U. S. ARMY TEST AND EVALUATION COMMAND
Aberdeen Proving Ground, Maryland 21005

TOP 1-2-500
AD 765456
CHANGE 3

20 March 1979

TRANSPORTABILITY

TOP 1-2-500, 7 February 1973, is changed as follows:

1. Remove pages and insert new pages as indicated below:

Remove pages--	Insert pages--
13 and 14	13 and 14
--	14A and 14B

2. A vertical line in the margin indicates the changed portion of the revised pages.

3. Attach this sheet to the front of the reference copy for information.

dlg 4/12/79 ltr

U. S. ARMY TEST AND EVALUATION COMMAND
Aberdeen Proving Ground, Maryland 21005

TOP 1-2-500
AD 765456
CHANGE 2

24 August 1976

TRANSPORTABILITY

TOP 1-2-500, 7 February 1975, is changed as follows:

1. The date 22 July 1970 shown on all pages supplied by Change 1 should be changed to 22 July 1976.

2. Attach this sheet to the front of the reference copy for information.

DRSTE-RP-702-100 22 July 1976
*Test Operations Procedure 1-2-500, C 1
AD 765456

TRANSPORTABILITY

*This TOP supersedes MTP's 5-2-575 (22 Jun 70), 6-2-520 (30 Apr 68), 7-2-515 (2 Dec 69), 8-2-503 (30 Nov 67), and 10-2-503 (30 Jul 70).

Approved for public release; distribution unlimited.

SECTION I
GENERAL

1. Purpose and Scope. This TOP provides guidance for preparing test plans to evaluate the transportability characteristics of military equipment whether towed, self-propelled, or moved by carrier over highway, off-road terrain, railway, waterway, or by air.

a. The tests in sections II and III are used as applicable to the particular test item and test type. A development test II (ET) plan, for instance, will include the subtests that will satisfy the criteria of the ROC, DP, or other governing document. A development test III test plan will include the subtests pertinent to the contractual provisions of the applicable military specifications and suitability criteria as established by the test directive. Environmental tests, as dictated by the size and nature of the test items, may require a combination of chamber testing of components and on-site climatic tests. The applicable system engineering TOP/MTP will indicate requirements peculiar to the test item commodity group.

b. All tests specified herein are not applicable to all test items. The test planner will be selective to include only those tests needed to satisfy the requirements document for the specific item to be tested. Data from previous and similar tests and data obtained by concurrent testing (para 19) will be considered to avoid duplication and reduce the scope of testing.

2. Background.

a. In compliance with DOD Directive 3224.1, the Secretary of the Army established an "engineering for transportability" program (AR 70-47) to insure that newly developed items of materiel meet the appropriate requirements, and that procured materiel can be efficiently transported in accordance with operational requirements.

b. Transportability is an important factor in maintaining the "inventory in motion" concept of the modern, highly mobile army. Materiel must be able to survive transportation in a military environment without reduction in functional performance. The environment imposes numerous constraints involving impacts, vibrations, interferences, and repetitive motions requiring attention to blocking, bracing, slinging, tiedown, and containerization in connection with the stowage, orientation, suspension, or transfer of cargo. Adequacy of design depends upon compatibility with the transportation media and performance after handling and transport. The media cover a wide range of air and surface vehicles and materials handling equipment. Supporting facilities and systems may be simple or complex. A single item in transit may be subjected to a considerable variation of environment, orientation, and forces ranging from negligible to potentially destructive. Test procedures are selective to insure that appropriate parameters of the item's intended service are encompassed.

c. This TOP is based upon reference 16 (app. A).

3. Equipment and Facilities. Equipment and facilities are indicated in the applicable paragraphs below.

SECTION II
TEST PROCEDURES

4. Preliminary Activities.

a. The procedures governed by the following TOP's/MTP's are performed as prerequisites to conducting the other test phases:

	TITLE	PUBLICATION NO.
(1)	Initial physical characteristics	10-3-500 1-2-504
(2)	Technical inspection	2-2-500
(3)	Training and familiarization	10-2-501 1-1-045 (Background Document 7-1-002 (Background Document

b. Upon receiving the test package, the test director inspects and evaluates the transportability guidance contained, addressing himself specifically to the shipping, handling, and transportation of the test item. If there is no transportability guidance or the guidance contained is not considered satisfactory, the test director notes and records the deficiency. When insufficient guidance is contained, the procedures in this TOP will be followed where applicable. All methods of lifting, tiedown, or other means of restraining used will be documented and sent with the test results to the Transportation Engineering Agency, Military Traffic Management Command, 12388 Warwick Boulevard, P. O. Box 6276, Newport News, Va. 23606.

c. When expedient and practical, transported materiel is observed at original shipping sites, in-transit, and at receiving and inter-test sites to obtain maximum transportability data concurrently with necessary transportation operations associated with the test. Such data are used where valid to conserve further testing effort.

5. Lifting and Tiedown Attachments.

a. Objective. To determine whether the lifting and tiedown attachments for cargo to be transported comply with standard requirements.

b. Standards. MIL-STD-209D, MIL-STD-814A.

c. Method.

(1) The lifting and tiedown attachments are measured for conformance with the dimensional requirements and subjected to the calculated static lateral, longitudinal, and vertical forces as required by MIL-STD-209D. A dynamometer is used to measure forces in the static pull tests. Throughout all transportability tests, the lifting and tiedown attachments are observed for adequacy with respect to strength, accessibility, and ease of securing, utilizing, and releasing, and the data are recorded.

(2) For air droppable materiel, tiedowns and attachments are tested for conformance with MIL-STD-814A (see para 13).

(3) For tiedown devices for aircraft (hooks, chains, straps, and tension and quick-release mechanisms), requirements are described in TOP/MTP 7-2-100.

d. Data Required.

(1) Observations and drawings regarding restrictions in the use of tiedowns and lifting points during all transportability tests; measurements of lifting and tiedown attachments, including number and location.

(2) The direction and measured force in pounds of each static test applied and the location of the cargo tiedown and lifting attachments that were subjected to each pull. Measurement data are presented in the format found in figure 1 and in other tabular or narrative form or sketches required.

(3) The adequacy of the supplied, or suggested, cargo handling slings; the need for spreader bars; and the probable damage to the test item through sling use.

e. Analytical Plan. Measurements and data are compared with the requirements of MIL-STD-209D or MIL-STD-814A to determine to what degree the test item meets the standard requirements. Deviations are analyzed to ascertain their impact on transportability, and a resulting judgment is made as to whether the test item has met the standard requirements.

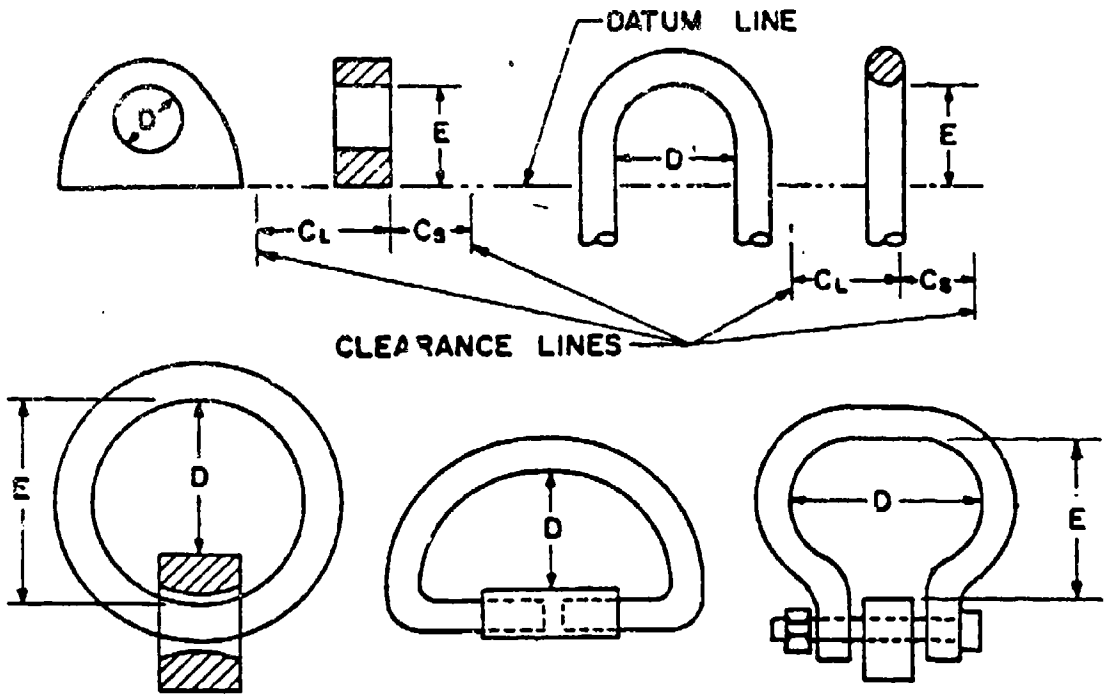
6. Rail Transportability.

a. Objective. To determine whether the test item can be transported by rail.

b. Standards. AR 70-44, AR 55-355, FM 55-15, TB 55-100, MIL-STD-810C, and Association of American Railroads Rules.

c. Methods.

(1) Humping Test. The test item must not be damaged by the humping test specified in the guidance documents. If not specified, the



Equipment Type	Weight Range (Long ton = 2,240 lb.)	C_L	C_S	D		E	
		Min (in.)	Min (in.)	Max (in.)	Min (in.)	Max (in.)	Min (in.)

1. There shall be no interference within C_L and C_S that could interfere with engaging a shackle and pin in the eye. Either side of the eye may be used as the datum from which to measure C_L and C_S.

2. Dimensions will be annotated as follows when applicable:

   a. Meets or exceeds minimum restrictions (indicate by asterisk at applicable dimension).

   b. Does not meet minimum restrictions (indicate by double asterisk at applicable dimension).

NOTES: Eye may be similar to any eye shown.
Eye may be designed to swivel.

(Extracted from MIL-STD-209D. See this standard for additional guidance.)

Figure 1. Format for Presenting Data on Static Pull Test of Lifting and Tiedown Attachments.

"rail impact" test of MIL-STD-810C will be assumed. Other possible tests are described by the Association of American Railroads (AAR), AR 55-355 and TB 55-100. (The test of MIL-STD-810C is generally considered a test of the test item, whereas the others are considered tests of the tiedowns and blocking methods.) For the tests of MIL-STD-810C and TB 55-100, the appropriate document will be consulted. The AAR and AR 55-355 method is described below.

Impact is accomplished by securing the test item on a railcar and propelling the car, by means of a locomotive (or by inclined ramp[1]), into a series of stationary buffer cars. (A minimum of 300 feet is required between the stationary and impacting cars to provide sufficient distance for the locomotive to accelerate the impact car to the desired velocity. The locomotive, impact car, and buffer cars require a minimum of 650 feet of reasonably level track for conducting this test.)

The test item is loaded, blocked, braced, and tied down on the freight car in accordance with procedures contained in the appropriate technical manuals. (If the technical manuals fail to contain appropriate instructions or if the instructions do not comply with the AAR rules governing the loading of defense material on open top cars, procedures recommended by the test agency and concurred with by the developing agency are used. An example is in app. B.)

An electric timer, to determine the approximate speed of the loaded railcar at impact, is placed on the tracks approximately 10 feet ahead of the point of impact. The electric timer is operated by passage of the impact car. Accelerometers are positioned at selected locations on the test item and railcar deck to measure impact forces in the vertical, lateral, and horizontal directions. (TOP/MTP 2-1-006 describes further instrumentation procedures.)

The buffer railcars, consisting of two to five railcars having a total gross weight of more than 169,000 pounds, are coupled together with couplers extended, and their brakes are set. Buffer cars shall have conventional couplers with a travel not exceeding 5 inches. Commonly known cushioned couplers shall not be permitted.

The impact car is then subjected to instrumented impacts at speeds of 4, 6, and 8 mph, $\pm$ 5 percent, respectively, in one direction, by accelerating the impact car to the desired speed using a locomotive equipped with a fifth wheel calibrated to 0.10 mph. The loaded car is released approximately 50 feet from the stationary buffer railcars and allowed to coast until it impacts them.

[1]An incline ramp facility may be used in lieu of a locomotive to accelerate the impact railcar if the facility provides the capability for reversing the direction of the impact car.

The impact car is then reversed, and the test executed in the opposite direction at 8 mph.

After each impact, the load is inspected to determine the amount of load shift, condition of blocking and bracing, and evidence of possible failure of tiedowns or equipment damage. Once the test has begun, there is no readjustment of the load nor any reconditioning of the bracing, chock material, or tiedowns. If the initial test is considered a failure, the test is rerun provided a revised loading method is considered feasible. Following the completion of the tests, the test item is examined for any displacement or damage, after which a functional and operational checkout test is conducted.

(2) Railroad Clearance. The test item, while loaded on a domestic or foreign service railcar or both, depending on test requirements, is passed through a rail clearance device to determine any restrictions within the AAR International Universal Gage (formerly Berne) and Composite clearance diagrams (figs. 2, 3A, 3B, and 3C). If the load has clearance restrictions, the disassembly necessary to achieve the clearance is accomplished and recorded.

(3) Railcar Compatibility. A study is made, when required, to determine whether the test item dimensions are compatible with those of various cars of the potential rail carrier. The physical dimensions of the test item are compared with the dimensions of the access and storage areas of various railway cars (table 1).

d. Data Required. The data required will include: the number, size, location, and type of lashing supports and blocking; time, personnel, and type of equipment used to load and unload the test item; ease of loading and unloading; direction of humping (front or rear); speed of railcar; diagrams and explanations of loading and type of material used for loading; measurements of weight, height, and vertical clearance of the test item; capacity, size, and type of railcar used for the test; speeds, measured g-forces, potential safety hazards; effects on the test item, including deficiencies, shortcomings, or limitations observed during transport operations. Photographs of rail humping and clearance tests are taken as required to illustrate interferences or damages.

e. Analytical Plan. Data are summarized in narrative, tabular, and graphic form, showing resulting peak and critical values, times, and measurements in relation to requirements in the governing standards. Sketches, lists of materials, and developed procedures are included for incorporation in transportability documents. Deviations are analyzed as to their extent and impact on transportability, and determination made as to whether the test item is capable of transport by rail.

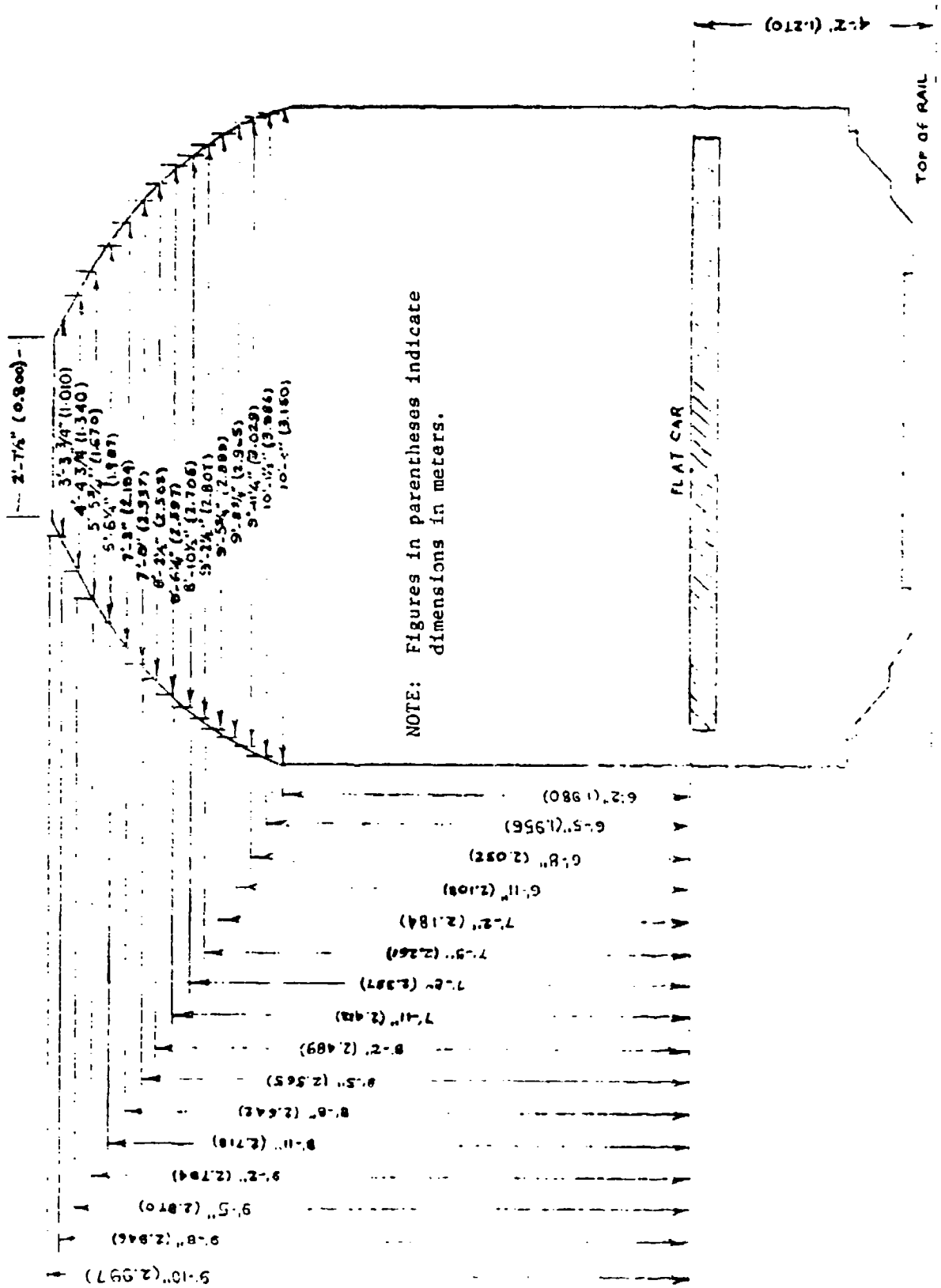


Figure 2. Railway Clearance Diagram, International Loading Gage (Berne).

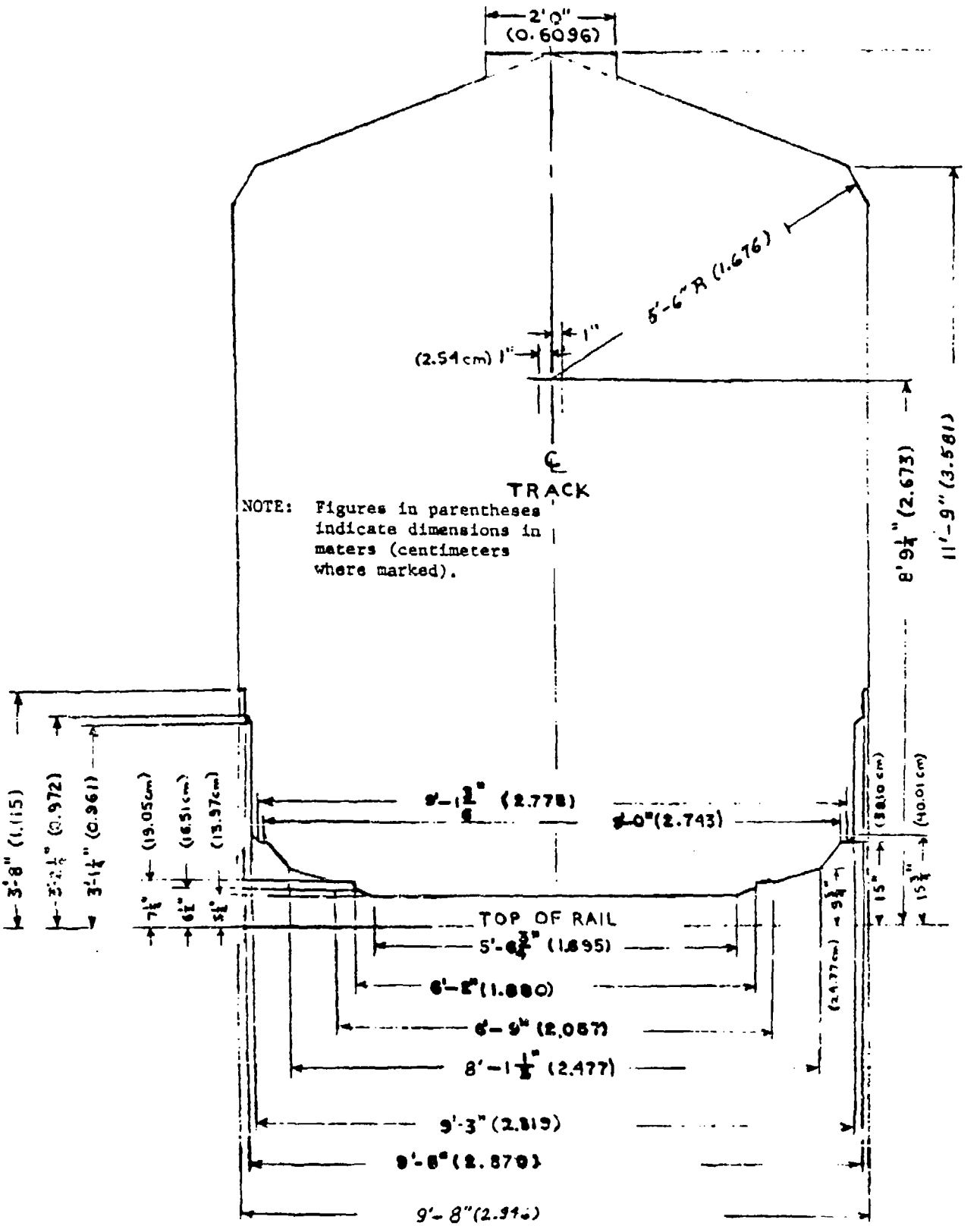
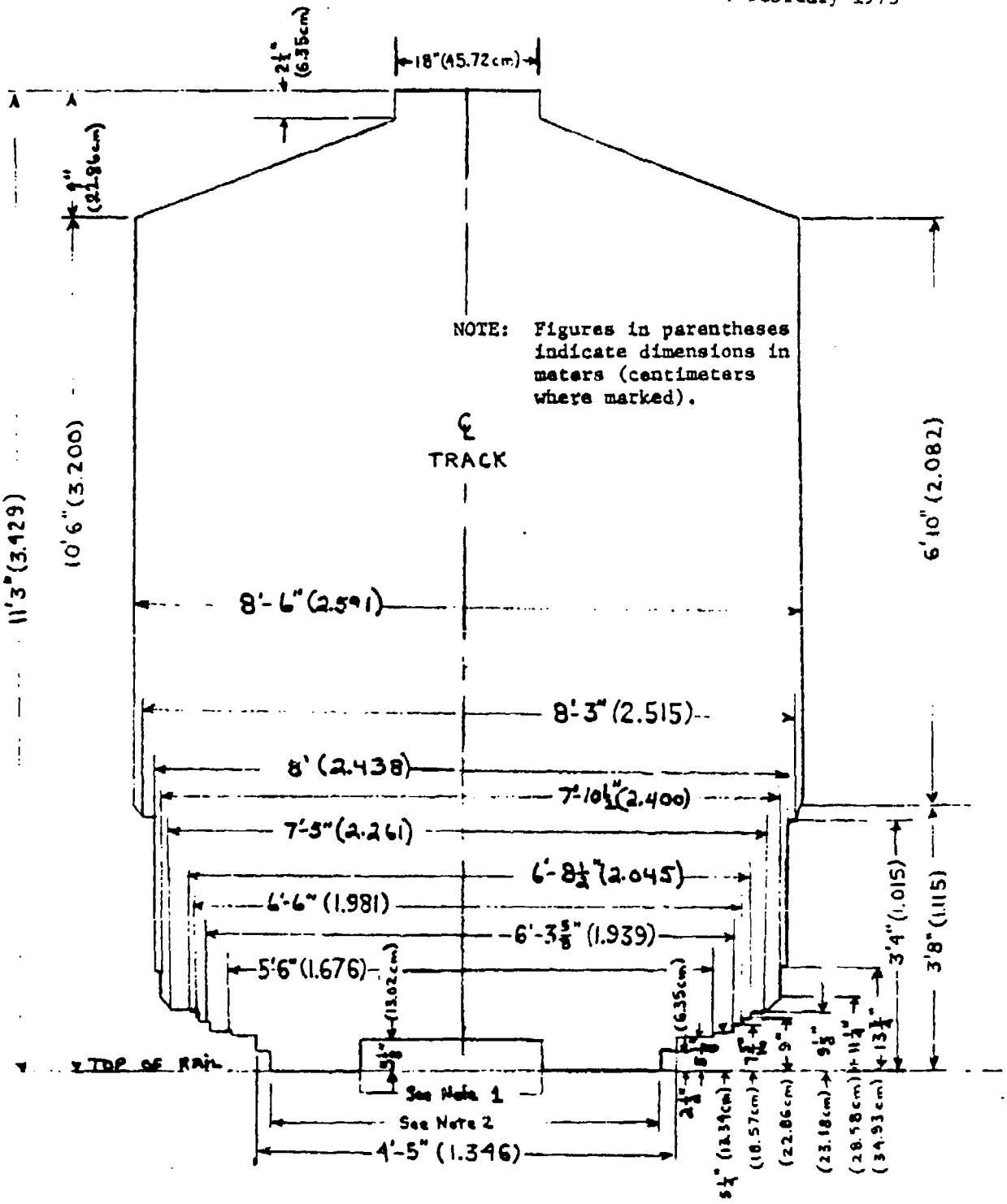


