state, respectively (U.S.)
$\qquad$
Route, military

Route:

Dispatch, operated by schedule system $\qquad$

Express


Reserved, can be used by specified traffic only $\qquad$


Vehicle:

| Armored |  |
| :---: | :---: |
| Cargo-carrying |  |
|  |  |
| Operatianal___ |  |
| Personnel-carrying | $\triangle$ |
| Tracked | $\square$ |
| Wheeled | $\bigcirc 0$ |

c. Rail.

Coaling station, Transportation Railway Service__
Engine terminal:
Turntable alone__

Railrood:


Track:


## Railway:

Vehicle
0000

- d. Terminal and Water Transport.

Amphibious, Cargo $\qquad$
Debarkation or Embarkation point, water $\qquad$
Landing:


Vehicle, tracked $\qquad$

Vehicle, tracked, armored


Leader gear (Energized cable to aid vessels through free passage

In marine mine fields. Show exact location on chart.) $\qquad$ Marine:

Mines, controlled:

(Length of either mine group is 1,800 feet, and symbol is drawn to scale, with upper edge seaward.)

Nets:


Sono-buoys $\qquad$

Terminal command:

3. Miscellaneous.
Booby frap___
Boundary line:

Advance or base logistical command
000
$\qquad$
$\qquad$
Brigade_

| Company, Battery, or equivalent unit | 1 |
| :---: | :---: |
|  | XXX |
| Corps |  |


Antitank, double $\odot$
Trip wire type of ontipersonnel mine $\qquad$

Mine belt (Numerals in rectangle indicate number of mines in
belt; Type af mines shown by symbols;
baundaries drawn to scale indicate actual extent of belt.)

Minefield:
Antipersannel, or boundary thereof, marked, fenced
Antitank, or boundary thereaf, marked, fenced
Antitank with antipersonnel mines, marked, fenced


Division

| Group, battle group or regiment | III |
| :--- | ---: |
| Platoon, detachment | $\bullet \bullet \bullet$ |
| Section |  |

Squad $\qquad$
Theater administrative zone or theater army logistical command ..... 0000
Bridge: ..... ) 1
Movable

$\qquad$
Control stations:

| Consolidating | station | $\otimes \mathrm{csto}$ |
| :---: | :---: | :---: |
| Holding and | reconsignment point | $\geqslant \mathrm{HRP}$ |
| Release or | regulating point | RP |

Culvert

Entanglements:
Barbed wire, general (Depth of wire in feet may be indicated.)_ xxxxxx
Concertina, multiple ..... 210110
Concertina, single bellele
Double-apron fence ..... Double barbed wire fence

$$
{ }_{* *}-x * \quad x *
$$



Mines:

Antlpersannel, string of $\qquad$
Antitank, single string of $\qquad$

## Obstacle:

General symbals:


Specific abstacles:


Fixed, prefabricated (In line; numeral indicates number af
abstacles between accurately lacated palnts.)___ Mavable_

Mavable, prefabricated (Numeral indicates number af abstacles in each row; lines indicate number of raws.)


Mavable, prefabricated (When used with wire ar mines, add apprapriate symbal.) $\qquad$

POL facilities $\qquad$

POL and minor maintenance facilities $\qquad$

$$
\text { - }-2
$$

POL and minor mairtenance facilities (Show type of screen, time, date, and method.)


Snow:


Staging area
Supply installations:
Classes of:
Class 1 (rations) $\qquad$
Closs $11^{\perp}$

Class III (POL)


Class $\mathrm{IV}^{\boldsymbol{V}}$


Occupied


Unoccupied $\qquad$

1/ Class II and Class IV are shown by using the symbol for the service or actlvity which is responsible for the supply of items of these classes of supply.Transportation Movement office.* TMOTunnel$\square----$Unit:

| Logistical Command | LOG |
| :--- | ---: |
| Transportation | $\boxed{O}$ |

Vehicle:
Shop truck__ Skid sled_

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By Order of the Secretary of the Army:

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EARLE G. WHEELER, General, United States Army,
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| CORC (2) | Instl (1) except |
| CRD (5) | Ft Eustis (20) |
| TPMG (5) | USACGSC (5) |
| CofEngrs (1) | USA MP Sch (15) |
| CSigO (1) | USAES (25) |
| TSG (1) | USAQMS (7) |
| CofT (5) | USASCS (5) |
| USATCDA (3) | USACMLSCH (2) |
| CofSptS (1) | USAARMS (25) |
| CNGB (10) | USAIS (5) |
| USCONARC (20) | USACAS (1) |
| ARADCOM (2) | MFSS (1) |
| ARADCOM Rgn (1) | USASESCS (5) |
| USACDC (10) | USA CBR Sch (1) |
| LOGCOMD (5) | Units org under fol TOE: |
| Armies (25) | $55-500(3)$ |
| Corps (15) | $55-510(3)$ |
| Div (10) |  |

NG: State AG (3); units-same as Active Army except allowance is one copy to each unit.
USAR: Same as Active Army except allowance is one copy to each unit.
For explanation of abbreviations used, see AR 320-50.



[^0]:    See footnotes on page 30 .

[^1]:    

[^2]:    

[^3]:    1 For time and space definitions, see FM 25-10.

[^4]:    ${ }^{1}$ If cargo includes explosives, include data required by local SOP and/or regulations.

[^5]:    ${ }^{2}$ Remarks should include statement of nature and quantity of all logistical support required.

[^6]:    ${ }^{1}$ Includes port and beach clearance.
    ${ }^{2}$ Figures are for long-range planning. Multiply by $4 / 3$ or 1.33 for short-range planning quantities.

[^7]:    - 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.
    - Increase by one for 12 -ton atake and platform trailer.

[^8]:    * Both factora should not be used; apply only the factor which gives the minimum capacity.

[^9]:    ${ }^{1}$ Factors are based upon the assumption that the road has been properly constructed, and thickness of base is adequate.

[^10]:    ${ }^{1}$ Under frozen conditions, a maximum movement can be supported for the duration of the freeze.
    ${ }^{2}$ See note 2, table IV.

[^11]:    See footnotes at end of chart.

[^12]:    ${ }^{1}$ Add 30 feet, 10 yards, or 9 meters to each total stopping distance shown when determining actual gap to use between vehicles.
    ${ }^{2}$ Does not include buses. For this type of passenger-carrying vehicle, select figures from an applicable section in the remainder of the chart.

[^13]:    a Full tralers are permitted the same gross weight as other single units with the following exeeptions: Alabama, Connecticut, Iowa, Kentucky-full trailers prohibited; Massachusetts-trailer and load limited to 3,000 pounds; Tennessee-trailer and load limited to 3,500 pounds.
    b Solid tires prohibited.

    - States where gross weight is determined by formula.
    d Automobile transporters allowed 1312 feet (also eovered vans in Washington; baled hay or atraw carriers in Maryland; hay, straw, or amall-boat carriers in Michigan).
    - Buses of 40 feet may be permitted in Virginia; 42 feet in Delaware; 45 feet in Oklahoma; 45.2 feet in Georgia.

    1 Not permitted.
    $s$ Not specified.
    b States where gross weight is determined by table of axle spacing.

    - No restrictions.
    , 104 inches for urban buses.
    $\boldsymbol{v}$ Vehicles over 35 feet in length must have three axles, exeept buses in Florida and South Carolina.
    1 Pneumatic tres.
    m Solid tires.
    n 102 -inch buses permitted subject to the following restrictions; Idaho, Montana, and Wyoming-only on highways at least 20 feet wide; New Mexicoonly on designated highways; Kansas, Massachusetts, Minnesota, North Carolina, and Texas-only in designated urban areas.
    - Permissible on balloon tires.
    p Pcrmasible on other than balloon tires.
    - Including tolerance.
    r 40-foot, 2-axle vehicles permitted on highways designated by Board of Highuay Directors.
    - Graduated according to width.
    - Limits shown arc permissiblc on designated highways; otherwise limited to $\mathbf{1 6 , 0 0 0}$ pounds on any 1 axle. Two-axle truck limited to $\mathbf{3 2 , 0 0 0}$ pounds under regiatration law.
    a Buses with 3 axles permitted 40 feet on designated highways, subject to 18,000 pound limit per axle.
    - Limits shown are permissiblc on designated highways; otherwisc limits arc: truck heiglat-111/2 feet, truck length-261/2 feet; semitrailer combination length -30 feet; gross weight 18,000 pounds.
    - Axles less than 10 fect apart limited to 16,000 pounds per axle.
    $\pm$ Michigan-32,000 pounds on one set of tandem axles in a combination on designatel highways; Mississippi-32,000 pounds on designated higbways; Ohio- 31,500 pounds on axles spaced over 4 feet but less than 8 feet apart.
    y Gross weight limits shown are permissible on designated highways. On other highways gross weight limits are graduated from 28,650 pounds (axle apacing of 4 feet) to 52,650 pounds (axle spacing of 30 feet or more).
    - Except on three-axle single units.
    a A Applies to vehicles registered after March 1. 1950.
    ab North Carolina-gross weight limit on most secondary highways is $\mathbf{1 6 , 0 0 0}$ pounds for 2 axles and 24,000 pounds for 3 axles.
    ac 30 -inch tolerance permitted auto-transporter semitrailers.
    ad Director of highways miay allow 3-axle buses 40 feet on designated higliways.
    as Permissible on class A highways.
    af Permissible on class $B$ highways.