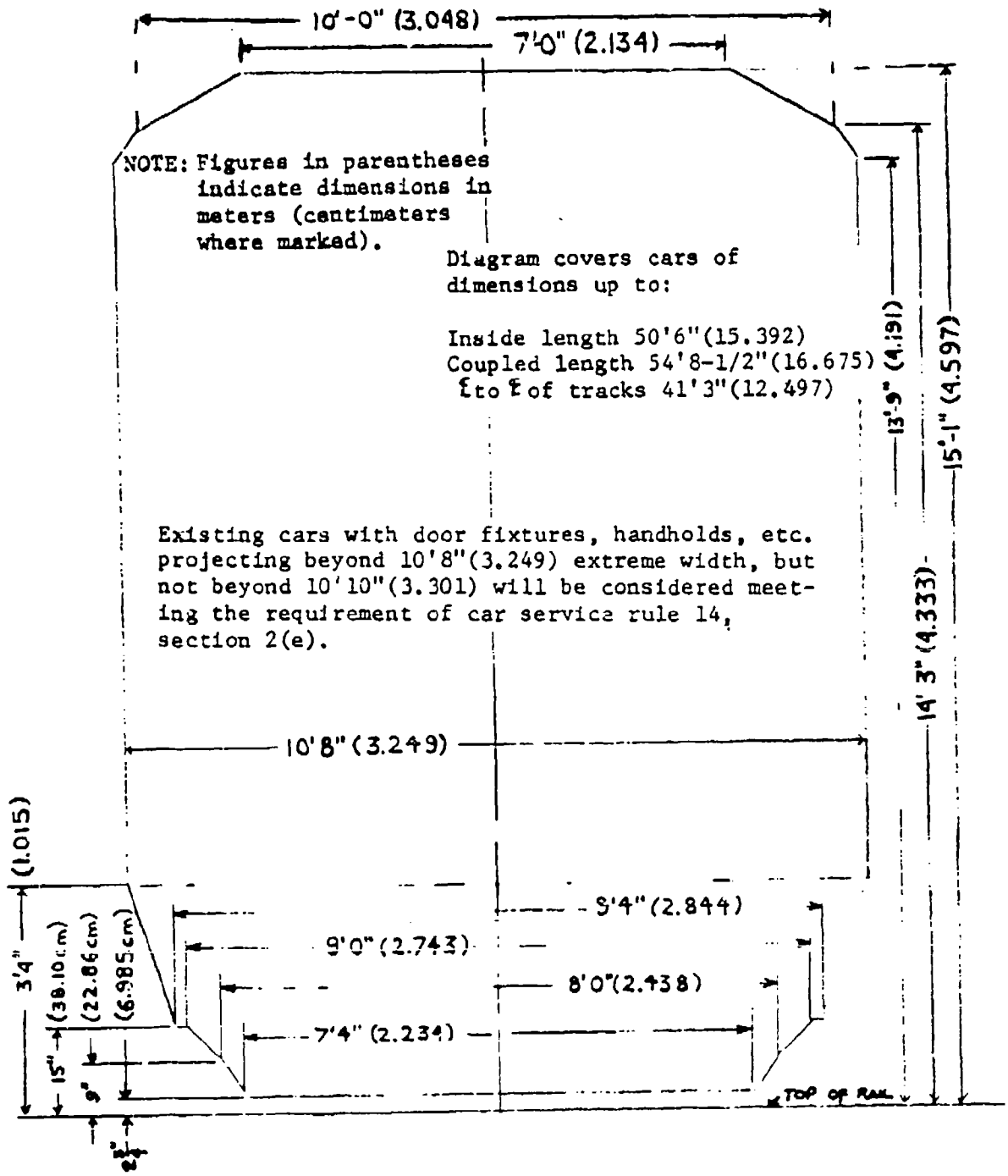
Figure 3A. A Composite Clearance Diagram: 56-1/2-, 60-, 63-, and 66-Inch Gages, Foreign Service.



Note 1: 2'8-3/4" (0.832) for 36-inch track gage, 3' (0.914) for 39-3/8- and 42-inch track gage.

Note 2: 4' (1.219) for 36- and 39-3/8-inch track gage, 4'5" (1.346) for 42-inch track gage.

Figure 3B. A Composite Clearance Diagram: 36-, 39-3/8-, and 42-Inch Gages, Foreign Service.



Cars built new or rebuilt on and after January 1, 1958 must be so designed that no part shall be less than 2-3/4" (6.985 cm) above the top of running rail under all allowable wear and spring deflection conditions.

Figure 3C. AAR Diagram, 56-1/2-Inch Gage, Domestic Service.

Table 1 - Characteristics of Typical Railway Cars

BOXCARS

Type	Gage (in.)	Capacity		Inside Dimensions			Door Dimensions	
		tons	cu ft	Length	Width	Height	Width	Height
8W, Narrow gage, foreign service	36,39-3/8,42	30	1,588	34' 5"	7'3/4"	6'4"	7' 10-1/4"	6' 1/16"
8W, Domestic service	56-1/2	50	3,975	40' 6"	9' 2"	10'6"	6'	8'
8W, Broad gage, foreign service	56-1/2,60,63, 66	40	2,520	40' 6"	8' 6"	6'5"	6' 8-3/4"	8' 3-1/4"

FLATCARS

Type	Gage (in.)	Capacity (tons)	Platform Length	Platform Width
8W Narrow gage, foreign service	36,39-3/8,42	30	34' 8-1/2"	7' 2"
12W, Domestic service	56-1/2	100	54'	10' 6-1/2"
8W, Domestic service	56-1/2	70	49' 11-1/2"	10' 3-1/4"
12W, Broad gage, foreign service, 80-ton	56-1/2,60,63,66	80	46' 4"	9' 8"
12W, Domestic service (passenger train)	56-1/2	100	54'	10' 6-1/4"
8W, Domestic service	56-1/2	50	43' 3"	10' 6"
8W, Broad gage, foreign service	56-1/2,60,63,66	0	40' 9"	8' 7-1/4"
8W, Broad gage, depressed center, foreign service	56-1/2,60,63,66	70	50' 7"	9' 8"

GONDOLAS

Type	Gage (in.)	Capacity		Inside Dimensions		
		tons	cu ft	Length	Width	Height
High side, 8W, narrow gage, foreign service	36,39-3/8,42	30	940	34' 5"	6' 10-1/2"	4'
Low side, 8W, narrow gage, foreign service	36,39-3/8,42	30	356	34' 6"	6' 10-1/2"	1' 6"
High side, 8W, broad gage, foreign service	56-1/2	40	1,680	40'	8' 3-1/4"	4'
Low side, 8W, broad gage, foreign service	56-1/2,60,63,66	40	500	40' 4-1/2"	8' 3-3/4"	1' 6"
Low side, 8W, drop ends, domestic service	56-1/2	50	1,184	41' 6"	9' 6-1/8"	3'
High side, standard gage, domestic service	56-1/2	50		41' 6"	9' 6"	4' 6"

7. Highway Transportability

a. Objective. To determine the degree of deterioration of a test item's operation, function, and interfacing, when transported over and off highways.

b. Standards. AR 70-44; AR 70-47; Limits of Motor Vehicle Sizes and Weights, International Road Federation (IRF); Legal Maximum Dimensions and Weights of Motor Vehicles Compared with American Association of State Highway and Transportation Officials (AASHTO) Standards; and TM 55-650.

c. Method.

(1) Transported Configuration.

(a) The test item is prepared for shipment in accordance with the procedures in the appropriate technical manuals for movement over highways. The item is loaded, blocked, braced, and tied down on a low-bed semitrailer or other appropriate vehicle designated as the prime mover. (If the technical manuals do not contain tiedown instructions, procedures recommended by the test agency and concurred with by the developing agency are used.) A loading diagram is provided for the method of tiedown. Once the item is securely loaded, the item and mover are inspected, measured, and compared with the limits for width, height, length, gross weight, and axle-wheel loading for unrestricted movement, as in appendix C (table 5, for the US, and tables 6a through d for foreign countries). The measurements and weight are recorded.

(b) The test item is then transported for 7 miles over a highway test course with the transporting vehicle negotiating five right and five left 90-degree turns, in an alternate pattern, to evaluate the turning characteristics of the vehicle and test load at intersections for unrestricted movement on principal highway systems. Turning diagrams are prepared by the test agency as follows:

(1) Standard width of roadway is shown versus clear width required for a 90-degree and a 180-degree turn.

(2) A trace of the inside and outside overhang and the outside front wheel of the loaded vehicle is measured (appendix C, figure 5, Highway Turning Diagram) and compared with highway limitations to ensure unrestricted movement.

(c) Instrumented emergency stopping tests are conducted at 10, 20, 30, and 45 mph to test the adequacy of the tiedown systems and to measure the force levels to which the test load has been subjected. In addition, driver reaction time (when required) and the average stopping distance of the vehicle are compared with the specifications of the Interstate Commerce Commision and the Atomic Energy Commission for traffic movement. After each emergency stop test, the load and tiedowns are inspected to determine the amount of load shift, condition of blocking and bracing, and evidence of displacement or damage. Following these tests, an operational and functional

checkout is made to determine if damage was sustained by the test item. The checkout must include pre-test performance checks and adjustments by setting up and operating the test item in accordance with the manufacturer's instructions. When the transportability test is completed, these performance checks and adjustments must be rerun to determine the changes.

(d) The dimensions and test results are compared with the requirements for geographical locations using appendix C (table 5, figure 6, and table 6) to determine if restrictions to highway movement exist. A computer program (SEO 276.00 Highway Vehicle Limits by Area), written in PL-1 language, is used at US Army Aberdeen Proving Ground for chis purpose. The passage of vehicles (loaded or unloaded) over highways in 105 foreign countries, 50 states of the US, the District of Columbia, and Puerto Rico can be determined by the program. Other agencies may use this program by accessing the computer at APG or by mailing the required data to the Commander, US Army Aberdeen Proving Ground, ATTN: STEAP-MT-G (Analytical Branch), Aberdeen Proving Ground, MD 21005, and requesting a run of the program. To use the program, the test director must obtain the following computer input data with the test item loaded on the transport vehicle:

Vehicle width.

Vehicle height.

Vehicle length (single vehicle).

Trailer length (if any).

Semitrailer length.

Vehicle length (truck and semitrailer).

Vehicle length (any other combination).

Single axle load.

Tandem axle load.

Gross weight limits.

Type of vehicle (fig 6, app C, TOP 1-2-500).

The units specified may be either metric or British. If the actual measured value of the test item and transport vehicle exceeds the legal limit in any state or country then the state or country, the restricting limits, and remarks will be printed out. No printout is made except where legal limits are exceeded.

It is the responsibility of the user of this program to ensure that up-to-date dimensional and weight restrictions have been inserted into the computer program. The authoritative source for the dimensional and weight limitations for vehicles traveling over highways

of the world are shown below together with the address of the organization responsible for thier publication:

Document/Data/Publisher	Geographical Coverage*
"Limits of Motor Vehicle Sizes and Weights", International Road Federation, 1023 Washington Building, Washington, DC 20005.	Africa; North, Central, and South America; Europe; Asia; Middle East; and Oceania. Document lists restrictions for countries in each of the geographical areas listed above.
Legal Maximum Dimensions and Weights of Motor Vehicles, American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capital St., N.W., Suite 225, Washington, DC 20001.	States of the United States; District of Columbia; Puerto Rico; Northwest Territories; and Nova Scotia.

*Where geographical areas appear in both documents, such as Puerto Rico, United States, etc., the AASHTO limits will be considered the authoritative source.

(2) Over-Highway and Off-Road Testing.

(a) Highway and off-road (cross-country) tests are performed to determine the capability of the test item and component assemblages (all components, equipment, accessories, and tiedown facilities), while mounted as onboard cargo on the prime mover, to withstand the shock and vibration to which a military vehicle is subjected when traveling over primary and secondary roads at speeds between 25 and 60 mph and over off-road (cross-country) level and hilly terrain at speeds between 5 and 20 mph. These tests are conducted on test courses representing typical primary and secondary roads and off-road terrain selected according to the type of equipment as shown in table 2 (TOP 1-1-011). The test item is loaded on its prime mover and tied down as in (1) (a) above. It is then transported over the preselected courses, which will include portions of primary (paved) and secondary (improved dirt and gravel) roads and off-road (hilly and level cross-country) terrain as specified in the table. The routes selected must provide an adequate representation of the above surfaces for each type of equipment tested and must lend themseleves to repeated use to form a comparative base for future testing. A towed test item (trailer-mounted), when required, is subjected to the same tests. When towed or self-propelled items are to be subjected to fording, beach mobility, over-the-shore soils trafficability, and adverse-environment tests, TOPs 1-2-510 (when published) and 2-2-612 are consulted.

(b) If the test item is a self-propelled vehicle, vehicle recovery operations are included in a portion of the highway and off-road testing. Using the appropriate maintenance vehicle, or the vehicle specified in the MN, the test item is towed over sections of the highway, secondary, and cross-country courses. This is accomplished to ensure the comparibility of the test item with the maintenance vehicle and to ensure that the test item can be retrieved if disabled. During towing operations the maintenance vehicle (or equivalent) and test item are required to negotiate four 90-degree turns in alternate directions. After this, the maintenance vehicle backs the towed test item in a straight line for between 40 and 50 feet. The towing vehicle and the test item are then backed while making turning maneuvers to both the left and right to simulate backing the test item into a maintenance shed or stall. During this entire portion of the test, the maintenance vehicle and test item are inspected continually to ensure unrestricted movement and to ensure that proper driver visibility is maintained in both towing and backing operations. The maintenance vehicle and the test item are inspected to ensure proper electrical connections and that towing pintles, lifting or tiedown eyes, and cables used in retrieving operations or movement are compatible. Recommended towing operations are documented and photographed.

Table 2 - Highway and Cross-Country Mileage for Transportability Testing*

Group	Type Equipment	Highway Movement 30 Percent	Secondary Roads (Perryman) 40 Percent		Cross-Country (Churchville) 30 Percent		Total Miles/Kilometers
			Dirt	Gravel	Hilly	Level	
NOTE: Kilometers (rounded) are shown in parentheses after the mileage figures.							
I	Bridges. Road and airfield surfacing equipment. Air drop equipment. Shelters, etc.	60 (97)	40 (64)	40 (64)	30 (48)	30 (48)	200 miles (322 km) in a 24-hour period.
II	Boats and marine equipment. Construction equipment (scrapers, bulldozers, loaders, etc.) Vehicles such as trucks and trailers. Combat vehicles such as tanks and personnel carriers.	150 (241)	100 (161)	100 (161)	75 (121)	75 (121)	500 (805)
III	Service support equipment (field laundries, bath units, printing equipment, etc.). Materials handling equipment (forklifts, cranes, etc.) POL handling equipment (pumps, filters, separators, etc.).	240 (386)	160 (257)	160 (257)	120 (193)	120 (193)	800 (1287)
IV	Electromechanical equipment (generators, air conditioners, welders). Maintenance tools and equipment (repair shops, tool sets, etc.)	300 (483)	200 (322)	200 (322)	150 (241)	150 (241)	1000 (1609)
V	Sensitive or high value items (missiles, radar systems, electronic equipment, sensors, fire control centers, etc.).	450 (724)	300 (483)	300 (483)	225 (362)	225 (362)	1500 (2414)

*Based on test courses described in TOP 1-1-011, Vehicle Test Facilities at Aberdeen Proving Ground. Applies to transported, not self-propelled items.

1. Unless otherwise stated in the guidance document, the miles and percentages shown will be used.
2. Proper safety regulations will be adhered to when using the test courses.
3. Speeds will be determined by specified type of test courses.
4. Where practical, transported items will be tested in conjunction with durability tests of appropriate carrier vehicles.

(c) Off-road soils trafficability data, if required for transportability guidance documents, is obtained using procedures described in TOP's/MTP's 2-2-619 and 2-2-801.

(3) Maximum-Environment Testing. When tests to the maximum attainable extremes are specified, either the complete test item and cargo or major system components are mounted in a jig or fixture; and input loads are supplied by shock, vibration, or special dynamic load-producing devices. (TOP 1-1-050, formerly TOP/MTP 2-1-003, provides general guidance.)

(a) Shock Tests. Shock loading is applied at the cargo bed or interface between the cargo and the vehicle and at other critical points dictated by the design of the vehicle. Shock directions are vertical, lateral, and longitudinal and progress in the following sequence for each direction: one each of 4 g's for 20 milliseconds, 6 g's for 40 milliseconds, 8 g's for 60 milliseconds, and 10 g's for 80 milliseconds. After the 10-g shock is administered, an additional 10 g's for 80 milliseconds is accomplished. Shock input is then increased at 5-g increments (80 msec) until the failure load is reached. Failure is determined when signs of yield, collapse, fracture, or fatigue are apparent from instrument readings or visual observations.

(b) Vibration Tests At the time of the writing of this TOP, some vibration schedules, and the documents describing them, are in a state of transition. The nature of the vibration test therefore must be in accordance with the latest document describing schedules, or in accordance with the customer's desires. MIL-STD-810C, Method 514, TOP 1-2-601, and letter instructions concerning specific commodities should be consulted to determine the applicable levels and duration of vibration for the particular commodity. Due to limited capacity of laboratory vibration equipment (30,000 force pounds), such tests are practical generally only for relatively small component and cargo items. Real time vibration tests of vehicles and vehicular transported items are conducted on the Washboard and Belgian Block vehicle test courses (see TOP 1-1-011). On the Washboard course, sinusoidal vibration is achieved up to about 1.25 Hz frequency, with vehicle speeds limited for safety reasons to about 5 mph. On the Belgian Block course, random vibration is achieved to frequencies up to about 7 Hz with vehicle speeds up to about 20 mph. In arranging vibration tests, Background Document TOP 1-1-050 should be consulted.

(4) Bridge Compatibility. Vehicles with test loads are checked for conformance with the AASHO (American Association of State Highway Officials) bridge design loading specifications for two-axle trucks, two-axle truck-tractors, and a one-axle semitrailer (app. C, fig. 7). Dimensions and weights of tracked vehicles for movement on highways and bridges are shown in appendix C, figure 8. Stress on a bridge resulting from movements of vehicles is computed and compared with the specific test vehicle type or configuration. The width of the vehicle, spacing of axles, placement of the vehicle, contact areas, floor strength, and speed are included in the evaluation. (Relationships for a number of

special vehicles have been computed, such as the ratings of a lowboy-type vehicle and a construction-equipment-type vehicle tested on H20-S16-44 and HI5-S12-44 bridges as shown in app. C, fig. 9. This illustrates the criticality of loading relative to span length and axle load distribution.) Vehicles passing over a bridge and inducing stresses of less than 100 percent of the allowable working stress are permissible for normal operations. Vehicles creating stresses of between 100 and 133-1/3 percent are considered safe and permissible for occasional use. Stresses of 133-1/3 to 167-2/3 percent are considered to be safe for emergency use only but may cause some permanent damage to the structure. Vehicles imposing stresses greater than 167-2/3 percent are considered to be unsafe for passage. To meet highway mobility requirements in the United States, wheeled and tracked vehicles must possess axle loads and spacing, or contact area distribution, that permit crossing of H15 bridges without creating stresses in excess of 133-1/3 percent of allowable working stress. Further comparisons will include the design loadings for all bridges carrying mainline traffic for compliance with requirements of the AASHO roadway bridges of H20-S16-44 or accepted alternate loadings, whichever is the stronger. Crossroad bridges are designed to the criteria for the specific highway and are included for comparison when required. (For additional guidance and procedures see TM 55-650.)

d. Data Required. Data will include the number, size, location, and type of lashing supports and blocking; time, number of personnel, and type of equipment used to load and unload the test item; and ease of loading and unloading. Measurements of weight, height, vertical clearance, length, gross weight, and turning characteristics are taken. Speeds, stopping distance, shock forces, and reaction time are measured during the stopping and impact tests. Shock effects, backing and turning diagrams as needed, safety hazards, deficiencies and shortcomings, or limitations during transport operations are recorded.

e. Analytical Plan. Measured and observed data are compared against the predetermined criteria for analysis of performance. Photographic sequences are studied for evidence of slipping, wear, or interference. Data are summarized and tabulated to show peak and critical measurements and displacements. Shock and vibration data are analyzed on an extreme value statistical basis. Plots and curves are used when appropriate. Narrative analysis is used for failures and important events.

8. Marine Transportability.

a. Objective. To determine whether the test item can be transported by marine vessels.

b. Standards. AR 70-44, TM 55-513, TB 55-100, MIL-STD-167B, MIL-STD-209D.

c. Method. Marine transportability testing is composed of the following:

(1) Lifting. The test item is properly prepared for marine transport as prescribed in the appropriate technical manuals. Recording accelerometers are mounted on the test item to obtain shock readings along the longitudinal, transverse, and vertical axes, when required. To simulate dockside loading, the test item is lifted off the ground by a mobile crane (or other suitable lifting device) to a height simulating ship deck height (up to 40 feet) and held for a period of 3 minutes. (Two guy lines are attached to the test item to guide and steady it during the simulated lift. The standard multileg sling assembly (17-ton capacity) is used when applicable for slinging the test item for simulated loading and unloading operations. The compatibility of the lifting assembly with the slinging eyes and conformance with the requirements of MIL-STD-209D, paragraph 4.1.2.2 for maximum allowable apex height and lift angle are determined.) The load is rotated 90° to the extreme left, reversed 180° to the right, and reversed again 90° left to the original starting position. The test item is then lowered to within 4 inches of the ground and released to free fall the remainder of the distance to the ground. Once this has been accomplished, the test item is inspected for damage. If more rigorous free-fall tests are required, and the capability of the lifting gear permits, the load is lifted to the maximum height of the crane and allowed to free fall approximately half the distance to the ground or deck, at which point it is abruptly stopped. Acceleration and deceleration forces are measured. The test item is then lowered to the ground, and a functional and operational check is conducted. All signs of impending failure of the equipment or its lifting or tiedown devices are recorded and photographed.

(2) Sea Movement Simulation. After the lifting test, the test item is loaded aboard a ship-motion simulation facility (which is capable of simulating ship loading conditions, hold or deck space, tiedown, and ship pitch and roll). For maximum exposure after the test item is in place and properly stowed, a seaway-induced loading, simulating transport on a ship for up to 20 days and up to Beaufort Sea State Condition 12, is accomplished. For an environment less severe than that of Beaufort Sea State Condition 12, the test item is placed or stowed on the simulating facility and subjected to rolls up to 30° at frequencies to 15 seconds and pitches to 5° at frequencies to 20 seconds for a minimum of 1 hour. Test sequences are designed to simulate increasing levels of force on the Beaufort Scale.[3] After each test the load is inspected to determine the amount of damage to the test item and adequacy of stowage and tiedown provisions. Recording transducers and strain gages are selectively placed and monitored at critical stress and energy points.

(3) Vessel and Test Item Compatibility. A study is made of various oceangoing vessels to determine the compatibility of the test item with marine stowage and handling provisions. (Where vessels are

[3]The Beaufort Scale is a measure of the open sea state (surface and wave action) resulting from various wind speeds. This scale may be used in conjunction with the Sea State vs Surface Environment developed by Dr. Alfred J. Carsola (app. D, fig. 10).

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13. ABSTRACT

Describes a method for evaluation of military equipment transportability characteristics. Discusses preliminary activities, facilities, and equipment required. Provides procedures for lifting and tiedown attachments; rail, highway, and marine transportability; terminals handling and movement; air portability, fixed and rotary wing, internal and external carried, to include airdropped materiel; shock; vibration; safety; human factors; and maintenance evaluation. Appendixes provide railway loading procedures, highway vehicle and load limits, marine transport environmental factors and characteristics, aircraft capacities, shock and vibration environments during transport by rail, sea, and air. Applicable to equipment whether towed, self-propelled, or moved by carrier over highway, cross-country, railway, waterway, or air.

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readily available, the study may be supported by some actual trials and measurements.) Comparison of the test item physical characteristics with the hatch and hold dimensions and cargo handling gear (app. D, table 7) is made. From this comparison an estimate is made regarding the capability of the item to be transported by various type vessels. An evaluation is also made of the capabilities of amphibious vehicles and landing craft with respect to loading and securing the test item and unloading it onto the beach. (For information on the characteristics of these vehicles see app. D, table 8.) The study, depending on requirements, encompasses the physical aspects of ramp negotiation, roll-on/roll-off maneuvering, loading, and tiedown arrangements. The review of ramp performance includes a comparison of ramp incline and land and ship intersecting angles with vehicle angles of approach, departure, break, and crest, as well as effects of beach gradients and gradeability capabilities of the vehicles. Complete logistics-over-the-shore (LOTS) performance test requirements will be given in TOP 1-2-510 (when published).

(4) Cargo Movement. If feasible, the test item is loaded on actual oceangoing vessels, using the ship's cargo handling gear or customary dockside lifts, and stowed and secured using the specific cargo restraints. The presence of combustibles, if any, in the test item is noted. Recording instrumentation, including strain gages and accelerometers, is applied at selected points to record angles of roll, pitch, and yaw, and the data are correlated with the environmental data logged by the ship during its voyage. When practical, the test item is inspected periodically during transport as well as at the beginning and end of the voyage.

d. Data Required. The following data are obtained:

(1) Type of ship or simulation gear used.

(2) Length of time and number of people required to rig the test item for shipment.

(3) Measurements of acceleration and deceleration.

(4) Equipment used in loading and difficulties encountered.

(5) Measurements of lifting eyes and sling lengths and apex angles.

(6) Location of stowage.

(7) Adequacy of broken stowage space in wings between decks or in other cargo areas used peculiar to the particular ship used.

(8) Method of securing test item.

(9) Duration of simulation or voyage and angles and periods of pitch, roll, and yaw encountered.

(10) Condition of bracing and securing gear during and after the voyage.

(11) Direction of shift (if any).

(12) Amount and type of damage.

(13) Vehicle and ramp angles of approach, departure, break, and crest, and gradeability capabilities of the test item.

e. Analytical Plan. Collected data are analyzed to determine whether the test item complies with AR 70-44, paragraph 4d and TB 55-100, paragraph 5. The various data are summarized and tabulated to show peak or critical measurements, displacements, and interferences. Supporting photographs, sketches, and curves are included as appropriate. Narrative analysis is used for failures and other test incidents.

9. Terminals Handling and Movement. General procedures for tests of containers and packaged equipment are included in Group 5000, FED-STD-101B. Those tests most pertinent to transportability, both surface and air, are discussed below.

NOTE: Special procedures apply to the testing of munitions. For transportability tests of these items refer to TOP's/MTP's 4-2-601 (drop tests), 4-2-602 (rough handling), and 1-2-601 (vibration).

a. Objective. To determine the capability of the test item to withstand handling by mechanical handling equipment and to determine the ability of the packaging and packing methods to provide protection to the contents.

b. Standards. TB 55-100, FED-STD-101B, MIL-STD-810C.

c. Method.

(1) Mechanical Handling Test. This test determines the capability of the test item to withstand handling by materials handling equipment and includes lifting and transporting by forklift truck, hoisting with slings, hoisting with grabs, pushing, towing, and conveying. The tests are performed according to FED-STD-101B, method 5011, and the data indicated therein are recorded. For some equipment provided with skids, a skidding test is performed as follows: The unit is skidded across 100 feet of each type of level road surface (paved, gravel, dirt) using appropriate prime moving equipment and a towing bridle or bar. A dynamometer is attached between the bridle or bar and the towing vehicle to determine towing resistance over the specified terrain. Skids and towing eyes are inspected for deformation or damage.

(2) Stackability Using Dunnage. Ability of the shipping containers or packages to resist loads such as that imposed on the bottom container in a stack, or on a container supporting top dunnage and superimposed loading, is determined. The tests described in FED-STD-101B, method 5016 are performed.

(3) Superimposed-Load Test (Without Dunnage). Ability of the shipping container to resist loads superimposed on their tops without benefit of top dunnage is determined. The tests described in FED-STD-

101B, method 5017 are performed. For failure testing of stacked loads, weights are added in appropriate increments, allowing 10 minutes at each weight, and increasing total weight to the point of failure. Instrumentation and photography are used to measure and record stresses and deflections. Lifting and slinging failure tests may be conducted in a similar manner, increasing specimen weight to the point of failure.

(4) Drop Test. Various drop tests are specified and must be selected based on the requirements of the particular item being tested. Unless otherwise specified, tests are conducted within the ambient temperature range of +32° to +110° F. Following are references for specific test methods:

Transit drop	MIL-STD-810B, method 516, procedure II
Cornerwise drop	FED-STD-101B, method 5005
Free fall	FED-STD-101B, method 5007
Edgewise drop	FED-STD-101B, method 5008
Munitions	TOP/MTP 4-2-601, 4-2-602

If failure testing is required, the following procedure is used: The drop surface is instrumented to measure the total force of the drop through the entire shock cycle, using column support of the contact plate and measuring forces through the columns by means of multichannel recording strain gages and accelerometers. For edgewise drops, the first drop is from a 2-inch height which is increased at 2-inch intervals until failure for each end. Cornerwise drops are conducted similarly on each of two diagonally opposite corners. Analyses of failures will include peak readings of forces and accelerations in conjunction with the associated impact velocities and frequencies.

(5) Incline-Impact Test. These procedures determine the ability of the container or packages to protect the contents or resist impacts on their surfaces or edges during loading ramp operations. The tests described in FED-STD-101B, method 5023 are performed for normal proof testing. The inclined track facility used for conducting the tests is described in Freight Container Bulletin 673, Association of American Railroads. If failure testing is required, the following procedure should be used: Apparatus is strengthened to withstand high failure loads. Either the specimen, secured on the dolly, is impacted against the barrier as described in FED-STD-101B, method 5023, or the dolly is impacted against the barrier to test the inertia load on the specimen. Accelerometers, strain gages, velocity and displacement transducers, and a timer are required. Both specimen and backstop are instrumented to record dynamic force flow and impact. Impacts are run, for each end of the item, in a sequence using 1-foot ramp increments from 2 feet to a ramp height that produces failure. Readings and mechanical measures between index points are recorded for each run number. High speed photography (128 frames per second) is used as appropriate to document impacts. Plots, time histories, and tabulated data are presented showing energy flow and peaks.

(6) Pendulum Impact Test. This procedure determines the ability of containers and packages to protect contents or resist horizontally applied impacts. The tests described in FED-STD-101B, method 5012 are performed for normal proof testing. For failure testing, the apparatus is strengthened to withstand high impact forces, and the backstop is instrumented to measure the entire force of impact. Impacts are made at 1-inch (vertical height) increments to point of failure, on each end of the specimen. Pendulum hight versus peak impact force is recorded.

(7) Rough Handling Tests. For some equipment, special handling tests are designed to simulate the treatment that may be accorded the item through the bumps, drops, or loose transport by hand or conveyance in service use. TOP/MTP 4-2-602 covers procedures for these tests for items such as munitions, rifles, rockets, radios, and mortars. Tests for other materiel may be selected from methods of MIL-STD-810C.

(8) Cargo Compatibility. Vehicles required to be evaluated in respect to cargo loading adaptability (i.e., to conditions and procedures encountered in loading/unloading operations during terminals transfer of various types of cargo) are subjected to the procedures of TOP/MTP 2-2-537. These tests usually can be integrated with other terminals handling and transporting procedures.

(9) Containers. Special procedures for tests applicable to the transportability of containers are included in the following TOP's/MTP's: 10-2-080, Containers and Pallets; 10-2-211, Packaging and Containers; 10-2-214, Large Cargo Containers; and 10-2-215, Containers Handling and Accessory Equipment (when published). The above documents contain test planning aids such as a container requirements checklist and schematic test course layouts for block operation and mobility and terminals handling operations. Specific test plans are developed for the containers themselves or for items transported within the containers as indicated in the requirements documents.

c. Data Required. The following data are recorded at the end of each subtest performed:

(1) Operational performance data for all specification requirements.

(2) Dimensions of the test item, spacing, size and type of fasteners, methods of closing and strapping, details of handling provisions, and net and gross weights.

(3) Description of the contents of the container, including blocking, bracing, and cushioning.

(4) The results of the test, describing the final condition of the container and the number of deflections under load.

(5) Shock and energy forces, duration times, and measurements of strains, deformations, and deflections.

e. Analytical Plan. Measured and observed data are compared against the predetermined criteria for analysis of performance. Data are summarized, tabulated, plotted, and graphed to show peak and critical measurements. Photographic sequences are studied for deflections and damages. Superimposed loads are computed by the methods described in FED-STD-101B. Shock data are analyzed on an extreme value statistical basis. Failures and test incidents are reported by narrative analysis.

10. Air Transportability - Fixed Wing Internal.

a. Objective. To determine the capability of the test item to be transported by fixed wing aircraft.

b. Standards. AR 70-39, AR 70-44, TM 55-450-15, TB 55-100, MIL-STD-209D, MIL-STD-810C, and TO 10-9 series (Air Force).

c. Method.

(1) In planning for air movement of supplies, scale drawings (templates) of the cargo to be loaded are used with the scale drawings of the floor plan of the aircraft in determining the air transportability of the cargo items. All drawings of the cargo are at a scale of 1/4 inch = 1 foot. The cargo templates are positioned to make maximum use of the aircraft space. When using cargo templates in load planning, a 10-inch space is required between cargo items. (For usable dimensions of aircraft see app. E.) After positioning the cargo, computation is made to determine whether the aircraft will balance within the desirable center-of-gravity limits.

(2) A primary consideration in aircraft loading is the pressure (in psi) exerted on the floor of the aircraft. In the floor of the aircraft will not support the concentrated weight of the test item, load spreaders are placed beneath the item to increase the floor bearing area and uniformly distribute the weight over the cargo floor. Individual wheel or axle loads and general floor loading, as determined from the plan view of the equipment, must conform to the fuselage zone and compartment limitation for the aircraft concerned.

(3) Once the general movement planning has been completed, the test item is subjected to the temperature-humidity-altitude test described in MIL-STD-810C, method 518, procedure I. This test is performed only when the test item will not be stowed in pressurized, air-conditioned cargo spaces during internal air transport. The test is not conducted if the test item, when properly packaged, will not be adversely affected by exposure to cycling between low temperature/low pressure and high temperature/high humidity (as encountered in flight between extreme environments).

(4) If an aircraft simulation facility cannot be obtained, a study is made of the appropriate Army and Air Force aircraft (app. E, table 12) to compare the test item's physical characteristics with those of the aircraft involved. From this comparison the adaptability and capability of the aircraft for transporting the test item can be determined. If further information is needed, reference should be made to TM 55-450-15.

(5) Before any physical testing, the test item is inspected. The location of, and data on, all tiedown, hauling, and lifting points are recorded and compared with the aircraft tiedown points. All anchoring points must be compatible. The lifting and tiedown eyes must conform with the design criteria of AR 70-39 and MIL-STD-209D.

(6) The cargo restraint factors normally caused by emergency landing are based on an aircraft vertical velocity at touchdown of 10 fps. It is recommended that the restraining system be capable of sustaining a minimum of 20 load applications based on the factors shown in table 3 either separately or in combination, depending on which is most severe. After each series or after completion of the test, the restraining system and restrained test item are inspected for degradation or fracture. These cargo restraint factors are ultimate values for the evaluation of internal cargo movement.

Table 3 - Controlled Emergency Landing Factors

Direction	For items of a size that can be transported in a C-130 and C-141 airplane	For larger items requiring transport in C-5 airplanes
Forward	8.0	3.0
Side	1.5	1.5
Vertical up	2.0	2.0
Aft	1.5	1.5
Vertical down	4.5	4.5

NOTE: The above factors include a built-in safety factor of 1.5 except for the forward factor in the first column, which includes a safety factor of 4.

(7) During physical testing the test item is subjected to shock amplitudes equal to the following without loss of serviceability:

(a) Acceleration of 3 g's for 50 to 100 milliseconds applied independently along both the longitudinal and vertical axes in each direction.

(b) Acceleration of 1-1/2 g's for 50 to 100 milliseconds applied independently along the lateral axis in each direction.

(8) Upon completion of the simulated controlled emergency landing tests, the crash landing load test is performed. For this test the test item is required to withstand crash landings without damage of the major components even though it may be unserviceable after the test. The following procedure is performed: A minimum load equivalent to 9 g is applied in a forward direction (as loaded) for 50 to 100 milliseconds. When the equipment is of such size or configuration that it can be loaded into cargo aircraft in either of two reverse positions (i.e., a truck that can be driven forward or backed into the aircraft), the above load must be met in both directions relative to the test item. When the loaded position is fixed or specified for an item (i.e., a truck that can only be driven forward into the aircraft), the above load requirement need be met only for the forward direction and a load equivalent to 2 g shall be applied in the rearward direction. For cargo carried on a wheeled or supported vehicle, a minimum load equivalent to 4-1/2 g is applied vertically downward for a minimum of 3 seconds.

d. Data Required. The following data are collected:

(1) Type of aircraft used for simulation or planning.

(2) Equipment used for loading.

(3) Number of people used in loading.

(4) Center of gravity of test item on the aircraft.

(5) Floor pressure computations (if needed).

(6) Type, number, and direction of cargo restraints used.

(7) Angle of tiedown used.

(8) Diagram of loaded test item.

(9) Duration, temperature, humidity, and altitude that the test item is subjected to during the temperature-humidity-altitude test.

e. Analytical Plan. Measured and observed data are compared with the predetermined criteria for analysis of performance. Data are summarized, tabulated, charted, and graphed to show critical measurements and characteristics. Interferences are measured and described. Shock data are analyzed on an extreme value statistical basis. Narrative analysis is used to describe failures and reportable test incidents.

11. Air Transportability - Rotary Wing Internal.

a. Objective. To determine the capability of the test item to be transported by rotary wing aircraft in an internal configuration.

b. Standards. AR 70-39, AR 70-44, TM 55-450-9, TM 55-450-15, TB 55-100, MIL-STD-810C.

c. Method.

(1) Flight and Taxiing g-Load Tests. When performing this test, a rocket sled or incline plane equipped to handle the weight of the test item and capable of applying the specified g-load for a minimum of 0.1 second is used. The test item is mounted on a pallet equipped with cargo tiedown points identical to those used in the aircraft/pod involved, including configuration, location, and loadcarrying strength. The test item is placed on the pallet in the desired orientation and tied down, or otherwise secured, in the same manner and using the same tiedown provisions as those which will be used in the aircraft/pod involved. Unless otherwise specified, the procedures and equipment used shall be as described in TM 55-450-9. The mounted test item is then rolled down the incline plane, or otherwise accelerated, and stopped so as to produce the following applicable accelerations:

(a) Cargo Without Pod. A specified acceleration of 3 g is applied independently along both the longitudinal and vertical axes in each direction, or as indicated in the maneuver and gust envelopes (V-N diagrams) of those aircraft considered suitable for transporting the test item.

(b) Cargo Attached to a Pod. When the test item is to be transported while attached to a pod, or is spring mounted, partly or wholly protected, and the pallet orientation is the same as when stowed in the aircraft involved, vibration testing is performed using MIL-STD-810C, method 514.2. Acceleration levels are as indicated in figure 514.2-7 of MIL-STD-810C. After vibration, the test item is inspected and placed in an operational and functional condition. Any damage, deficiencies, or shortcomings are recorded. A determination of the cause of damage is made. Upon complete analysis of the damage, another packaging or tiedown method will be recommended.

(2) Ramp Negotiation Test. The test item is moved up to, over, and down the ramp assembly of the appropriate aircraft. If an aircraft cannot be obtained for the test, the test is conducted on an equivalent ramp negotiation course. During the test, observations are made to determine whether all portions of the test item (except the wheels or track gear) remain clear from contact with the ground, ramp assembly, or top horizontal landing deck. All clearances, unrestricted or restricted, are measured and recorded.

(3) Emergency Aircraft Landing Loads Tests. After the test item has passed the operational evaluation, it is repackaged for transport and mounted on the pallet for g-load testing. Using the aircraft simulation device, the test item is subjected to the following accelerations:

(a) A minimum of 4-1/2 g's vertically downward for a minimum of 0.1 second for a test item stowed in a pod/cargo compartment which imposes a load on the wheels or other floor supports in a downward direction.

(b) A minimum of 8 g's in either direction applied independently along each horizontal axis for a minimum of 0.1 second while the test item orientation is the same as when stowed in the aircraft. After testing, the test item is inspected for any damage; it need not, however, be serviceable after being subjected to this test.

(4) Physical Characteristics. The physical characteristics of the test item are compared with the internal ramp and loading door characteristics of the appropriate helicopter. If any restrictions are found, the test item is disassembled so that loading can be accomplished. If the test item is too large, bulky, or heavy, however, another type of transportation will be recommended.

d. Data Required. The following data are acquired:

(1) Type of item shipped.

(2) Weight, dimensions, and cubage of test item.

(3) Load capacity of tiedowns.

(4) Hoisting and hauling fitting points.

(5) Shipping weight.

(6) Orientation in flight, when critical.

(7) Center of gravity of test item.

(8) Instructions for special servicing.

(9) Precautions to be observed during loading and unloading.

(10) Restrictions and clearances for loading, including ramp.

(11) Any disassembly of the item required for loading.

(12) G-forces encountered in testing.

(13) Reduction of tire pressure to meet loading standards.

e. Analytical Plan. All data are analyzed to insure that the test item has met the criteria for air transportability found in AR 70-39, AR 70-44, TM 55-450-15, and TB 55-100. Data presentation is by means of summaries, tables, charts, graphs, and narrative analysis of failure incidents, interferences, and effects of shock forces.

12. Air Transportability - Rotary Wing External.

a. Objective. To determine the capability of the test item to be transported by rotary wing aircraft in an external configuration.

b. Standards. AR 70-39, AR 70-44; TM's 38-250, 55-450-8, 55-450-11, 55-450-19; TB 55-100; MIL-STD's 810C, 814A; letter, MTT-TRC, 17 March 1975, subject: External Helicopter Lift Criteria.

c. Method. Prior to physical testing, the test item is inspected and the locations and conditions of all tiedown, hauling, and lifting points are recorded. A check is made to insure that points correspond with the slinging points of appropriate aircraft. All dangerous or hazardous materiel is identified and packed in accordance with TM 38-250. The following inspections and tests are conducted:

(1) Conformance to Class of Materiel (Based on Projected Frontal Area). Frontal area ratio (FAR), if not provided, or if required to be validated, is computed as the item's weight (pounds) divided by the maximum area (square feet) projected on a vertical plane perpendicular to the line of flight as the suspended item is rotated about a vertical axis. Classification is stated as follows:

Type A materiel: FAR = 60 lb/square foot or greater.

Type B materiel: FAR = less than 60 lb/square foot.

(2) Dimensions of Lift Points. Lift points on the test item are measured to determine conformance with dimensions shown on figure 16, 17, or 18, appendix H, selected depending on whether suspension is single or multipoint, number of lift points, and weight range of the test item.

(3) Location of Lift Points. Locations of points are measured in both the measured and horizontal planes of the suspended test item. Location of the test item's center of gravity (C.G.) will have been determined for both the empty and loaded condition, if different. Measurements are taken to determine whether the following criteria are met:

(a) Vertical Plane. For four-point and three-point lift configurations, all lift points shall be located above the C.G. If this requirement cannot be met, the C.G. must fall within a triangle whose apex angle is 120° and whose base leg is formed by a line between the lift points (fig. 19, app. H). For two-point and single-point suspension, the lift points shall be located above the C.G. at a height that will leave at least 60 percent of the maximum projected vertical area below the lift points.