[^14]:    * To determine vehicle-carrying capacity of fatcars, use these three columns in conjunction with the information contained in paragraph 3.2. Determine

[^15]:    * Amphibious trucks will be deleted from Army inventory and all units organized under this TOE are acheduled for elimination from the actlve Army troop list by the end of fiscal year 1964, and TOE 55-138, TOE 55-139, and TOE 55-140 are acheduled to replace this TOE.
    ${ }^{*}$ See TOE 55-500 and TOE 55-510 for additional teams.

[^16]:    1 Obsolescent, nonstandard.
    ${ }^{2}$ Prototype, nonstandard.

[^17]:    1 Obsolescent, nonstandard.

[^18]:    - Liberty ships have either a 30 - or 50 -ton boom at No. 2 hateh and a 15 - or 30 -ton boom at No. 4 hatch.
    b The FS is the 176 -foot supply vessel built for the Army. It is an oceangoing vessel, but, because of its small capacity, is used principally as an interisland carrier.

[^19]:    * See footnote at end of b.

[^20]:    * Wharf No. 6 is only 295 feet long. In paragraph 5.25 three ships require 300 feet. However, the 5 -foot shortage will not affect operations appreciably and three lighters are docked here.

[^21]:    * If metric system is used, it must be sdhered to for both distance snd speed.

[^22]:    * If metric system is used, it must be adhered to for $W, L, R$, and $\mathbf{R}^{\prime}$.

[^23]:    See footnotes at end of table.

[^24]:    * Same modes of activity as $2 f(1)$.

[^25]:    I Daily forward tonnage, assuming sustained operations, adequate road maintenance, and two-way traffic.
    '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.
    ${ }^{2}$ Water teminal discharge rate of $1,440 \mathrm{ST}$ per day required to adequately maintain 1 division slice. See also paragraph 5.26.

[^26]:    1 Includes weight of sled.
    ${ }^{2}$ Reduce 50 percent when load is doubled.

[^27]:    See footnotes at end of table.

[^28]:    See footnotes at end of table.

[^29]:    See footnotes at end of table.

[^30]:    ${ }^{1}$ Multiply by $\mathbf{3 9 3 7}$ to obtain inches.
    ${ }^{2}$ Multiply by 3.2808 to obtain feet.

[^31]:    See footnotes at end of table．

[^32]:    See footnotes at end of table.

[^33]:    ${ }^{1}$ DANC is not recommended for G-agent decontamination; 19-percent alkaline solutions are recommended for G-agent decontamination on material except fabrics to include canvas and leather.

    * Applicable to small vital areas only.
    * DS2 is not recommended for woolen items.
    ${ }^{4}$ DS2 may soften fresh paint.
    ${ }^{5}$ DS2 and DANC solution are destructive to plastics if not rinsed from them.

[^34]:    * Does not necessarily indicate the pipe is actually this size.

[^35]:    * Refers to change in unit volume per degree over or under $60^{\circ} \mathrm{F}$.

[^36]:    I For well-trained troops.
    2 In northern areas, the water requirements per man per day will be comparable to rates for temperate zones.

[^37]:    ${ }^{1}$ Two letters together are shown for leap years. The first is to be used for January and February, the second for other months.

[^38]:    I Does not include aircraft or overwelght and outdize vehicles or equipment. Typleal aircraft loads, to include conter of gravity, are not included in this table. If distance is too great for Army alrcraft in