(b) Horizontal Plane. All lift points shall be located within a 28-foot-diameter circle with the C.G. as the center, as far apart as practical. Points shall be symmetrical about longitudinal and vertical axes passing through the C.G. Limited asymmetry is permitted provided that the ratio of the largest to the smallest vertical force does not exceed 1.2. For multipoint suspensions the angle between the vertical and line of action (fleet angle) shall not exceed 20° for the suspended item.

(4) Strength of Lift Points. Each lifting point is tested by applying loads according to the following two conditions, withstanding the larger force without permanent deformation to slinging eye or connecting structure:

(a) A working load equal to the maximum static resulting tensile force determined by calculating the sling leg static resultant force at each lift point, times a load factor as follows:

Type A materiel - 3.2 (item weight less than 20,000 pounds or greater).

Type B materiel - as specifically stated for the particular item or obtained from the Transportability Agent (MTMCTEA).

(b) Ultimate strength equal to the working load times a 1.5 factor of safety (computed as to maximum static resultant force on the lift point times the load factor times 1.5). For items that can be shipped in a loaded or unloaded condition, lift point strength is calculated for the loaded condition.

(5) Sling Leg Clearance. There shall be a clearance of at least 8 inches between the centerline of any sling leg and any appurtenance of the materiel when freely suspended.

(6) Flight g-Load Test. The test item is inspected and properly prepared for external air movement as prescribed in TM 55-450-8. Once the test item has been prepared for shipment and an accelerometer has been attached to the test item pallet, the load is attached to a load-lifting and drop facility. The lifting device will be high enough to permit the bottom of the cargo to clear the ground by not less than 5 feet when it is suspended by the maximum expected sling or sling assembly length. The cargo is supported above the ground a sufficient distance to allow it to fall freely before its downward motion is stopped by a nonslipping hoist drum brake. The distance that the cargo falls up to the time the brake is applied must be controllable, and is measured with an accuracy that is within $\pm$ 5 percent of the desired value. The deceleration is measured by an accelerometer mounted on the cargo pallet or on the most rigid portion of the test item. Unless otherwise specified, the peak amplitude of the vertical deceleration during the drop will be 4.0 g.

(7) Long and Short Sling Suspension Test. The test item is rigged using the shortest sling length that will be used in service, and the load is suspended from the lifting crane hook at a suitable distance above the ground. The test item is dropped a distance of 6 inches, at which time the resulting forces are recorded. Using the g-load reading obtained, the trial and error method is used to determine the distance that the test item must fall to obtain the specified vertical deceleration in g's. Once the vertical deceleration distance has been obtained, the test item is dropped at that distance a total of six times. The test is then repeated while using a long sling.

(8) Operational Test. If an aircraft is obtained for the test, the test item is rigged and test flown by the aircraft, during which the aerodynamic stability of the slung load is observed. Note is made of test item characteristics during flight in respect to trailing attitude, rotation, oscillation, and clearances of slings against rubbing or chafing actions.

(9) Inspections. After each subtest described in (6) through (8) has been completed, the test item is visually inspected and subjected to a functional check, if appropriate. Any evidence of physical or chemical damage, including liquid, gas fumes, or air leakage, is recorded; and a determination is made as to the cause of the damage. Photographs are taken of the test item as necessary.

d. Data Required. The following data are collected:

(1) Dimensional and strength measurements of tiedown and slinging points, number and location.

(2) Compatibility of test item with aircraft slinging provisions.

(3) Tiedown diagrams of pallet loads, if applicable.

(4) Suspension distances.

(5) Deceleration rates and g-loads.

(6) Sling lengths and types.

(7) Observations on in-flight load stability.

e. Analytical Plan. Measured and observed data are summarized into narrative, tabular, and charted form and are analyzed for compliance with stated requirements. Analysis of failures, incidents, and effects of stresses is made.

13. Air Transportability - Airdropped Materiel.

a. Objective. To determine the capability of the test item to be airdropped from aircraft.

b. Standards. AR 70-39, AR 70-44, TM 10-500, TM 450-15, MIL-STD-669B, MIL-STD-810B, and MIL-STD-814A.

c. Method. The test item is inspected for location and compatibility of tiedown and lifting points. Data obtained from previous tests (paras 5 and 12) are used when appropriate. A check is made to insure compatibility of test item points with load anchoring points of the aircraft or airdrop platform. Tiedown, suspension, and extraction provisions are checked for number, location, dimensions, and clearances as required by MIL-STD-814A. (See TOP/MTP 2-2-512 for airdrop of vehicles.) A high-speed camera is set up to record the effects of the tests on the test item.

(1) Design Check. The test item is prepared for airdrop by either the suspension or extraction method or both, as appropriate, following guidance in TM 10-500 and MIL-STD-669B. The rigged load is weighed and measured for conformance with the requirements of MIL-STD-814A and for compatibility with the designated carrier aircraft. Static pull tests are conducted on suspension or extraction eyes or components to check compliance with the design details of MIL-STD-814A.

(2) Initial Tests. If specific provisions for energy dissipation are not provided, the prepared system is initially subjected to deceleration force levels less than the g plus 1, or 19.5 times the item airdrop weight, specified by MIL-STD-669B, using trial force levels as recommended by the developer. Selected low force levels are progressively increased, observing for indications of damage, to the maximum ratio of g plus 1, or 19.5 plus or minus 10 percent.

(3) Ground Impact Test (Low Velocity). The test item is assembled, secured, balanced, and cushioned (in accordance with MIL-STD-669B) on a pallet or other appropriate carrier. The test item is then attached to a cargo lifting hook of a load-lifting and dropping facility. (The lifting device will be high enough to permit the bottom of the cargo to be raised a minimum of 12.7 feet - the equivalent of 28.5 fps free fall - above the ground. The ground will be level, of reinforced concrete or similar rigid material.) The cargo is attached to the lifting hook using the same slings, devices, load couplers, and hardware as are used to suspend the cargo from the recovering parachute in actual practice. An accelerometer is attached to the cargo skids, platform, or pallet. When this has been accomplished, the test item is raised off the ground until its lower edge is positioned at 12.7 feet. The load attitude is corrected, if necessary, to insure level suspension. The cargo is allowed to free-fall to the ground, and the drop height and maximum accelerometer reading are recorded. The platform or skid shall strike the impact surface at an angle not greater than 2-1/2° in any direction to insure valid results.

(4) Rollover and Tipover Test. The rollover and tipover test for an item that is to be airdropped is conducted only on a test item whose minimum width is not greater than one-fourth of its height. The

orientation of the test item in space will be the same as when it impacts the ground during this test. The test item is subjected to the test procedures of FED-STD-101B, methods 5014 and 5018 for rollover and tipover tests.

(5) Functional Checks. Functional checks are conducted on test items after the above test phases as required to insure item integrity. Photographs are examined for evidence of effects of motion or damage. Any need for deviations from prescribed procedures or limitations in the referenced standards is fully described along with appropriate remedial actions when appropriate.

d. Data Required.

(1) Dimensional and strength measurements of tiedown, lifting, and anchoring points, number and location.

(2) Compatibility of the test item with the airdrop platform and the aircraft.

(3) Tiedown diagrams.

(4) Restraint g-factors.

(5) Free-fall acceleration.

(6) Load characteristics as rigged.

(7) Observations on design compliance and adequacy of standard procedures as indicated in c(5) above.

e. Analytical Plan. Collected data are summarized in narrative, tabular, and charted form, and are analyzed for compliance with the stated requirements. Analysis of failures, incidents, and effects of stresses is made, supported by the photographs when advantageous.

14. Shock.

a. Objective. To determine the capability of the test item to withstand expected dynamic shock stresses that occur during normal transportation.

b. Standards. MIL-STD-810B.

c. Method. The shock test procedures indicated below may be used when the test agency determines that additional shock testing, or testing different from that in preceding subtests, is required to satisfy the criteria requirements.

(1) The test item is prepared for shipment as directed in the appropriate technical manuals. The test item is rigidly attached to a

shock machine table capable of producing the shock environments described below. The shock table is calibrated and instrumented for the tests. (See app. F for representative cargo shock environments.)

(2) For testing under laboratory conditions, TOP/MTP 6-2-541, which covers basic design, transit drop, crash safety, high intensity, and bench handling tests, is consulted. For the testing of vehicles (or of cargo carried on vehicles) over controlled test courses, TOP/MTP 2-2-808, which covers the determination of field shock induced during operation over rugged terrain courses, is consulted.

d. Data Required. The following det. s are obtained and recorded:

(1) Test procedure used and time duration.

(2) Shock pulse selection, shape, peak value, and duration.

(3) Temperature extremes, if any.

(4) Filters used, if any.

(5) Amount and type of damage.

e. Analytical Plan. All data collected are analyzed to determine whether the test item conforms with the stated requirements.

15. Vibration.

a. Objective. To determine whether the equipment is constructed to withstand, without performance degradation or malfunctions, the dynamic vibrational stresses for which it was designed.

b. Standards. MIL-STD-167B, MIL-STD-810B, TOP/MTP 4-2-804, MIL-STD-810C (when issued), TOP 1-2-601 (when issued).

c. Method. The procedures indicated below may be used when the test agency determines that additional vibration testing, or testing different from that in the preceding subtests, is required to satisfy criteria requirements. (For purposes of this test method, equipment is categorized according to the vehicle in which it will be transported.)

(1) All equipment transported by common carrier, land or air, is normally subjected to the vibration procedures previously described for each mode. If those procedures are not used, MIL-STD-810B, method 514 may be used.

(2) Any equipment transported by ship shall comply with the previously stated requirements in paragraph 8. If further testing is needed, MIL-STD-167B should be consulted for environmental vibration. This applies to equipment intended for installed shipboard use and may be adapted for shipments that must withstand the environmental vibration

conditions that may be encountered aboard naval vessels. (See app. F for representative cargo vibration environments.) For tests of vehicles, or of cargo carried on vehicles, over controlled test courses, TOP/MTP 2-2-808 is consulted. For laboratory testing of packaged or component items, ammunition, and electronic or mechanical assemblies, TOP/MTP 4-2-804 applies. For laboratory tests of communication, surveillance, and avionic electronic equipment, TOP/MTP 6-2-540 is consulted. MIL-STD-810C and TOP 1-2-601 will, when issued, replace MIL-STD-810B and TOP/MTP 4-2-804, respectively.

d. Data Required. Data are indicated in the applicable references above.

e. Analytical Plan. All data acquired are analyzed to insure that the test item complies with specified requirements.

SECTION III
SUPPLEMENTARY INSTRUCTIONS

16. Safety Evaluation. Maximum safety precautions are exercised during all transportability operations, with emphasis on those that apply to each particular mode of transportation used during the tests; and all safety procedures prescribed in AMCR 385-100 are observed. Any existing or potential safety hazard disclosed as a result of any test procedures in this TOP is described in the test results. Procedures of TOP/MTP 2-2-508 and 10-2-508 are followed as applicable.

17. Human Factors Evaluation. Throughout all testing procedures observations are made and recorded with respect to the simplicity of design inherent in the test item and with respect to ease of handling, transporting, and maintenance by the user. Procedures of TOP/MTP 2-2-803 and 10-2-505 are followed as applicable.

18. Maintenance Evaluation. Scheduled maintenance is conducted in compliance with instructions provided in the maintenance test package for the test item. Unscheduled maintenance is performed as required. Maintenance analysis is developed by identifying and recording all maintenance and downtime required during testing. Procedures of TOP 1-2-501 are followed as applicable.

19. Other Tests. Depending on the MN or other governing document, other tests of the item may be required and realistically scheduled during or in conjunction with the transportability testing phase. Concurrent testing to obtain data applicable to more than one test phase should be practised, when possible, in the interest of economy. Some of the more pertinent tests or procedures are prescribed in the following TOP's/MTP's:

2-1-005, Automotive Field Test Equipment and Instrumentation

2-2-501, Amphibious Vehicle Characteristics

2-2-506, Endurance Testing of Wheeled Vehicles

2-2-507, Endurance Testing of Tracked Vehicles

2-2-619, Soft-Soil Vehicle Mobility

2-2-704, Tires

2-2-707, Tracks

2-2-800, Center of Gravity

2-2-801, Load Distribution and Ground Pressure

7-2-100, Tiedown, Cargo, Aircraft (when published)

9-2-251, Waterway Equipment - Boat, Barge, Motor

10-2-214, Large Cargo Containers

20. Planning. In planning the transportability test, appendix G should be consulted. This checklist, taken from reference 16 (app. A), pinpoints and relates all aspects of transportability pertinent to effective test planning, completeness, and scheduling. On completion of tests, a completed appendix G should be provided to the DT (II)(ST) agency for use in further test planning.

Recommended changes to this publication should be forwarded to Commander, U. S. Army Test and Evaluation Command, ATTN: AMSTE-ME, Aberdeen Proving Ground, Md. 21005. Technical information may be obtained from the preparing activity: Commander, U. S. Army Aberdeen Proving Ground, ATTN: STEAP-MT-M, Aberdeen Proving Ground, Md. 21005. Additional copies are available from the Defense Documentation Center, Cameron Station, Alexandria, Va. 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A
REFERENCES

1. DOD Directive 3224.1, "Engineering For Transportability."

2. AR's:

   a. 55-55, "Transportation of Radioactive and Fissile Materials Other Than Weapons."
   b. 55-56, "Transportation of Dangerous or Hazardous Chemical Materials."
   c. 55-355, "Military Traffic Management Regulation."
   d. 70-39, "Criteria for Air Transport and Airdrop of Materiel."
   e. 70-44, "DOD Engineering for Transportability."
   f. 70-47, "Engineering For Transportability."
   g. 750-1, "Maintenance Concepts."

3. FM's:

   a. 55-15, "Transportation Reference Data."
   b. 55-20, "Army Rail Transport Operations."
   c. 55-40, "Army Combat Service Support Air Transport Operations."
   d. 55-50-1, "Transportation Amphibian Operations."
   e. 101-20, "United States Army Aviation Planning Manual."

4. TM's:

   a. 10-500 series, "Airdrop of Supplies and Materiel."
   b. 38-250, "Packaging and Handling of Dangerous Materials for Transportation by Military Aircraft."
   c. 55-315, "Transportability Guidance for Safe Transport of Radioactive Materials."
   d. 55-450-8, "Air Transport of Supplies and Equipment: External-Transport Procedures."
   e. 55-450-9, "Internal-Transport Procedures."
   f. 55-450-11, "Helicopter External Loads Rigged With Air Delivery Equipment."
   g. 55-450-12, "Helicopter External Loads for Sling, Nylon and Chain, Multiple Leg."
   h. 55-450-15, "Air Movement of Troops and Equipment (Nontactical)."
   i. 55-450-19, "Helicopter External Lift Rigging Materiel, Techniques and Procedures."
   j. 55-513, "Military Stevedoring."
   k. 55-650, "Highway Transportability Criteria for the United States."

5. TB 55-100, "Transportability Criteria Shock and Vibration."

6. TO 10-9 series. (Air Force Technical Orders)

7. AMCR 385-100, "Safety Manual."

8. FED and MIL STD's:

a. FED-STD-101B, "Preservation, Packaging, and Packing Materials, Test Procedures."
b. MIL-STD-167B, "Mechanical Vibrations of Shipboard Equipment."
c. MIL-STD-209D, "Slinging and Tiedown Provisions for Lifting and Tying Down Military Equipment."
d. MIL-STD-331, "Fuze and Fuze Components, Environmental and Performance Tests For."
e. MIL-STD-435A, "Railway Cars, Flat, Domestic and Foreign Service."
f. MIL-STD-669B, "Loading Environment and Related Requirements For Platform Rigged Airdrop Materiel."
g. MIL-STD-810C, "Environmental Test Methods."
h. MIL-STD-814A, "Requirement for Tiedown, Suspension and Extraction Provisions on Military Materiel for Airdrop."
i. MIL-STD-1366, "Packaging, Handling, Storage, and Transportation System Dimensional Constraints, Definition of."
j. MS-35822, "Diagram, Equipment, Composite, Railway, 36-, 39-3/8-, and 4_-Inch Gages, Foreign Service."
k. MS-35833, "Diagram, Equipment, Composite, Railway, 56-1/2-, 60-, 63-, and 66-Inch Gages, Foreign Service."
l. MS-35858, "Diagram, Equipment, Composite, Railway, Freight, 56-1/2-Inch Gage, Domestic Service."

9. NAVSHIP OP 3221, "Shiploading and Dunnaging of Military Explosives Cargo Aboard Merchant Type Ships."

10. "Freight Containers," USASI MH5, American National Standards Institute.

11. "Limits of Motor Vehicle Sizes and Weights," International Road Federation, 1971.

12. "Rules Governing the Loading of Commodities on/in Open Top and Closed Cars," Association of American Railroads.

13. "State Legal Maximum Dimensions and Weights of Motor Vehicles Compared With AASHO Standards," American Association of State Highway Officials, December 1970.

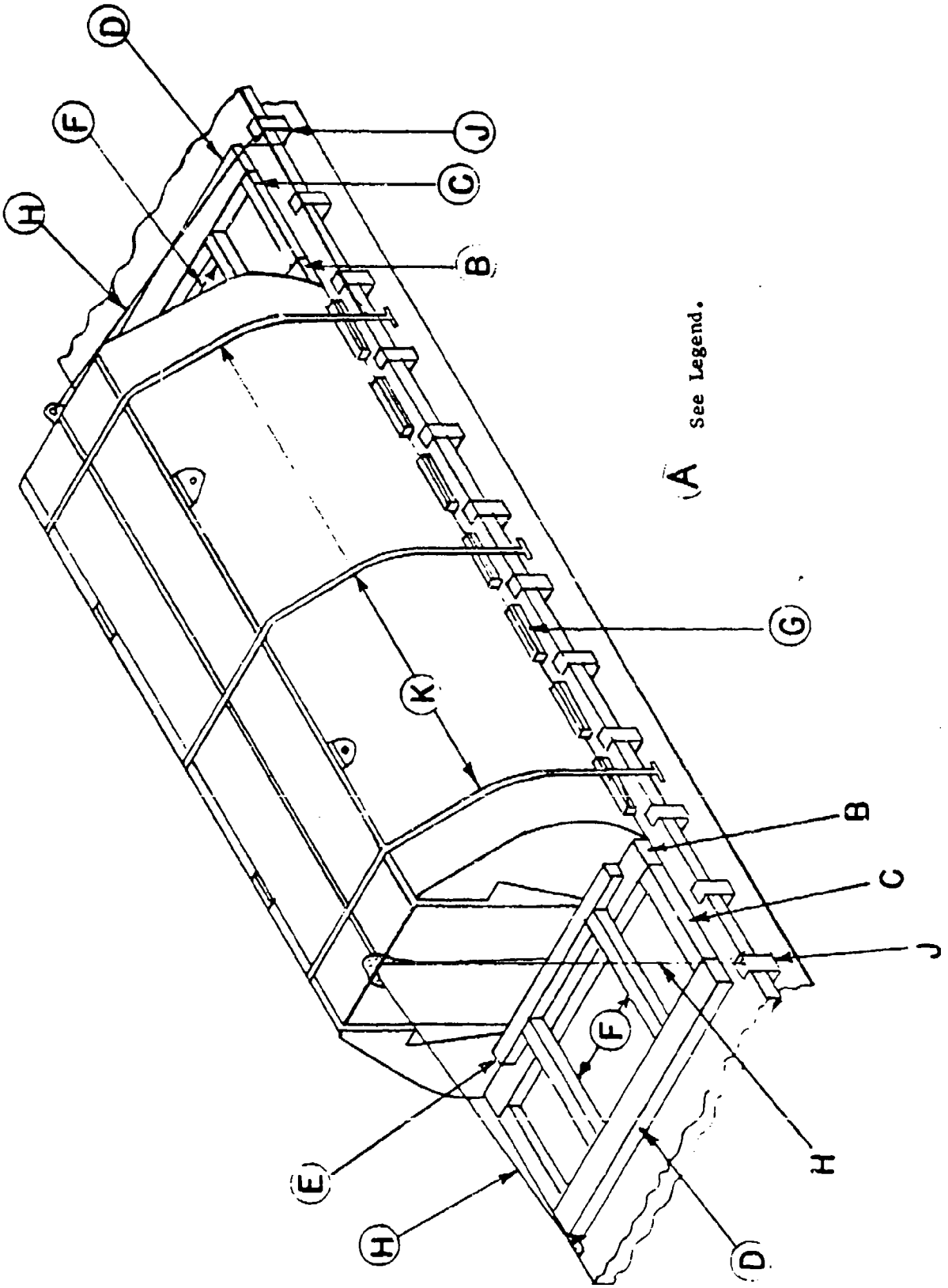
14. Bowditch, Nathaniel, "American Practical Navigator," U. S. Government Printing Office, Washington, D. C., 1958.

15. Letter DAAG-PAP-A(M) (12 Dec 72) MTMTS-SA, dated 21 Dec 72, Subject: "Transportability Criteria for Design."

16. Nye, John H., "Final Report of Special Study of Analytical Techniques and Facilities for Evaluating Transportability of Military Equipment," TECOM Project No. 9-CO-001-00-081, Aberdeen Proving Ground, Md., Report APG-MT-4240, April 1973. (Distribution controlled by TECOM, ATTN: AMSTE-ME.)

17. Letter, MTT-TRC, 17 March 75, Subject: "External Helicopter Lift Criteria," US Army Military Traffic Management Command Transportation Engineering Agency, Newport News, Va.

APPENDIX B
RAILWAY LOADING PROCEDURE (EXAMPLE)



BILL OF MATERIAL (PERTAINING TO FIG. 4)

Item	Amount (Approx.) or Number
Lumber, 2 x 10 in. (5.08 x 25.4 cm)	120 linear ft (36.58 m)
Lumber, 2 x 6 in. (5.08 x 15.24 cm)	84 linear ft (25.6 m)
Lumber, 6 x 6 in. (15.24 x 15.24 cm)	16 linear ft (4.88 m)
Lumber, 2 x 4 in. (5.08 x 10.16 cm)	100 linear ft (30.48 m)
Rope, Steel Wire, 5/8-in. (1.59 cm)	120 linear ft (36.58 m)
Clips, Cable, 5/8-in. (1.59 cm)	16
Banding, 2 x 0.050-in. (5.08 x 0.13 cm)	120 linear ft (36.58 m)
Thimble, Std., 5/8-in. (1.59 cm) (Open Type)	4
Nails, 30-D, 40-D, and 80-D	As required

MATERIAL SPECIFICATIONS

Lumber: Douglas Fir or compatible lumber with straight grain and free of material defects, Fed Spec MM-L-751.
Rope: Steel Wire, plain, preformed, regular lay, 6 x 19, flexible, 1 WRC, Fed Spec RR-W-410.
Nails: Type II, Style 8, cement coated (sinkers), Fed Spec FF-N-105.

LEGEND (FIG. 4)

Item	No. Required Per Unit	Application
A	-	Brake wheel clearance: 6 inches (15.24 cm) required in back of, on both sides of, and above brake wheel; 4 inches (10.16 cm) required below wheel.
B	4	Each to consist of three 2-inch x 10-inch x 10-foot boards (5.08 cm x 25.4 cm x 3.05 m). Locate against face of item and notch out when irregularities prevent lumber from making firm contact with face of item. Secure bottom piece to floor with sixteen 30-D nails in a staggered pattern. Secure the next two pieces to the one below in like manner, using 40-D nails.

Item	No. Required Per Unit	Application
C	4	Each to consist of three 2-inch x 6-inch by 3-1/2-foot boards (5.08 cm x 15.24 cm x 1.07 m). Locate on each side of the item and butt to Item B. Secure the bottom pieces with six 30-D nails in staggered pattern. Secure next two pieces to the one below in like manner, using 40-D nails.
D	4	Each to consist of three 2-inch x 10-inch by 10-foot boards (5.08 cm x 25.4 cm x 3.05 m). Locate against Item C. Secure bottom piece to floor with sixteen 30-D nails in staggered pattern. Secure other two pieces to the one below in like manner, using 40-D nails.
E	2	Each to consist of three 2-inch x 6-inch by 7-foot boards (5.08 cm x 15.24 cm x 2.13 m). Locate against the face, centered on the item, and notched out when irregularities prevent the lumber from making firm contact with face of the item. Secure bottom piece to Item B with ten 30-D nails in staggered pattern. Secure next two pieces to the one below in like manner.
F	4	Each to consist of one piece of 6- x 6-inch lumber (15.24 x 15.24 cm), length cut to suit. Locate between Items D and E as shown. Secure each end with four 80-D nails.
G	14	Each to consist of 2- x 4- x 32-inch lumber (5.08 x 10.16 x 81.28 cm). Locate against each side of item as shown. Secure bottom pieces with four 30-D nails in staggered pattern. Secure other piece to the one below in like manner.
H	4	Each to consist of 5/8-inch (1.59 cm) wire rope length, cut to suit. Attach one to each eye on load as shown. Pass the cable through the stake pockets over the thimbles (Item J) and the tiedown eyes. Secure each end of the cables with four 5/8-inch (1.59 cm) cable clips.
J	4	Each to consist of one 5/8-inch (1.59 cm) thimble. Locate at bottom of stake pockets.
K	3	Each to consist of 2- x 0.050-inch (5.08 x 0.13 cm) high tension banding. Locate around item as shown and secure by crimping.

APPENDIX C

HIGHWAY VEHICLE AND LOAD LIMITS, U. S. AND FOREIGN

TOP 1-2-500

Table 5 - Maximum Limits for Motor Vehicle Sizes and Weights for United States

Truck tractor semitrailer	Other combination	Number of towed units[1]: Semitrailer	Full trailer	Semitrailer and full trailer	Axle load pounds: Single: Statutory limit	Single: Including statutory enforcement tolerance	Tandem: Statutory limit	Tandem: Including statutory enforcement tolerance	Operating tire inflation pressure pounds per sq. in.	Gross weight limit: Pounds per engine net horse power delivered to clutch or equivalent	Type of restriction	Applicable to: Any group of axles	Applicable to: Total wheel-base only	Specified maximum gross weight per truck: 2 axle	3-axle	Truck tractor semitrailer: 3 axle	4 axle
55	NP	1	NP	NP	18,000	19,800	36,000	39,600	NS	NS	Table		X				
60	60	1	1	2	18,000		32,000		NS	NS	Table tire cap.	Under 18'	Over 18'	29,000	43,000	47,000	61,000
65	65	1	1	2	18,000		32,000		NS	NS	Table	Under 18'	Over 18'				
55	55	1	1	NP	[6]18,000		32,000		NS	NS	Spec. maximum						
60	65	NR	NR	NR	18,000		32,000		NS	NS	Table	Under 18'	Over 18'				
60	[12]60	1	2	2	18,000		36,000		NS	NS	Formula-spec. lim.		X				
50	NP	1	NP	NP	22,400	22,848	36,000	36,720	NS	NS	Spec. lim. tire cap.			32,000	53,800	53,800	67,400
55	60	1	1	NP	20,000		36,000		NS	NS	Table spec. lim.	X		30,000	46,000	48,000	
55	55	1	1	NP	20,000	22,000	40,000	44,000	NS	NS	Table		X				
55	55	NR	NR	NR	18,000	20,340	36,000	40,680	NS	NS	Spec. max.[14]						
55	65	1	1	2	[13]18,000		[13]32,000		NS	NS	Formula[13]	X					
[11]60	65	1	1	2	[13]18,000		[13]32,000		NS	NS	Table[29]	X					
[11]55	60	1	1	2	[13]18,000		32,000		NS	NS	Spec. lim. tire cap.			36,000	50,000	50,000	64,000
55	[11]55	1	1	2	[24]18,000	[24]19,000	[24]32,000	[24]33,000	NS	NS	Spec. lim. tire cap.			36,000	50,000	54,000	
[24]55	[24]55	1	1	2	18,000	18,540	32,000	32,960	NS	NS	Table	X					
50	50	1	1	NP	18,000		32,000		NS	NS	Table		X				
[24]55	[24]55	1	1	NP	18,000	[29]18,900	32,000	[29]33,600	NS	NS	Spec. lim. tire cap.[19]			27,000	42,000	42,000	49,660
55	60	1	1	NP	18,000		32,000		NS	NS	Axle lim. tire cap.						
55	55	1	1	NP	[21]22,000		[21]32,000		NS	NS	Table tire cap.	X		32,000	[31]51,800	51,800	62,050
55	[26]55	NR	NR	NR	22,400		[26]40,000		NS	NS	Table		X			[36]55,000	[36]55,000
50	NP	1	NP	NP	22,400		36,000		NS	NS	Table spec. lim.		X	[34]46,000	[35]60,000	[35]60,000	[35]73,000
[11]55	[11]55	1	1	2	[37]18,000		[38]32,000		NS	NS	Axle lim. tire cap.						
50	50	1	1	NP	18,000		32,000		NS	NS	Table	X					
55	55	1	1	NP	18,000		28,650	[32]32,000	NS	NS	Table tire cap.	X					
50	50	1	1	2	18,000		32,000		NS	NS	Table	X					
60	60	1	1	2	18,000		32,000		NS	NS	Table	Under 18'	Over 18'				
60	60	1	1	2	18,000	18,900	32,000	33,600	NS	NS	Table	X		36,000	54,000	54,000	71,146
NR	NR	NR	NR	NR	18,000	18,900	32,000	33,600	NS	NS	Table	Under 18'	Over 18'				
55	55	NR	NR	NR	22,400		36,000		NS	NS	Table spec. lim.		X	33,400	[39]55,000	[39]52,800	56,400
55	50	1	1	NP	22,400	23,520	32,000	33,660	NS	NS	Axle lim. tire cap.						
[11]	[11]	1	1	2	[11]20,000		34,320		NS	NS	Table	Under 18'	Over 18'				
55	55	1	1	NP	22,400		36,000		NS	NS	Formula		X				
55	55	1	1	NP	18,000	19,000	36,000	38,000	NS	NS	Spec. lim.			31,500	49,875	49,875	67,200
60	60	1	1	2	19,000		32,000		NS	NS	Formula	Under 18	Over 18'				
55	60	1	NR	NR	19,000		31,500		NS	NS	Formula		X				
[11]50	[11]50	1	1	NP	18,000		32,000		NS	NS	Table	X					
[11]55	[11]65	1	1	[11]2	[40]18,000		[40]32,000		NS	NS	Table[42]	Under 18'	Over 18'				
[10]50	[24]50	1	1	NP	22,400	23,072	36,000	37,080	NS	NS	Spec. lim.[49]			33,000	47,000	50,000	60,000
50	50	1	1	NP	22,400		NS		NS	NS	Spec. lim.			[10]36,000	[31]44,000	[42]53,800	[31]67,400
55	[31]55	1	1	NP	20,000		[43]32,000		NS	NS	Spec. lim.			37,000	46,000	50,000	55,000
[11]65	[11]65	1	1	2	18,000		32,000		NS	NS	Table	X					
50	50	1	[44]1	NP	18,000		32,000		NS	NS	Table		X		44,000	48,000	62,000
50	50	1	1	NP	18,000		32,000		NS	NS	Table	X					
60	60	NR	NR	NR	18,000		33,000		NS	NS	Table	X		36,000	51,000	54,000	59,000
55	55	1	1	NP	22,400	23,520	[41]36,000		NS	NS	Table tire cap.	X					
50	50	1	1	NP	18,000		[45]32,000		NS	NS	Table		X				
[11]60	65	1	1	2	18,000		32,000		NS	NS	Table	Under 18	Over 18'	28,000	36,000	46,000	60,000
50	50	1	1	NP	18,000	18,900	32,000	33,600	NS	NS	Table	X					[10]70,000
55	55	1	1	NP	18,000	[46]19,500	30,400	32,000	NS	NS	Table[47]	X					
65	65	1	1	2	18,000		32,000	[47]36,000	NS	NS	Table	X					
50	50	1	1	NP	22,000		38,000		NS	NS	Table tire cap.	X					
50	50	1	1	NP	NS		NS		NS	NS	Spec. lim. tire cap.						
55	65	1	1	2	20,000		32,000		95	400	Table	X					
14	1	6	8	7	16		26		52	52	Formula 5						
24	[illegible]	46	41	18	2		25		0	0	Table 33	18	20				
14	[illegible]	0	3	27	34		1		0	0	Spec. lim. 14						

nd Weights for United States

Applicable to: Any group of axles	Applicable to: Total wheel-base only	Specified maximum gross weight pounds[4] Truck 2 axle	Truck 3-axle	Truck tractor semitrailer 3 axle	4 axle	5 axle	Other combination	Practical maximum gross weight pounds[5] Truck 2 axle	Truck 3-axle	Truck tractor semitrailer 3 axle	4 axle	5 axle	Other combination	Line
	X					73,280		27,800	47,600	47,600	67,400	73,280	NP	1
Under 18'	Over 18'	29,000	43,000	47,000	61,400	75,000	74,800	28,000	40,000	44,000	58,000	72,000	76,000	2
Under 18'	Over 18'							26,000	40,000	44,000	58,000	72,000	76,800	3
Under 18'	Over 18							25,000	40,000	44,000	58,000	72,000	73,280	4
								26,000	40,000	44,000	58,000	72,000	76,800	5
	X							26,000	44,000	44,000	62,000	76,000	76,000	6
X		32,000	53,800	53,800	67,400	73,000	NP	30,848	44,720	53,800	67,400	73,000	NP	7
	X	30,000	46,000	48,000				28,000	44,000	48,000	64,900	73,280	73,280	8
								30,000	52,000	52,000	73,280	73,280	73,280	9
X						73,280	73,280	28,340	48,650	48,680	69,110	73,280	73,280	10
X								32,000	40,000	56,000	64,500	72,000	80,000	11
								26,000	40,000	44,000	58,000	73,280	76,800	12
		36,000	50,000	50,000	64,000	[3]73,280	[3]73,280	26,000	40,000	44,000	58,000	72,000	73,280	13
		36,000	50,000	54,000			72,000	27,000	41,000	45,000	59,000	[3]73,000	[3]73,000	14
X								26,540	40,960	45,080	59,500	73,280	73,280	15
	X							26,000	40,000	44,000	58,000	72,000	73,280	16
		27,000	42,000	42,000	59,640	73,280	NP	27,000	42,000	42,000	57,640	73,280	73,280	17
								26,000	40,000	44,000	58,000	72,000	76,000	18
X		32,000	[2]51,800	51,800	62,450	73,280	72,280	30,000	40,000	51,800	62,000	72,000	73,280	19
	X			[3]55,000	[3]55,000	[3]73,280	[3]73,280	30,490	48,000	52,800	55,000	73,280	73,280	20
	X	[3]46,000	[3]60,000	[3]60,000	[3]73,100	[3]73,000	NP	30,400	44,000	52,800	66,400	73,000	NP	21
X								26,000	[2]40,000	44,700	[2]58,900	[2]66,000	[2]72,000	22
X						73,280	73,280	26,000	40,000	44,000	58,000	72,000	73,280	23
X								26,000	[2]40,000	44,000	58,000	[2]72,000	[2]73,280	24
								26,000	40,000	44,000	58,000	[2]72,000	[2]73,280	25
Under 18'	Over 18							26,000	40,000	44,000	58,000	72,000	76,000	25
X		36,000	54,000	54,000	71,146	71,146	71,146	26,780	41,290	45,320	57,740	73,280	73,280	27
Under 18'	Over 18'							26,900	41,600	45,800	60,500	75,000	76,800	28
	X	33,400	[4]55,000	[4]52,800	56,400	73,280	73,280	30,400	44,040	52,800	66,400	73,280	73,280	29
Under 18'	Over 18'							31,520	41,600	55,040	65,120	73,280	73,280	30
	X							29,600	42,320	51,200	63,920	76,640	86,000	31
		31,500	49,875	49,875	67,200	71,000	71,000	30,400	44,000	52,800	66,400	71,000	71,000	32
						73,280	73,280	27,000	46,000	46,000	65,000	73,280	73,280	33
Under 18	Over 18							26,000	40,000	44,000	58,000	72,000	73,280	34
X	X							27,000	39,500	46,000	58,500	71,000	78,000	35
Under 18'	Over 18'							26,000	40,000	44,000	58,000	72,000	73,280	36
						[4]76,000	[4]76,000	26,000	40,000	44,000	58,000	72,000	[4]76,000	37
		33,000	47,000	50,000	60,000	71,145	71,145	31,072	45,080	51,500	61,800	73,280	73,280	38
		[3]36,000	[2]44,000	[2]53,800	[3]67,400	73,280	88,000	30,400	44,000	53,800	67,400	73,280	88,000	39
	X	32,300	46,000	50,000	55,000	71,280	73,280	28,000	40,000	48,000	60,000	72,000	73,280	40
								26,000	40,000	44,000	58,000	72,000	73,280	41
	X		44,000	48,000	62,000	73,280		26,000	40,000	44,000	58,000	72,000	73,280	42
X								26,000	40,000	44,000	58,000	72,000	73,280	43
X		36,000	51,000	54,000	69,000	79,900	79,900	26,000	41,000	44,000	59,000	74,000	79,900	44
X						73,280	73,280	31,570	44,000	54,000	66,400	73,280	73,280	45
	X					70,000	70,000	26,000	40,000	44,000	60,000	70,000	70,000	46
Under 18	Over 18'	28,000	36,000	46,000	60,000	68,000	72,000	26,000	36,000	44,000	60,000	68,000	72,000	47
X					[3]70,000	[3]70,000	[3]70,000	26,900	41,600	45,800	60,500	71,280	73,280	48
X								27,500	40,000	47,000	57,500	73,000	73,000	49
X								26,000	44,000	44,000	62,000	73,000	73,000	50
X						70,000	70,000	30,000	46,000	52,000	68,000	70,000	70,000	51
														52
								28,000	40,000	48,000	60,000	74,000	80,000	
18	20							15	25	15	22	27	2	
								2	24	2	1	2	2	
								34	2	34	24	1	42	

Table 5 (Continued)

NP–Not permitted. NR–Not restricted. NS–Not specified.

Various exceptions for farm and construction equipment; public utility vehicles, house trailers, urban, suburban, and school buses, haulage of agricultural and forest products, at wheels of vehicles for safety accessories, on designated highways, and as administratively authorized.

[2] Various exceptions for utility vehicles and loads, house trailers and mobile homes.

[3] When not specified, limited to number possible in practical combinations within permitted length limits, various exceptions for farm tractors, mobile homes, etc.

[4] Legally specified or established by administrative regulation.

[5] Computed under the following conditions to permit comparison on a uniform basis between States with different types of regulation:

A. Front axle load of 8,000 pounds.

B. Maximum practical wheelbase within applicable length limits

(1) Minimum front overhang of 3 feet, minimum spacing from first to second axle of truck tractor 8 feet.

(2) In the case of a 4-axle truck-tractor semitrailer, rear overhang computed as necessary to distribute the maximum possible uniform load on the maximum permitted length of semitrailer to the single drive-axle of the tractor and to the tandem axles of the semitrailer, within the permitted load limits of each.

(3) In the case of a combination having 5 or more axles, minimum possible combined front and rear overhang assumed to be 5 feet, with maximum practical load on maximum permitted length of semitrailer, subject to control of loading on axle groups and on total wheelbase as applicable.

C. Including statutory enforcement tolerance as applicable.

[6] Less than three axles 35 feet.

[7] Trailer 35 feet.

[8] Steering axle 12,000 pounds.

[9] On specific routes in urban or suburban service under special permit from P.U.C. 40 feet, also 3-axle buses with turning radius less than 45 feet without restriction.

[10] Buses 102 inches on highways of surfaced width of least 20 feet or otherwise as administratively authorized.

[11] On class AA, or designated highways, 12 ft. 6 in. on other highways.

[12] Except 3-unit combinations may use up to 65 ft. combinations on certain highways designated by the Department of Highways.

[13] Three-axle vehicles 40 feet.

[14] Two-axle trailer 35 feet, three-axle trailer 40 feet.

[15] Auto transports permitted 63 feet.

[16] 73,280 pounds maximum, except on roads under Rural Roads Authority 56,000 pounds maximum.

[17] 700 (L - 40) when L is 18' or less; 800 (L - 40) when L is greater than 18', 900(L - 40) on highways having no structures with span of 20' or over.

[18] On designated highways 40 feet.

[19] Auto transports on designated highways 65 feet.

[20] Special limits for vehicles hauling timber and timber products, ores, concentrates, aggregates, and agricultural products including livestock; single axle 18,900 pounds, tandem axle 37,800 pounds, gross weight table. vehicle with 3 or 4 axles permitted 66,000 pounds maximum at 21-foot axle spacing, vehicle with 5 or more axles permitted 79,000 pounds maximum at 43-foot axle spacing.

[21] 60 ft. in special cases: Illinois, auto transports only, Indiana, trucks pulling house trailers only, Oregon, truck tractor semitrailers on designated major routes.

[22] On designated highways only.

[23] On designated highways, 16,000 pounds on other highways.

[24] Axle spacing 44 feet or more, otherwise 72,000 pounds.

[25] On designated highways, single axle 22,400 pounds, tandem axle 36,000 pounds, tolerance of 1,000 pounds on total of all excesses of weight under one or more limitations of axle load and gross weight, depending upon the placing of 9000 lbs on the front or steering axle.

[26] Auto and boat transports and three-unit combinations permitted 60 feet on highways with surface width 22 feet or more, otherwise 50 feet for all combinations.

[27] On designated highways, trucks 26.5 feet and buses 30 feet on other highways.

[28] State maintained highways, 45 feet on other highways.

[29] Class AA highways only.

[30] Maximum gross weight on Class A highways 42,000 pounds, on Class B highways 30,000 pounds.

[31] Including load 14 feet, various exceptions for vehicles hauling forest products and construction materials.

[32] Vehicles loaded with tobacco hogsheads–103 inches.

[33] Auto transports 13 feet 6 inches. Maryland also allows 13 feet 6 inches for vehicles loaded with hay or straw, or carrying flat glass.

[34] Exception for poles, pilings, structural units, rowing sheels etc., permitted 70 feet.

[35] Less than 48-inch spacing, 36,000 pounds.

[36] Subject to axle and tabular limits.

[37] Single axle spaced less than 9 feet from nearest axle limited to 13,000 pounds.

[38] On designated highways only and limited to one tandem axle in combination; otherwise 26,000 pounds.

[39] Trailer 40 feet.

[40] On Interstate System 47,500 pounds.

[41] Vehicles in excess may be operated under special permit obtained in advance; in New Jersey from the Department of Motor Vehicles, in North Dakota, from State Highway Truck Regulatory Department.

[42] Or as prescribed by P.U.C.

[43] On designated highways 102 inches. Body restricted to 96", additional 6" for tires only.

[44] Trackless trolleys and buses 7 passengers or more, P.S.C. certificate 40 feet.

[45] Auto transports, oil field equipment, by special permit only, 60 feet.

[46] Logging vehicles permitted 7-foot wheelbase tolerance 19,000-single axle, 34,000-pounds tandem axle.

[47] Governs gross weight permitted on highways designated by resolution of State highway commission.

[48] Where truck-tractor was properly registered in Pennsylvania as of December 31, 1961, 55 feet.

[49] Single unit truck with 4 axle permitted 60,000 pounds.

[50] Axles spaced less than 6 feet 32,000 pounds, less than 12 feet 36,000 pounds; 12 feet or more gross weight governed by axle limit.

[51] Single vehicle with 3 or more axles spaced less than 16 feet 40,000 pounds; less than 20 feet 44,000 pounds, 20 feet or more governed by axle limit.

[52] Tractor semitrailer with 3 or more axles spaced less than 22 feet 46,000 pounds, not less than 27 feet 53,900 pounds.

[53] Legal limit 67,400 pounds, axle spacing 27 feet or more.

[54] House trailers, auto transports, and double saddle mounts in daylight hours, 60 feet.

[55] On Interstate System, 36,000 pounds on other roads.

[56] Limited to 3,500 pounds.

[57] Three-axle tandem 42,700 pounds.

[58] Vehicles registered before July 1, 1956, permitted limits in effect January 1, 1956, for life of vehicle.

[59] Only on certain highways, or portions thereof, designated by State Roads Commissioner, and consistent with Congressional action.

[60] Axle load 21,000 pounds on 2-axle trucks hauling peeled or unpeeled forest products cut crosswise or transporting milk from farm to market but not over Interstate System.

[61] On Class A highways. All axles of a vehicle or combination–73,300 pounds maximum. Wheel, axle, axle group and gross vehicle weights on Class B highways are 60% of weights including tolerance authorized for Class A highways.

[62] Based on ruling of Attorney General.

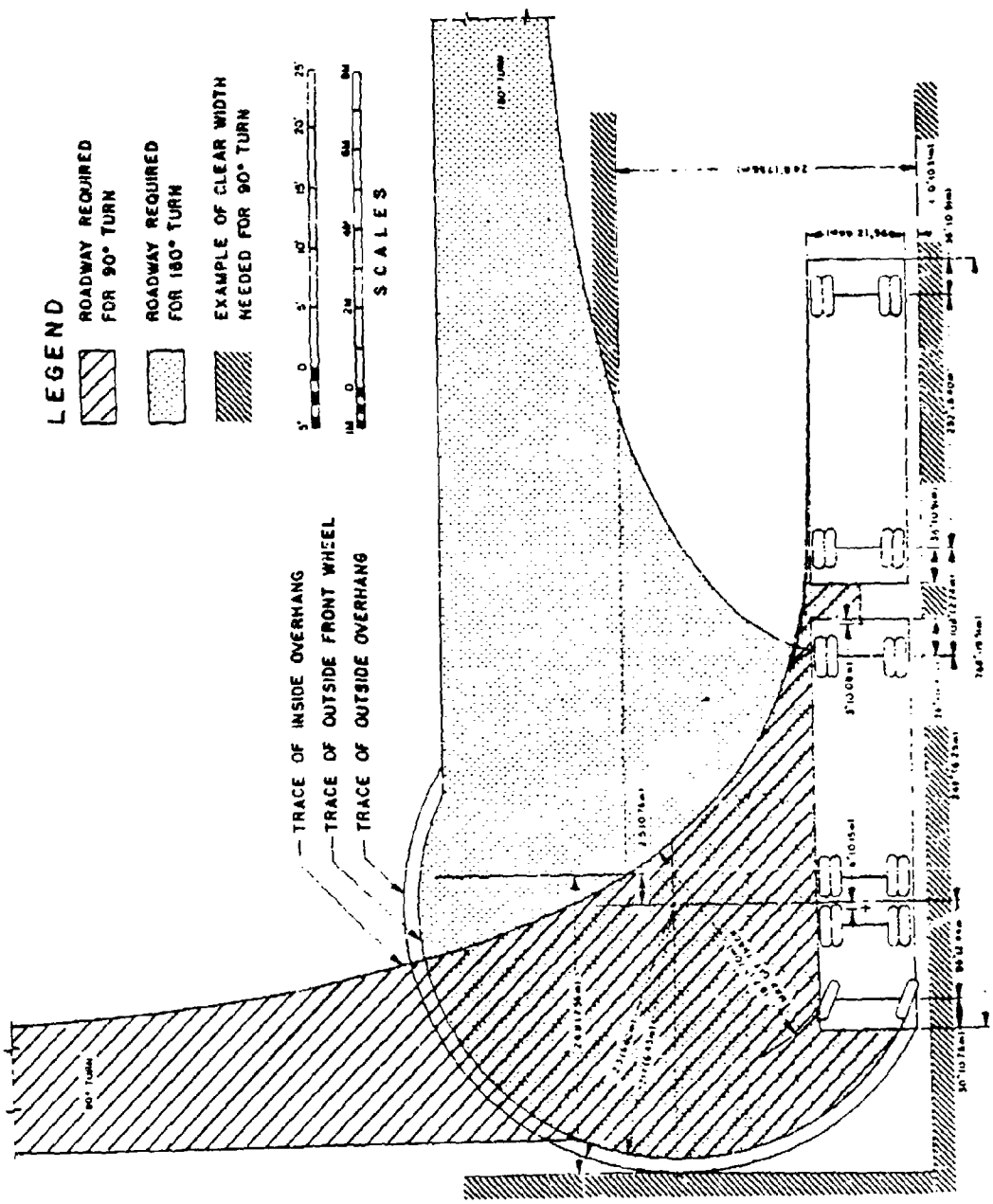


Figure 5. Highway Turning Diagram. (Turning diagram for a tractor-semitrailer combination. The semitrailer and trailer are each 27 feet long.)

Type 2

Type 3

Type 2-S1

Type 2-S2

Type 3-S1

Type 3-S2

Type 2-2

Type 2-3

Type 3-2

Type 3-3

Notation

The figure shows silhouettes of most basic commercial vehicle types in regular operation as designated by code based on axle arrangement. The first digit indicates the number of axles of the truck or truck-tractor. The Letter "S" indicates a semitrailer, and the digit immediately following an "S" indicates the number of axles on the semitrailer. Any digit other than the first in a combination, when not preceded by an "S", indicates a trailer and the number of its axles. For instance, a 2-S2 combination is a two-axle truck-tractor with a tandem-axle semitrailer. A 3-S1-2 combination is a three-axle truck-tractor with tandem rear axles, a semitrailer with a single axle, and a trailer with two axles.

Figure 6. Vehicle Types (Legend for Table 6).

Table 6a - Maximum Limits for Motor Vehicle Sizes and Weights for Africa

COUNTRY	WIDTH	HEIGHT	LENGTH				AXLE LOAD		MAXIMUM GROSS WEIGHT (1)									
			SINGLE UNIT		TRUCK SEMI TRAILER	OTHER COMBINATION	SINGLE	TANDEM	2	3	3-S1	3-S2	4-S1	3-S2	2-2	2-3	3-2	3-3
			TRUCK	BUS														
	meters	meters	meters	meters	meters	meters	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons
Algeria	2.5	-	11.0	12.0	15.0	18.0	13.0	(2)	19.0	26.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Botswana (3)																		
Cameroon	2.5	3.8	11.0	11.0	15.0	18.0	13.0	16.7 / 21.0 (4)	19.0	26.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Central African Republic (7)	2.5	-	11.0	12.0	14.0 (9)	18.0 (9)	10.0	20.0 (5)	16.0	22.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Chad (7)	2.5	-	11.0 / 12.0 (6)	12.0	14.0	18.0 (8)	10.0	20.0	16.0	22.0	30.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Congo Republic (K)	2.5	4.0	12.0	12.0	14.0	22.0	8.0	12.0	12.0	18.0	20.0	24.0	24.0	28.0	32.0	32.0	32.0	32.0
Dahomey (13) (17)	2.5	-	11.0	12.0	15.0	18.0	9.5 / 11.5 (13)				35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Ethiopia	2.4	3.8	11.0	11.0	14.0	18.0	8.0	-	Dependent		On	Axle	Spacing					
French Territory of Afars and Issas (11)																		
Gabon	2.5	4.0	11.0	12.0	15.0	20.0	10.0	16.0	16.0	22.0	26.0	32.0	32.0	38.0	36.0	38.0	38.0	38.0
Ghana	2.5	3.4	11.0		13.0				16.3	22.4	24.4	32.5	32.5	32.5	32.5	32.5	32.5	32.5
Ivory Coast	2.5		11.0	12.0	15.0	18.0	10.0	(10)	16.0	23.0	25.0	32.0	32.0	41.0	41.0	41.0	41.0	41.0
Lesotho	2.5	3.8	10.0 / 11.0 (6)	11.0	15.2	21.9	8.15	-	Dependent		On	Axle	Spacing					
Liberia (12)																		
Libya (LAR)	2.5	4.0	11.0	11.0	15.2	17.0	8.0	16.0	16.0	24.0	16.0	24.0	24.0	32.0	32.0	32.0	32.0	32.0
Malagasy	2.5	4.0	12.0	12.0	15.0	18.0	10.0	16.0	16.0	22.0	26.0	32.0	36.0	36.0	36.0	38.0	38.0	38.0
Malawi	2.5	4.3 (16)	11.0	11.0	15.2	18.3	8.0	16.0	16.0	24.0	24.0	32.0	32.0	40.0	32.0	40.0	40.0	48.0
Mali	2.5	3.4	-	10.5	13.0	-	13.0	-	17.2		22.9	35.0	-					
Mauritania (12)																		

Table 6a (Continued)

COUNTRY	WIDTH	HEIGHT	LENGTH				AXLE LOAD		MAXIMUM GROSS WEIGHT (1)									
			SINGLE UNIT		TRUCK SEMI TRAILER	OTHER COMBINATIONS	SINGLE	TANDEM	2	3	3-S1	3-S2	3-S1	3-S2	3-2	3-3	3-2	3-3
			TRUCK	BUS														
	meters	meters	meters	meters	meters	meters	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons
Morocco (7)	2.5	4.0	11.0	12.0	15.0	18.0	12.0	–	19.0	26.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Niger (20)	2.5	–	11.0	12.0	14.0	18.0	11.5	23.0	17.0	22.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Nigeria (20)	2.3	3.8	–	–	–	–	10.0 (13)	15.0 (13)	32.0	32.0	32.0	32.0	32.0	32.0				
Reunion (11)																		
Rhodesia (5) (3)																		
Senegal	2.5	–	11.0 12.0 (6)	12.0	18.0	18.0	10.0	14.0	16.0	22.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
Seychelles Isls.	2.3	3.0	7.0	7.0	(12)	(12)	(12)	(12)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Sierra Leone	2.3	3.35	9.14	9.14	10.7	14.5	4.0 (14)		13.0	18.0	20.0		35.0	50.0				
Somalia (3) (15)	2.5	4.5	10.0 11.0 (6)	11.0	14.0	18.0	10.0	16.0	14.0	18.0	18.0	28.0	28.0	32.0	28.0	37.0	32.0	36.0
South Africa (3)																		
Swaziland	2.5	3.8 (16)	10.0 11.0 (6)	11.0	15.2	–	8.2	–	16.3	24.5	24.5	32.6	32.6	36.3	32.6	36.3	36.3	36.3
Tanzania	2.5	4.4	10.0 11.0 (6)	11.0	14.0	18.0	8.2	14.5	22.7	22.7	32.0	32.0	32.0	32.0	43.5	43.5	43.5	43.5
Tunisia	2.5	4.0	11.0	12.0	15.0	18.0	13.0	21.0	19.0	26.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Upper Volta	2.5	–	11.0	12.0	15.0	18.0	11.0	(19)	18.0	25.0	25.0	32.0	32.0	35.0	32.0	35.0	35.0	35.0
Zambia (3)																		

1. In accordance with vehicle type See Page C-7.
2. The maximum weight for tandem axles is obtained from the formula $t = 7.35 + 0.35\left(\frac{d-90}{b}\right)$, where 90 cm < d < 136 cm.
3. Legislation under revision
4. 14.7 tons for tandem axles spaced 0.90 m. For tandem axles separated 1.35 m or more 21.0 tons.
5. The distance between two consecutive axles must be 1.36 m. or more.
6. Three axle vehicles have the highest load
7. All self propelled vehicles or trailers must not exceed 8 tons per meter of length measured between the first and the last axle
8. 20 meters for vehicle types 3-2 and 3-3
9. For trucks and trailers, each component vehicle must not exceed 11.0 m. of length.
10. The permissible maximum weight for a tandem axle is 12.5 tons, where the distance in the two axles is 0.9 m., but must not exceed 17.0 tons for a distance of 1.35 m. or more between the axles.
11. Follows the legislation of France
12. There is no legislation
13. Maximum axle load limits vary in accordance with different roads of the network
14. Special permits are issued by the Ministry of Works for overweight vehicles. The limit in practice is 9 tons gross weight
15. Actual law prescribes only size limits.
16. Two deck buses are permitted 4.57 m. height
17. Vehicle Maximum Gross Weight figures are applicable to specific road sections
18. Combination of truck and two trailers: 21.0 meters.
19. 13.0 tons, for tandem axles separated 0.9 m. For tandem axles separated 1.35 m. or more, 18.0 tons.
20. This is the latest report received from the country, year 1967.

Table 6b - Maximum Limits for Motor Vehicle Sizes and Weights for Asia, Middle East, and Oceania

COUNTRY	WIDTH	HEIGHT	LENGTH				AXLE LOAD		MAXIMUM GROSS WEIGHT (1)									
			SINGLE UNIT		TRUCK SEMI TRAILER	OTHER COMBINATIONS	SINGLE	TANDEM	2	3	3-S1	2-S2	3-S1	3-S2	3-2	3-3	3-2	3-3
			TRUCK	BUS														
	meters	meters	meters	meters	meters	meters	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons
Afghanistan (11) (19)																		
China, Rep. of	2.5	3.8	11.0	12.0	18.0		8.8	14.5	12.0	21.0	35.0				42.0			
Hong Kong (3) (4)	2.44	3.7(2)	9.14	9.14	10.9	10.0	–	–	9.14	12.19	12.19	12.19	12.19	12.19	12.19	12.19	12.19	12.19
India (26)																		
Iran (22)	2.5	4.8	10.0	11.0	14.0	16.0	11.0	20.0	19.0	26.0	–	34.0	34.0	36.0	–	–	–	–
Iraq (26)	2.6	3.8	10.65 (5) 12.19 (5)	10.65	15.24	20.0	11.0	17.0	16.0	22.0	27.0	33.0	33.0	35.7	38.0	44.0	44.0	50.0
Israel	2.5	4.0	10.0 (5) 12.0 (5)	11.0	15.0 (15)	18.0 (15)	12.0	17.5	16.0	22.5	30.0	30.0	30.0	30.0	39.0	39.0	39.0	39.0
Japan (6) (16)	2.5	3.5 (17) 3.8	12.0	12.0	16.5 (17)	–	10.0	–	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0 ,
Jordan	2.5	3.8	11.0	11.0	14.0	22.0	12.0	–	19.0	24.0	30.0	35.0	35.0	35.0	40.0	46.0	40.0	40.0
Korea (9)	2.5	3.5	10.0	10.0			10.0		Total		Weight		Not	to	Exceed		20	Tons
Laos	2.5		11.0		14.0		7.4		18.0	23.0	30.0	30.0	30.0	30.0	30.0			
Lebanon	2.56	3.80	11.0	12.0	14.0	14.0	14.0	14.7 (7)	19.0	26.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Malaysia (8) , (18)	2.75	3.20 (2)	9.14	9.14	11.24	12.19 (10)	8.14	12.2	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3
Philippines	2.50	4.00	10.0	11.00	11.00	14.00	8.00	14.5	16.0	22.5	24.0	30.5	30.5	37.0	32.0	38.5	38.5	45.0
Saudi Arabia (11) (26)																		
Singapore	2.75	3.28	8.38	8.38	10.06	15.24	3.94	15.74	11.81	15.74	15.74	15.74	15.74	15.74	15.74	15.74	15.74	15.74
Syria	2.50	3.80	10.00 11.00 (45)	11.00	14.00	18.00	12.00		18.0	22.0	24.0	26.0	26.0	35.0	26.0		30.0	
Thailand	2.50	(9)	10.0	12.00	14.00	(70)	8.0	14.4	14.0	20.4	22.0	28.4	28.4	32.4	(21)	(21)	(21)	(21)
Australia (17)	2.44 2.50	3.81 4.42	9.45 20.12	10.06 20.12		15.24 30.48	(23)	(23)	Dependent		On	Axle	Spacing	and	Other		Regulations	
Fiji Islands	2.44 (24)	3.35	10.06	10.06	10.06	10.06	7.98	14.52	15.96	22.50	23.94	30.48	30.48	30.48	30.48	30.48	30.48	30.48
New Caledonia	2.50	3.80					13.08		19.00	26.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00
New Guinea, Papua	2.44	4.27	9.45	10.06	13.72	15.24	8.18	13.21	12.75	17.78	20.93	25.96		30.99	29.11		29.52	
New Zealand (10)	2.50 (25)	4.27	(13)	(13)	(13)		10.29 (13)											

1 In accordance with vehicle type. See Page C-7.
2 4.57 m for double deck buses
3 The regulations with respect to maximum weights state: For trucks, 5.08 tons, unladen. For buses, 8.14 tons, unladen, 10.25 tons, laden. 0.65 tons maximum axle load
4 Except for the Hong Kong Island, the Commissioner for Transport may authorize an increase in all other limits
5 These axle vehicles have the highest limits
6 The stated gross load limits requires approval of the Ministry of Transport (Board of the Road Administration (Japan)
7 Each tire pressure of the tandem axle is allowed an increase of 0.35 tons for every 5 tons over 0.90 as up to a maximum of 14 tons, provided that the maximum gross weight of the vehicle is not exceeded
8 Maximum axle loads and maximum gross weights of vehicles vary on different routes of the highway network
9 No regulations
10 Refers to towing length of draw bar.
11 There is no legislation
12 Regulations vary by States. Figures indicate range of variation in most-used forms
13 Vehicle lengths has different interpretations, depending on several variables. One of the regulations is that any vehicle or combination must be able to clear a circle of 80 ft (24.38 m) diameter without projecting over the kerb alignment
14 Maximum axle load and vehicle gross weights depend on axle spacing, number of axles, type of axles and road classification
15 Each articulated vehicle must not exceed 17.0 m in length.
16 Legislation under revision
17 Especially after April 1972.
18 Maximum Gross Weight regulations exclude special purpose vehicles and trailers for unbreakable loads.
19 There is a yearly quota of 300 new car vehicle import
20 Maximum length of trailers, 6.0 meters.
21 Requires permission from the Department of Highways.
22 Current legislation provides for automated yearly reductions in vehicle weights only up to the year 1976
23 Depends on tire pressure and number of tires.
24 Vehicles carrying sugar cane only 3.05 m
25 Agricultural vehicles may be up to 3.66 m wide
26 This is the latest report received from this country: year 1967.

Table 6c - Maximum Limits for Motor Vehicle Sizes and Weights for Europe

COUNTRY	WIDTH	HEIGHT	LENGTH				AXLE LOAD		MAXIMUM GROSS WEIGHT (1)									
			SINGLE UNIT		TRUCK SEMI TRAILER	OTHER COMBINATIONS	SINGLE	TANDEM	2	3	2-S1	2-S2	3-S1	3-S2	2-2	2-3	3-2	3-3
			TRUCK	BUS														
	meters	meters	meters	meters	meters	meters	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons	metric tons
Austria	2.50	4.00	12.00	12.00	15.00	18.00	10.0	16.0	16.0	22.0	-	38.0	38.0	38.0	38.0	38.0	38.0	38.0
Belgium	2.50	4.00	11.00	12.00	15.00	18.00	13.0	20.0	19.0	26.0	38.0	38.0	38.0	38.0	38.0	40.0	40.0	40.0
Cyprus (3)	2.29	3.35	7.92	7.92	12.19	12.19	5.0		10.0	10.0	10.0	10.0	10.0	10.0	N.P.	N.P.	N.P.	N.P.
Denmark (4) (5)	2.50	3.60	10.00 / 12.00 (2)	10.00 / 12.00 (2)	14.00	18.00	8.0	14.5	16.0	22.0	24.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
Eire	2.50	4.57 (8)	10.97	12.00	14.94	16.46	10.0	16.0 (6)	16.3	22.4	22.4	25.4	25.4	25.4	32.5	32.5	32.5	32.5
Finland	2.50	3.80	11.00	12.00	14.00	18.00	8.0	13.0	12.5	17.5	20.5	25.0	25.5	27.0	25.0	30.0	30.0	32.0
France	2.50	-	11.00	12.00	15.00	18.00	13.0	(7)	19.0	26.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Germany (19)	2.50	4.00	12.00	12.00	15.00	18.00	10.0	16.0	16.0	22.0	26.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0
Gibraltar	2.1	3.7	6.1	6.1	6.7	6.7	9.1	11.2	14.2	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3
Great Britain	2.50	4.57 (8)	11.00	11.00	15.00	18.00	(9)	(9)	(9)	22.4	(9)	(9)	(9)	(9)	32.5	32.5	32.5	32.5
Greece	2.50	3.80	12.00	12.00	15.00	18.00	9.0 / 11.0 (20)	16.0	(21)	(21)	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Iceland	2.35 (12)	3.80					6.0 (13)	8.0 (13)			See	Note	(14)					
Italy	2.50	4.00	11.00	10.00	14.00	18.00	10.0	14.5	14.0	18.0	18.0	24.0	24.0	32.0	28.0	32.0	32.0	44.0
Luxembourg	2.50	4.00	10.10 / 12.00 (2)	12.00	15.00	18.00	15.00	19.00	19.0	26.0	38.0	38.0	38.0	38.0	38.0	40.0	40.0	40.0
Malta	2.45	3.20		8.70 / 9.10 (2)														
Monaco	2.50	4.00	11.00	12.00	15.00	18.00	13.0	14.0	19.0	26.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Netherlands	2.50	4.00	11.00	12.00	15.00	18.00	10.0	16.0	20.0	26.0	30.0	36.0	36.0	42.0	40.0	46.0	46.0	50.0
No. Ireland	2.50	4.57 (8)	11.00	12.00	15.00	18.00	9.1 / 10.2 (9)	16.3 / 18.3 (9)	14.2 / 16.2 (9)	20.3 / 22.4 (9)	20.3 / 24.4 (9)	24.4 / 32.5 (9)	24.4 / 32.5 (9)	24.4 / 32.5 (9)	32.5	32.5	32.5	32.5
Norway	2.35 (10)	-	10.00	10.00	10.00	10.00	6.0 (10)	9.0 (10)	Dependent	Solely	On	Axle	Loading					
Poland	2.50	4.00	11.00	12.0	15.00	18.00	8.0 (22)	14.5 (22)	16.0	24.0	32.0	32.0	32.0	38.0	32.0	40.0	40.0	40.0
Portugal	2.50	4.00	12.00	12.00	15.00	18.00	10.0	16.0	16.0	22.0	26.0	32.0	32.0	30.0	32.0	38.0	[illegible]	38.0
Spain	2.50	4.00	11.00 / 12.00 (2)	12.00	16.50	18.00	13.00	14.7	20.0 (7)	26.0 (15)	26.0 (15)	38.0 (15)	38.0 (15)	38.0 (15)	38.0	38.0	38.0	38.0
Sweden (16) (17) (18)	2.50	-	-	-	-	21.00	8.0 / 10.0	12.0 / 16.0	14.0	22.0	26.0	32.0	32.0	38.0	36.0	37.4	42.0	46.0
Switzerland	2.30 (4)	4.00	10.30	12.00	14.00	18.00	10.0	14.0	16.0	16.0	21.0	21.0	21.0	21.0	26.0	26.0	26.0	26.0
Turkey	2.50	3.80	10.30 / 11.30 (2)	11.00	15.00	18.00	8.0	14.5	Dependent	On	Axle	Spacing						
Yugoslavia	2.50	4.00	11.00 / 12.30 (2)		15.00	18.00	10.0	16.0	See	Note	(11)							

1. In accordance with vehicle type. See Page C-7.
2. Three axle vehicles have the highest limit.
3. Special permission may be granted for vehicles exceeding these limits. [illegible]
4. There are special regulations for commercial vehicles engaged in [illegible]
5. The maximum weight depends on the distance between [illegible]
6. Tandem axle maximum load is 18.0 tons for vehicle types 2-S2, 3-S1, and 3-S2.
7. Maximum weight for a tandem axle is [illegible]
8. Only for buses.
9. Depends on axle spacing and other conditions.
10. Exceptions may be made allowing vehicles to have a maximum width of 2.50 m and/or a maximum weight of 13.0 tons and/or a total length of 22.0 m [illegible]
11. The maximum gross weight for all types and categories of vehicles [illegible] is limited only by the maximum axle loads permitted.
12. A maximum width of 2.50 m is allowed on 10% of the state roads [illegible]
13. A maximum of 10.0 tons for single axle and 16.0 tons for tandem axle is allowed on [illegible]
14. A maximum gross weight of [illegible] is allowed on 65% of the state roads and [illegible]
15. Provided it does not exceed 4.25 tons per meter of length measured between the first and the last axle.
16. Vehicles 8/12 tons [illegible] load permitted on 40% of road network [illegible]
17. Vehicles 10/16 tons [illegible] load permitted on 60% of the net work.
18. On certain roads 2.50 m.
19. The maximum weight depends on the distance between the outer axles [illegible]
20. The highest limit is for national roads only.
21. [illegible]
22. A maximum weight for single axle of 10 tons and for tandem axle 16 tons is allowed on certain roads.

Table 6d - Maximum Limits for Motor Vehicle Sizes and Weights for North,

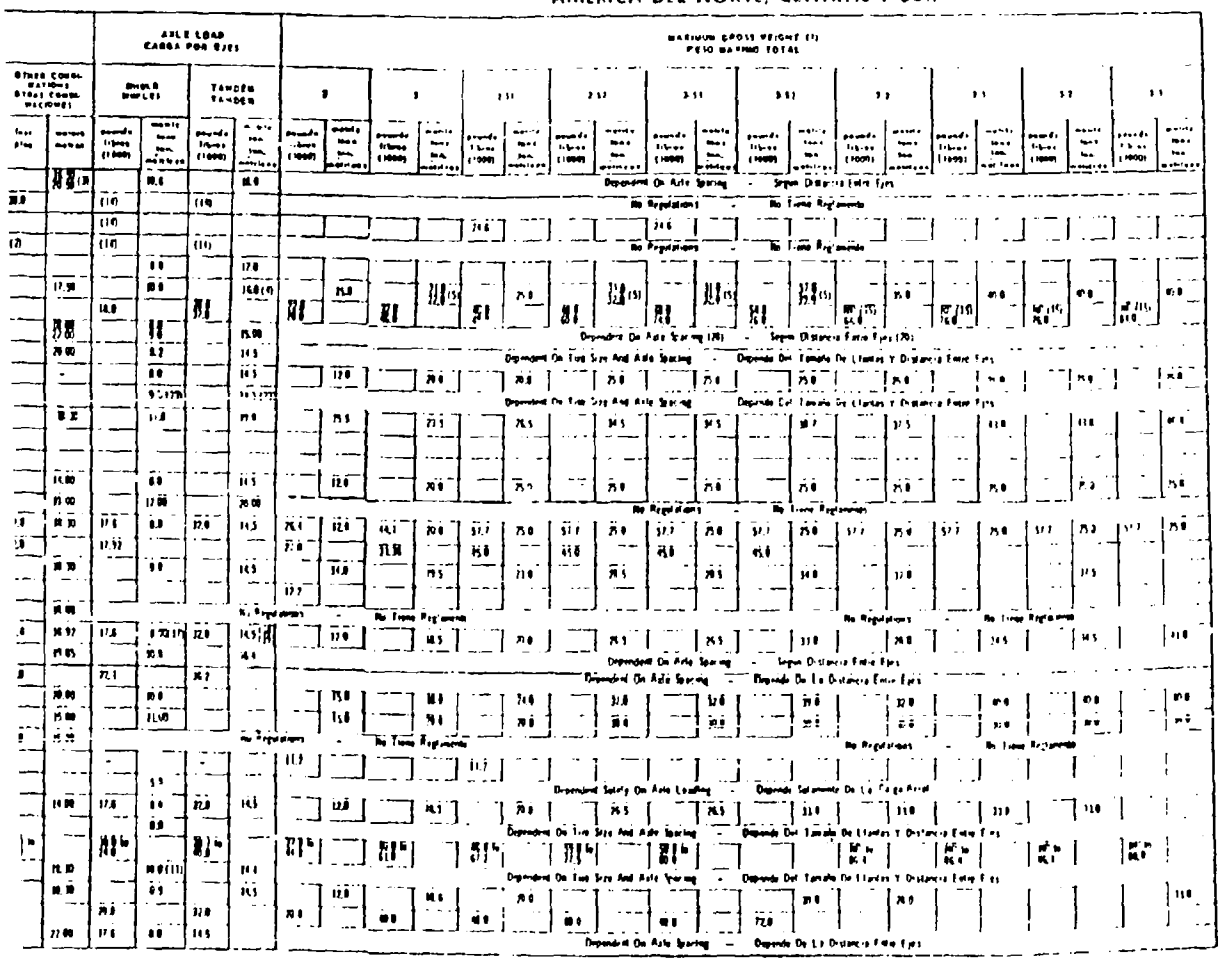
NORTH, CENTRAL & SOUTH AMERICA

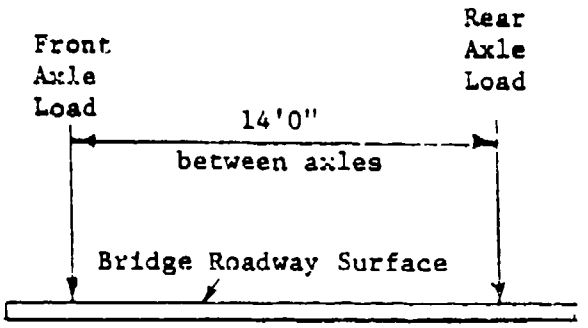
COUNTRY PAIS	WIDTH ANCHO		HEIGHT ALTURA		LENGTH LONGITUD - TOTAL								AXLE LOAD CARGA POR EJE								
					SINGLE UNIT				TRUCK & SEMI TRAILER CAMION CON SEMIREMOLQUE		OTHER COMBINATIONS OTRAS COMBINACIONES		SINGLE SIMPLE		TANDEM TANDEM		2		3		
					TRUCK-CAMION		BUS-BUS														
	feet pies	metres metros	feet pies	metres metros	feet pies	metres metros	feet pies	metres metros	feet pies	metres metros	feet pies	metres metros	pounds libras (1000)	metric tons ton. metricas	pounds libras (1000)	metric tons ton. metricas	pounds libras (1000)	metric tons ton. metricas	pounds libras (1000)	metric tons ton. metricas	pounds libras (1000)
Argentina		2.50		(7)		11.00		12.00		20.00				18.0		18.0					
Bahamas	8.0		12.0		30.0		30.0		30.0		30.0		(10)		(10)						
Barbados	7.5		(10)		25.0		30.0		25.0				(10)								24.6
Bermuda	(7)		(7)		(7)		(7)		(7)		(7)		(10)		(10)						
Bolivia		2.50		3.80		10.00				15.30				8.0		17.0					
Brazil		2.60		4.00		11.00		11.00		17.50		17.50		18.0		16.0 (9)		15.0			
Canada (1)													14.0								
Chile		2.50		3.80		10.00		11.00		14.70						15.00					
Colombia		2.50		4.00		10.55				16.00		16.00		8.2		14.5					
Costa Rica		2.50		3.80		(7)		11.00		14.00				8.0		14.5		17.0		19.0	
Dominican Republic		2.50		4.00		(7)		11.00		15.77				9.0 (29)		14.5 (7)					
Ecuador (21)		2.50		3.80		10.70				13.70		18.30		11.0		19.0		19.5		23.5	
El Salvador (16)																					
Guadeloupe (16)																					
Guatemala (29)		2.50		3.80		(7)		11.00		14.00		14.00		8.0		14.5		17.0		20.0	
Haiti		2.50		3.50		11.00		11.00		15.00		18.00		17.00		20.00					
Honduras (22)	8.2	2.50	12.5	3.80	(7)	(7)	36.0	11.0	46.0	14.0	48.0	18.30	17.6	8.0	32.0	14.5	26.4	12.0	46.1	20.0	57.7
Jamaica (5)	8.2		10.4		30.0		32.0		42.0		52.0		11.92				27.0		31.54		43.8
Mexico (15)		2.50		4.15		11.00		11.00		(17)		18.30		9.0		14.5		14.0		19.5	
Nicaragua	7.0		-		22.0												27.7				
Netherland Antilles		2.50		3.50		10.00		11.00		14.00		18.00					No Regulations	-	No Time Regiment		
Nicaragua	8.2	2.50	12.5	3.80	(7)	(7)	36.0	11.00	46.0	14.00	56.0	16.17	17.6	8.00 (17)	32.0	14.5 (7)		17.0		18.5	
Panama (18) (9)		2.50		4.10		(7)				15.75		19.85		10.0		16.4					
Canal Zone (18)	8.2		13.5		42.0 (7)				38.0		65.0		22.1		36.2						
Paraguay		2.40		4.00		(7)				20.00		20.00		10.0				15.0		18.0	
Peru		2.50		4.00		(7)		10.50		15.00		15.00		11.00				15.0		20.0	
Puerto Rico	8.0	2.40	12.5	3.80	35.0	11.00	40.0	12.00	38.0	15.70	38.0	15.70					No Regulations	-	No Time Regiments		
Saint Christopher, Nevis, Anti	7.5		-		27.0		32.0		-		-		-		-		21.2				31.1
Saint Pierre et Miquelon		2.50				8.00								5.0							
El Salvador		2.50		3.80		(7)		11.00		14.00		14.00	17.6	8.0	32.0	14.5		17.0		18.5	
Surinam		2.50		3.80		11.00								8.0							
United States (19)																					
Uruguay		2.50		4.00		10.70		10.70		15.30		18.30		10.0 (11)		14.1					
Venezuela		2.60		3.90		(7)		(7)		15.30		18.30		8.5		14.5		17.0		18.5	
AASHO Policy - 1946 (23)	8.5		13.5		40.0		40.0		55.0		65.0		20.0		32.0		26.0		40.0		48.0
Pan-Am Hwy Congress Policy	8.2	2.5	12.5	4.0			36.0	11.00	46.0	14.00	72.0	22.00	17.6	8.0	32.0	14.5					

Limits for Motor Vehicle Sizes and Weights for North, Central, and South America

A

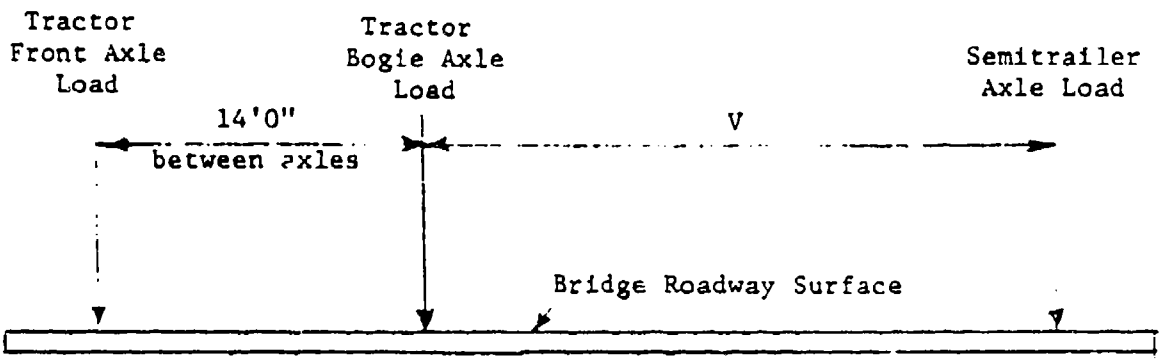
AMERICA DEL NORTE, CENTRAL Y SUR





8,000 lb.	(3,628.80 kg)	H20-44	32,000 lb.	(14,515.20 kg)
6,000 lb.	(2,721.60 kg)	H15-44	24,000 lb.	(10,886.40 kg)
4,000 lb.	(1,814.40 kg)	H10-44	16,000 lb.	(7,257.60 kg)

a - Standard H-Design Load



8,000 lb. (3,628.80 kg)	32,000 lb. (14,515.20 kg)	H20-S16-44	32,000 lb. (14,515.20 kg)
6,000 lb. (2,721.60 kg)	24,000 lb. (10,886.40 kg)	H15-S12-44	24,000 lb. (10,886.40 kg)

V = Variable spacing 14 feet to 30 feet inclusive.
Spacing to be used is that which produces maximum stresses.

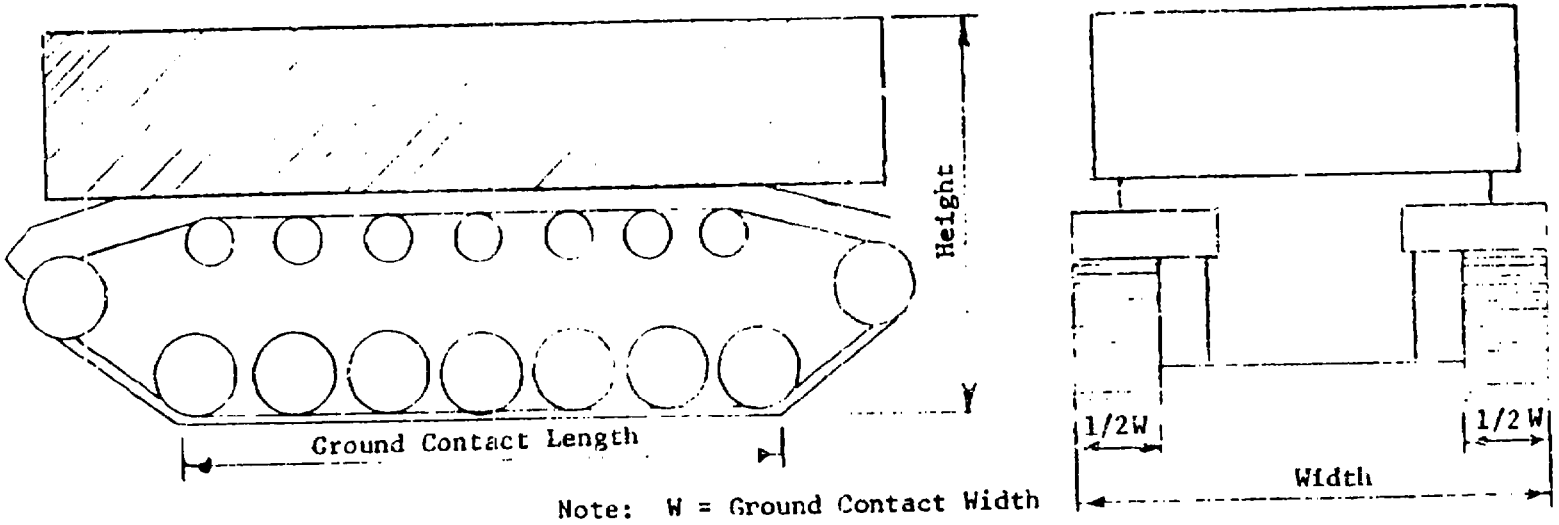
b - Standard H-S-Design Load

NOTE: Bridges supporting interstate highways shall be designed in accordance with the current standard specifications for highway bridges of the American Association of State Highway Officials, using the H20-S16-44 loading except that to overcome deficiencies for systems of bridges designed for such loading all bridges and floor systems with spans under 40 feet shall be designed using the alternate limitations of 2 axles 4 feet apart with each axle weighing 75% of the rear loading of the H20-S16-44 loading.

Figure 7. Bridge Design Loadings.

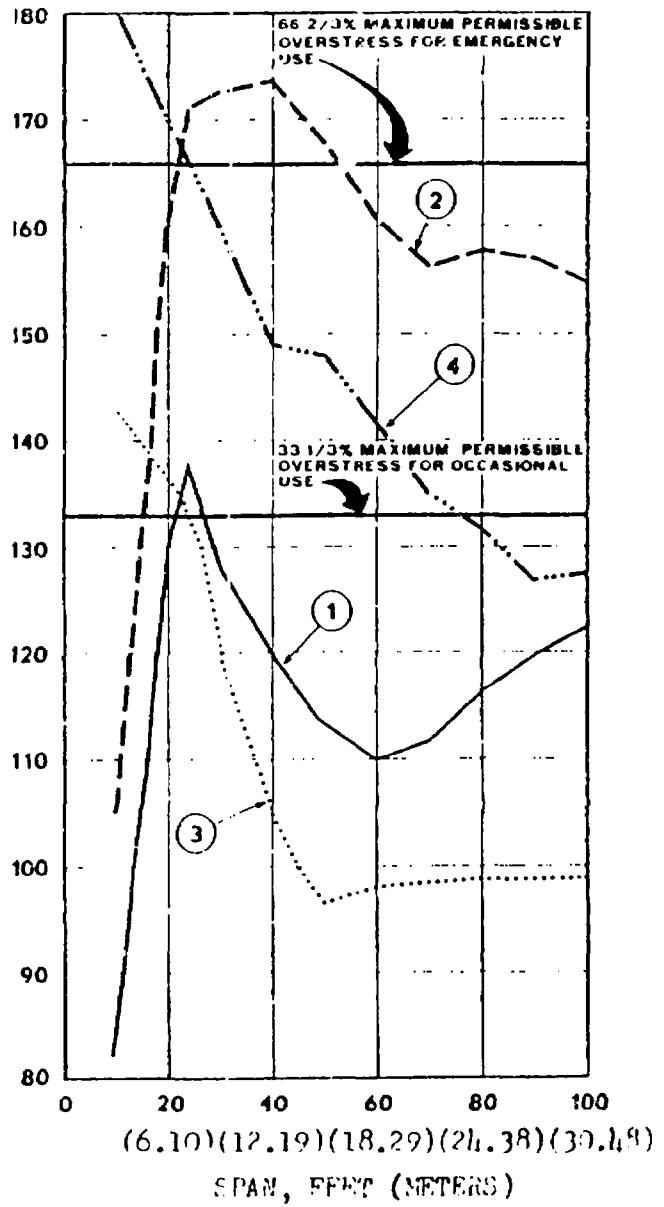
Maximum Gross Weight, lb. (kg)	Maximum Width, in. (cm)	Minimum Width, in. (cm)	Maximum Height, in. (cm)	Minimum Ground Contact*	
				Length in. (cm)	Width in. (cm)
8,000 (3,628.80)	96 (238.84)	None	132 (335.28)	32 (81.28)	20 (50.80)
16,000 (7,257.60)	96 (238.84)	78 (198.12)	132 (335.28)	55 (139.70)	24 (60.96)
24,000 (10,886.40)	96 (238.84)	80 (203.20)	132 (335.28)	73 (185.42)	27 (68.58)
32,000 (14,515.20)	96 (238.84)	84 (213.36)	132 (335.28)	87 (220.98)	30 (76.20)
40,000 (18,144.00)	120 (304.80)	96 (238.84)	132 (335.28)	98 (248.92)	33 (83.82)
48,000 (21,772.80)	120 (304.80)	100 (254.00)	132 (335.28)	107 (271.78)	36 (91.44)
60,000 (27,216.00)	120 (304.80)	100 (254.00)	132 (335.28)	132 (335.28)	37 (93.98)
80,000 (36,288.00)	120 (304.80)	112 (284.48)	132 (335.28)	144 (365.76)	45 (114.30)

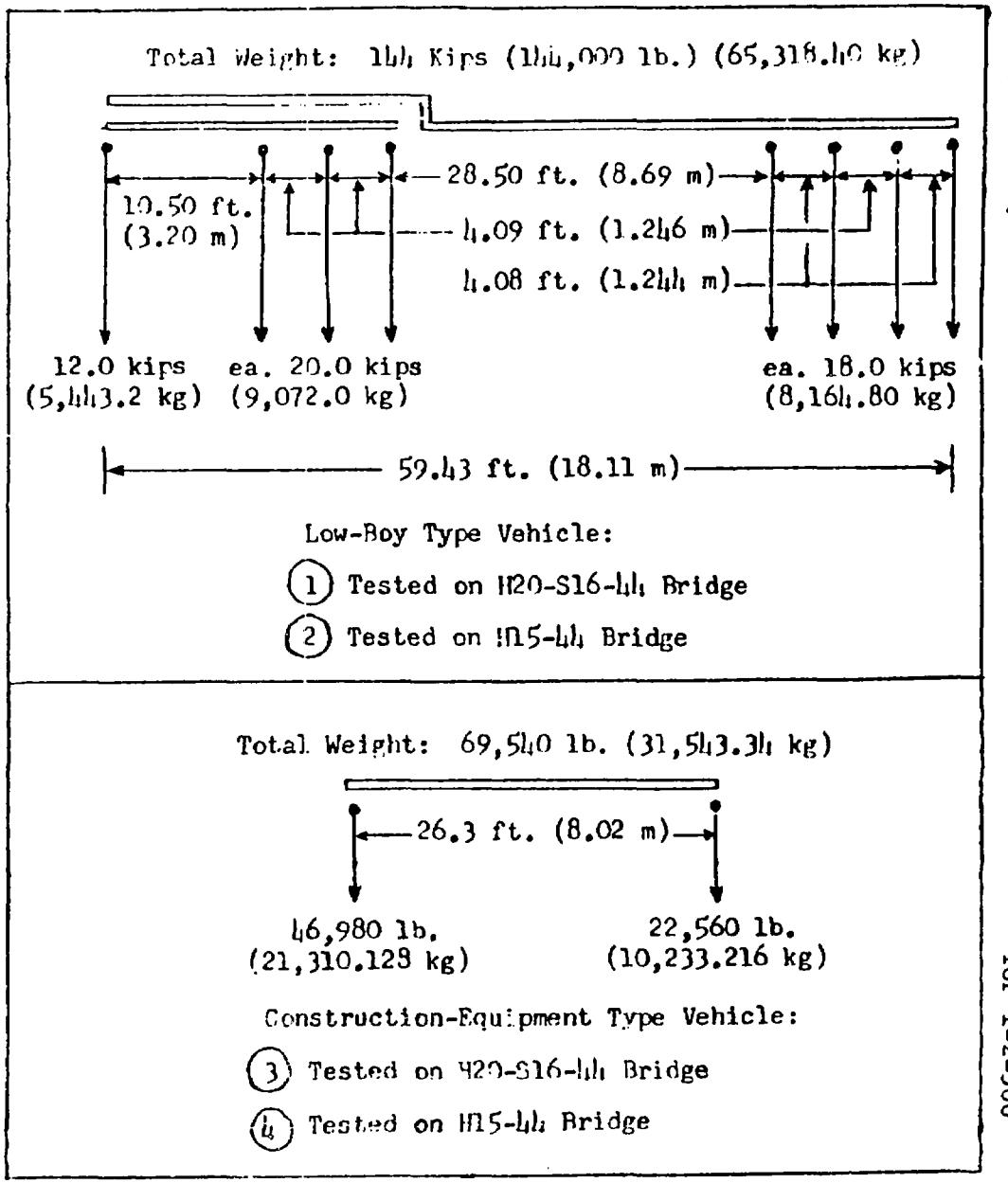
*Maximum ground contact length for any vehicle: 180 inches (457.20 cm).



Note: W = Ground Contact Width

Figure 8. Dimensions and Weights of Tracked Vehicles Equipped With Rubber Pads for Movement on Highways and Bridges.





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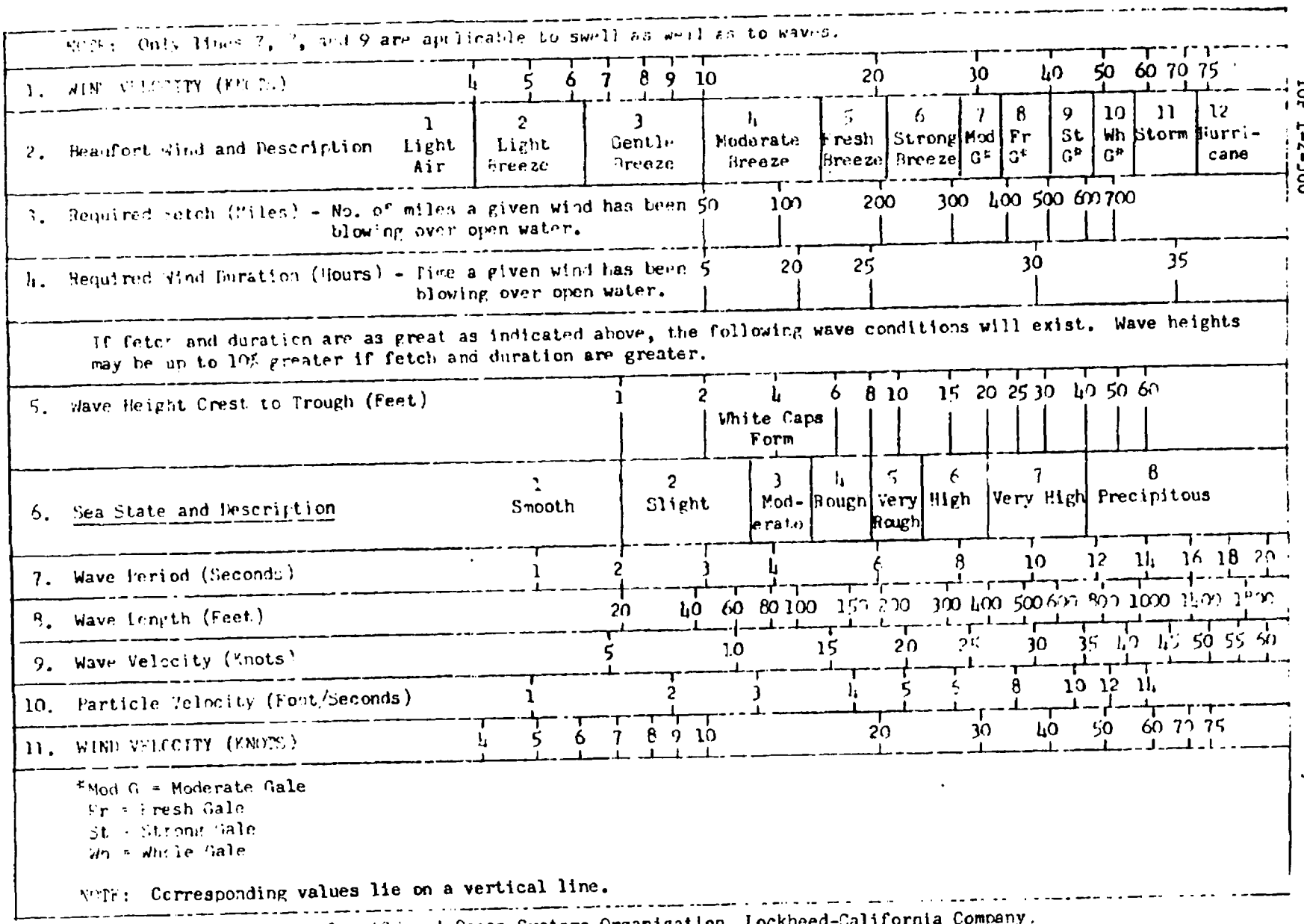
TOP 1-2-500

Figure 9. Ratings of a Lowboy-Type Vehicle and a Construction-Equipment-Type Vehicle Tested on H20-S16-44 and H15-44 Bridges.

APPENDIX D

MARINE TRANSPORT ENVIRONMENTAL FACTORS AND VESSEL CHARACTERISTICS



Credit: Dr. Alfred J. Caracia, ASW and Ocean Systems Organization, Lockheed-California Company.

Figure 10. Sea State vs Surface Environment.

Table 7 - Containership Characteristics

Typical Vessel	Size of Ship Cell	Container	Vessels In Class	Hatch Sizes (ft/meters)	Hold-Access Size (ft/meters)	Hold Space (sq ft/sq m)	Deck Space (sq ft/sq m)	Cargo Deadweight (L ton/m ton)	Length (ft/meters)	Beam (ft/meters)
NOTE: Metric equivalents (rounded) are shown in parentheses.										
Azalea City	S-35**	266	13	17 x 35 (5.18 x 10.67) 26 x 35 (7.92 x 10.67)	16 x 33 (4.88 x 10.06) 24 x 33 (7.32 x 10.06)	34,160 (3,173.46)	11,700 (1,092.50)	13,000 + (13,208)	469 (142.95)	72 (21.95)
Seatrain Delaware	S-40	277	5	26 x 40 (7.92 x 12.19) 34 x 40 (10.36 x 12.19)	24 x 37 (7.32 x 11.28) 32 x 37 (9.75 x 11.28)	17,280 (1,605.31)	15,680 (1,456.67)	13,000 + (13,208)	524 (159.72)	68 (20.73)
Guam Bear	M-20	496	4	48 x 20 (14.63 x 6.10)	48 x 17 (14.63 x 5.18)	25,600 (2,378.24)	12,480 (1,159.39)	13,000 + (13,208)	523 (159.41)	72 (21.95)
Pacific Trader	M-24	499	2	52 x 24 (15.85 x 7.32)	50 x 22 (15.24 x 6.71)	41,472 (3,852.75)	12,096 (1,123.72)	12,000 + (12,192)	544 (165.81)	72 (21.95)
Mobile	M-35	356	28	42 x 35 (12.80 x 10.67) 52 x 35 (15.85 x 10.67) 62 x 35 (18.51 x 10.67)	42 x 33 (12.80 x 10.06) 52 x 33 (15.85 x 10.06) 62 x 33 (18.90 x 10.06)	47,600 (4,422.08)	14,560 (1,352.62)	13,000 + (13,208)	523 (159.41)	72 (21.95)
American Ace	M-40	454	26	17 x 40 (5.18 x 12.19) 26 x 40 (7.92 x 12.19) 42 x 20 (12.80 x 6.10)	17 x 37 (5.18 x 11.28) 26 x 37 (7.92 x 11.28) 42 x 17 (12.80 x 5.18)	56,160 (5,217.26)	24,000 (2,229.60)	13,000 + (13,208)	661 (201.47)	76 (23.16)
President Jefferson	L-20	978	10 (8 under construction)	16 x 20 (4.88 x 6.10) 25 x 20 (7.62 x 6.10) 34 x 20 (10.36 x 6.10) 34 x 40 (10.36 x 12.19)	16 x 17 (4.88 x 5.18) 25 x 17 (7.62 x 5.18) 34 x 17 (10.36 x 5.18) 34 x 37 (10.36 x 11.28)	70,720 (6,569.89)	21,760 (2,021.50)	15,000 + (15,240)	668 (204.61)	90 (27.43)
Hawaiian Enterprize*	L-24	1,168	8 (4 under construction)	55 x 24 (16.76 x 7.32) 72 x 24 (21.95 x 7.32)	55 x 22 (16.76 x 6.71) 72 x 22 (21.95 x 7.32)	69,888 (6,492.60)	28,272 (2,626.47)	15,000 + (15,240)	720 (219.46)	95 (28.96)

*This ship is capable of carrying 20- or 24-foot (6.10 or 7.32 m) containers under hatches 2 through 5 by rearrangement of cell guides and 20-, 24-, or 40-foot (6.10, 7.32, or 12.19 m) long containers on deck over hatch 13/14.

**S (Small): Vessels capable of transporting over 100 containers but less than 300 containers.
M (Medium): Vessels capable of transporting at least 300 containers but not more than 700 containers.
L (Large): Vessels capable of transporting over 700 containers.

[illegible] is basically equipped to transport. Example: S-35 is a small vessel capable of

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Table 7b - Dry Cargo Container Characteristics*

NOTE: Metric equivalents (rounded) are shown in parentheses.

Outside Dimension			Interior Dimension			Reduced Interior			Capacity (lb/kg)
Width	Height	Length	Width	Height	Length	Width	Height	Length	
8 ft (2.44)	8 ft (2.44)	20 ft (6.10)	7 ft 8 in (2.33)	7 ft 3 in (2.21)	19 ft 6 in (5.94)	7 ft (2.13)	6 ft 9 in (2.06)	19 ft (5.79)	40,000 (18,144.00)
8 ft (2.44)	8 ft 6 in (2.59)	24 ft (7.32)	7 ft 8 in (2.33)	7 ft 10 in (2.38)	23 ft 6 in (7.16)	7 ft (2.13)	7 ft 4 in (2.23)	23 ft (7.01)	42,000 (19,051.20)
8 ft (2.44)	8 ft 6 in (2.59)	35 ft (10.67)	7 ft 8 in (2.33)	7 ft 10 in (2.38)	24 ft 7 in (10.54)	7 ft (2.13)	7 ft 4 in (2.23)	34 ft 1 in (10.39)	45,000 (20,412.00)
8 ft (2.44)	8 ft 6 in (2.59)	40 ft (12.19)	7 ft 9 in (2.36)	7 ft 9 in (2.36)	39 ft 6 in (12.04)	7 ft 1 in (2.16)	7 ft 3 in (2.21)	39 ft (11.89)	60,000 (27,216.00)

*The dry cargo container is essentially a completely enclosed, demountable van with doors either at the rear or side.

Table 7c - Special Purpose Container Characteristics*

NOTE: Metric equivalents (rounded) are shown in parentheses.

Outside Dimension			Interior Dimension			Reduced Interior			Capacity (lb/kg)
Width	Height	Length	Width	Height	Length	Width	Height	Length	
Platform Type									
8 ft (2.44)	8 ft 6 in (2.59)	24 ft (7.32)	8 ft (2.44)	7 ft 1 in (2.16)	22 ft 4 in (6.81)	7 ft 4 in (2.23)	7 ft 1 in (2.16)	21 ft 10 in (6.65)	43,300 (19,640.88)
Open Top Type									
8 ft (2.44)	8 ft 6 in (2.59)	35 ft (10.67)	8 ft (2.44)	7 ft 8 in (2.33)	34 ft 6 in (10.52)	7 ft (2.13)	7 ft 8 in (2.33)	34 ft (10.36)	45,300 (20,548.08)

*Of the various types of special purpose containers, only three - the platform, open top, and vehicle carrier - are suitable for transporting military equipment.

Table 7d - Special Design Container Characteristics*

NOTE: Metric equivalents (rounded) are shown in parentheses.

Outside Dimension			Interior Dimension			Reduced Interior			Capacity (lb/kg)
Width	Height	Length	Width	Height	Length	Width	Height	Length	
8 ft (2.44)	8 ft 6 in (2.59)	40 ft (12.19)	7 ft 11 in (2.41)	7 ft 11 in (2.41)	39 ft 6 in (12.04)	7 ft 3 in (2.21)	7 ft 5 in (2.26)	39 ft (11.89)	60,000 (27,216.00)
8 ft (2.44)	9 ft (2.74)	40 ft (12.19)	7 ft 9 in (2.36)	8 ft 3 in (2.51)	39 ft 6 in (12.04)	7 ft 1 in (2.16)	7 ft 9 in (2.36)	39 ft (11.89)	60,000 (27,216.00)
8 ft (2.44)	9 ft 6 in (2.90)	40 ft (12.19)	7 ft 9 in (2.36)	8 ft 9 in (2.67)	39 ft 6 in (12.04)	7 ft 1 in (2.16)	8 ft 3 in (2.51)	39 ft (11.89)	60,000 (27,216.00)
8 ft (2.44)	8 ft (2.44)	6 ft 6 in (1.98)	7 ft 8 in (2.33)	7 ft 4 in (2.23)	6 ft 3 in (1.91)	7 ft (2.13)	6 ft 10 in (2.08)	5 ft 9 in (1.75)	13,000 (5,896.80)

*Special design containers are designed to carry small items needed for military use.

Table 7e - Roll-On/Roll-Off (RO/RO) Characteristics

/pical Vessel: Admiral Callaghan
/pe Equipment: Trailers and Vehicles
essels in Class: 4

Cargo Deadweight: 12,000+ L tons (12,192 m tons)
Length: 694 ft (211.54 m)
Beam: 92 ft (28.04 m)

Hatch Sizes	Deck Space (sq ft/sq m)	Clearance Heights					Ship's Gear Hatch Booms (L ton/m ton)	
		Main Deck	2d Deck	3d Deck	4th Deck	Tank	2, 3, 4, and 6	All
26 ft x 40 ft 6 in (7.92 x 12.34 m)	165,000 (15,328.50)	12 ft 6 in Fwd (3.81 m)	12 ft 6 in (3.81 m)	10 ft 8 in (3.25 m)	8 ft 6 in (2.59 m)	8 ft 6 in (2.59 m)	120 (121.92)	25 (25.40)
30 ft x 40 ft 6 in (9.14 x 12.34 m)		12 ft 3 in Aft (3.73 m)						
atch 4 (2d and 3d deck only):								
30 x 26 ft (9.14 x 7.92 m)							15 (15.24)	

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Table 7f - Roll-On/Roll-Off Combination (RO/COMB) Characteristics

Typical Vessel: Red Jacket
Type Equipment: 241 Containers plus vehicles on RO/RO deck
399 Containers with no RO/RO capability
Vessels in Class: 4

Cargo Deadweight: 13,589 L tons (13,806.4 tons)
Length: 602 ft (183.49 m)
Beam: 90 ft (27.43 m)

Hatch Sizes	Hold Access	Stern Ramp Size		Side Ramp Size		RO/RO Deck
		Width	Height	Width	Height	
17 ft 6 in x 40 ft (5.33 x 12.19 m)	16 ft x 37 ft (4.88 x 11.28 m)	15 ft (4.57 m)	14 ft 6 in (4.42 m)	15 ft (4.57)	13 ft (3.96)	32,000 sq ft (2,972.80 sq m); clearance 14 ft 3 in (4.34 m).
25 ft 11 in x 40 ft	24 ft x 37 ft					

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Table 7g - Lash and Seabee Specifications

NOTE: Metric equivalents (meters or metric tons, as applicable, rounded) are shown in parentheses.

Specification	LASH	SEABEE
External Dimensions	Length: 820 ft (249.94) Width: 100 ft (30.48) Draft: 37 ft (11.28) (design maximum)	875 ft (266.70) 106 ft (32.31) 36 ft (10.97) (design maximum)
Speed	22.1 knots	22.1 knots
Lighter/Barge Capacity	Without containers: 73 L tons (74.17) With containers: 62 L tons (62.99)	38 L tons (38.61)
Container Capacity	170 40-ft (12.19) containers	160 40-ft (12.19) containers
Total Cargo Capacity	Approximately 18,000 L tons (18,288)	Approximately 19,000 L tons (19,304)
Crane Type Capacity	500 L-ton (508.00) gantry (Pacific Far East Lines ships will also have a 35 L-ton (35.56) gantry crane in the forward portion of the ship to load and discharge containers.)	2,000 L-ton (2,032) stern elevator plus a hydraulic barge transport system for each deck.

Barge Specifications

Specification	LASH Lighter	SEABEE Barge
External Dimensions*	Length: 62 ft (18.90) Width: 32 ft (9.75) Depth: 13 ft (3.96)	97 ft 6 in (29.72) 35 ft 6 in (10.82) 17 ft 1 in (5.43)
Internal Dimensions*	Length: 59 ft 5 in (18.11) Width: 29 ft 5 in (8.97) Depth: 11 ft 7 in (3.53)	90 ft (27.43) 30 ft 3 in (9.22) 14 ft 9 in (4.50)
Hatch Opening	Length: 42 ft (12.80) Width: 29 ft 5 in (8.97)	84 ft (25.60) 30 ft 3 in (9.22)
Maximum Draft	8 ft 8 in (2.64)	10 ft 8 in (3.25) (approximately 8 ft (2.44) with 500 L-ton (508) load)
Cargo Capacity	370 L tons (375.92)	850 L tons (863.60) (maximum average load for the ship is estimated at 500 L tons (508) per barge)

*Barge/lighter dimensions may vary slightly between carriers.

Table 8 - Characteristics of Amphibious and Landing Craft

Craft	Length	Beam	Cargo (tons) L = long S = short m = metric	Cargo Space Dimensions		Ramp Opening	Remarks
				Length	Width		
LCU 1466	115 ft 1 in. (35.08 m)	34 ft 0 in. (10.63 m)	150 L (152.40 m)	52 ft 0 in. (15.85 m) 22 ft 0 in. (6.71 m)	29 ft 6 in. (8.99 m) 14 ft 4 in. (4.37 m)	14 ft 4 in. (4.37 m)	Fresh water capacity 9,563 gal
LCM	73 ft 8 in. (22.45 m)	21 ft 0 in. (6.40 m)	53.5 L (54.36 m)	42 ft 9 in. (13.03 m)	14 ft 6 in. (4.42 m)	14 ft 6 in.* (4.42 m)	*Combat equipped troops carried: 20
LARC V	35 ft 0 in. (10.67 m)	10 ft 0 in. (3.05 m)	5 S (4.54 m)	16 ft 0 in. (4.88 m)	9 ft 9 in. (2.97 m)	NA	
LARC XV	45 ft 0 in. (13.72 m)	14 ft 7 in. (4.43 m)	15 S (13.61 m)	24 ft 0 in. (7.32 m)	13 ft 6 in. (4.11 m)	9 ft 0 in. (2.74 m)	
LARC LX	62 ft 6 in. (19.05 m)	26 ft 7 in. (8.10 m)	60 S (54.42 m) 100 S* (90.70 m)	38 ft 8 in. (11.78 m)	13 ft 8 in. (4.16 m)	14 ft 6 in. (4.42 m)	*Can carry in an emergency
LST	442 ft 0 in. (134.72 m)	62 ft 1 in. (18.92 m)	2,400 L FL* (2,438.40 m) 900 L MB (914.40 m) 500 L NB (508.00 m)	Tank Deck 320 ft 0 in. (97.54 m) Main Deck 208 ft 0 in. (63.40 m)	 30 ft 0 in. (9.14 m) 60 ft 0 in. (18.29 m)	Inside width: 15 ft 5-7/8 in. (4.77 m) Width between bulkheads: 17 ft 0 in. (5.18 m) Overhead clearance: 17 ft 8 in. (5.38 m)	*FL = Full load MB = Maximum beaching NB = Normal beaching

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APPENDIX E
AIRCRAFT CAPACITIES

Table 9 - Dimensions of Aircraft Cargo Compartments

Dimension	Aircraft		
	C-130	C-141	C-5
Length (excluding ramp)	41 ft 0 in. (12.497 m)	70 ft 0 in. (21.366 m)	121 ft 1 in. (36.906 m)
Width	10 ft 3 in. (3.124 m)	10 ft 3 in. (3.124 m)	19 ft 0 in. (5.791 m)
Width of cargo entrance	10 ft 10 in. (3.302 m)	10 ft 3 in. (3.124 m)	19 ft 0 in. (5.791 m)
Height	9 ft 1 in. (2.769 m)	9 ft 1 in. (2.769 m)	*13 ft 6 in. (4.115 m)
Height of cargo entrance	8 ft 10 in. (2.692 m)	9 ft 1 in. (2.769 m)	10 ft 6 in. (3.200 m)

*Kneeling - Capability which permits various positioning of the cargo floor above the ground.

Table 10 - Ramp Data

Dimension	Aircraft			
	C-130	C-141	C-5[a]	
			(Forward)	(Aft)
Length	10 ft 0 in. (3.048 m)	11 ft 1 in. (3.378 m)	10 ft 1 in. (3.079 m)	13 ft 4 in. (4.054 m)
Angle w/ground	11.5°	10° to 15°	11.9°	3.5°
Angle w/airplane floor	11.5°	10° to 15°	11.0°	[b]8.7° [c]3.8°

[a]Two loading ramps - forward and aft.
[b]Ramp.
[c]Ramp toes.

NOTE: See AR 70-39 for other older aircraft.

Table 11 - Typical Total Cargo Loads

Load Condition		Aircraft				
		C-130A	C-130B	C-130E	C-141A	C-5[b]
Weight:						
Maximum takeoff	lb	124,000	135,000	155,000	316,000	728,000
	kg	(56,246)	(61,236)	(70,308)	(143,337)	(330,220)
Operating[a]	lb	70,000	76,000	79,400	140,500	336,858
	kg	(31,752)	(34,474)	(36,016)	(63,731)	(152,799)
Zero fuel	lb	102,000	111,000	117,892	204,620	543,904
	kg	(46,267)	(50,350)	(53,476)	(92,816)	(246,715)
Nautical Miles:						
500	lb	32,500	35,000	38,492	64,120	207,046
	kg	(14,742)	(15,876)	(17,460)	(29,085)	(93,916)
1,000	lb	32,500	32,000	38,492	64,120	207,046
	kg	(14,742)	(14,515)	(17,460)	(29,085)	(93,916)
2,500	lb	17,800	24,000	27,000	64,120	207,046
	kg	(8,074)	(10,886)	(12,247)	(29,085)	(93,916)

[a]Operating weight of the aircraft including crew and all equipment required for mission but excluding fuel or payload.

[b]These are design specifications and subject to change.

Table 12 - Army Aircraft Characteristics

NOTE: Metric equivalents are shown in parentheses.

Aircraft	Cargo Door		Cargo Compartment			External Hook or Sling Capacity (lb/kg)	Basic Mission Payload (lb/kg)
	Width	Height	Length (Usable)	Floor Width	Height		
U-1A*	3 ft 8 in (1.118)	3 ft 9 in (1.143)	12 ft 8 in (3.861)	3 ft 9 in (1.143) to 4 ft 4 in 1.320	4 ft 9 in (1.448)	NA	1,800 (816)
UH-1B/C/M	4 ft 0 in (1.219)	4 ft 0 in (1.219)	4 ft 0 in (1.219)	6 ft 8 in (2.032)	4 ft 8 in (1.422)	4,000 (1,814)	800 (363)
UH-1D/H	6 ft 2 in (1.880)	4 ft 0 in (1.219)	7 ft 8 in (2.337)	8 ft 10 in (2.692)	4 ft 1 in (1.245)	4,000 (1,814)	2,420 (1,097)
CH-34C	4 ft 5 in (1.346)	4 ft 0 in (1.219)	13 ft 5 in (4.089)	4 ft 11 in (1.500)	3 ft 6 in (1.067)	5,000 (2,268)	3,211 (1,456)
CH-47B/C	7 ft 6 in (2.286)	6 ft 6 in (1.981)	30 ft 6 in (9.296)	7 ft 6 in (2.286)	6 ft 6 in (1.981)	20,000 (9,072)	CH-47B: 6,000 (2,722) CH-47C: 12,000 (5,443)
CH-54A/B	NA	NA	NA	NA	NA	CH-54A: 20,000 (9,072) CH-54B: 25,000 (11,340)	CH-54A: 11,522 (5,225) CH-54B: being established
CH-54A/B Universal Military Pod	8 ft 10 in (2.692)	6 ft 6 in (1.981)	27 ft 4 in (8.331)	8 ft 10 in (2.692)	6 ft 6 in (1.981)	NA	16,980 (7,701) (maximum)

*Fixed-winged aircraft; all others shown are rotary-wing aircraft.
For additional data see FM 101-20 and Army aircraft operator's manuals (TM 55-series)

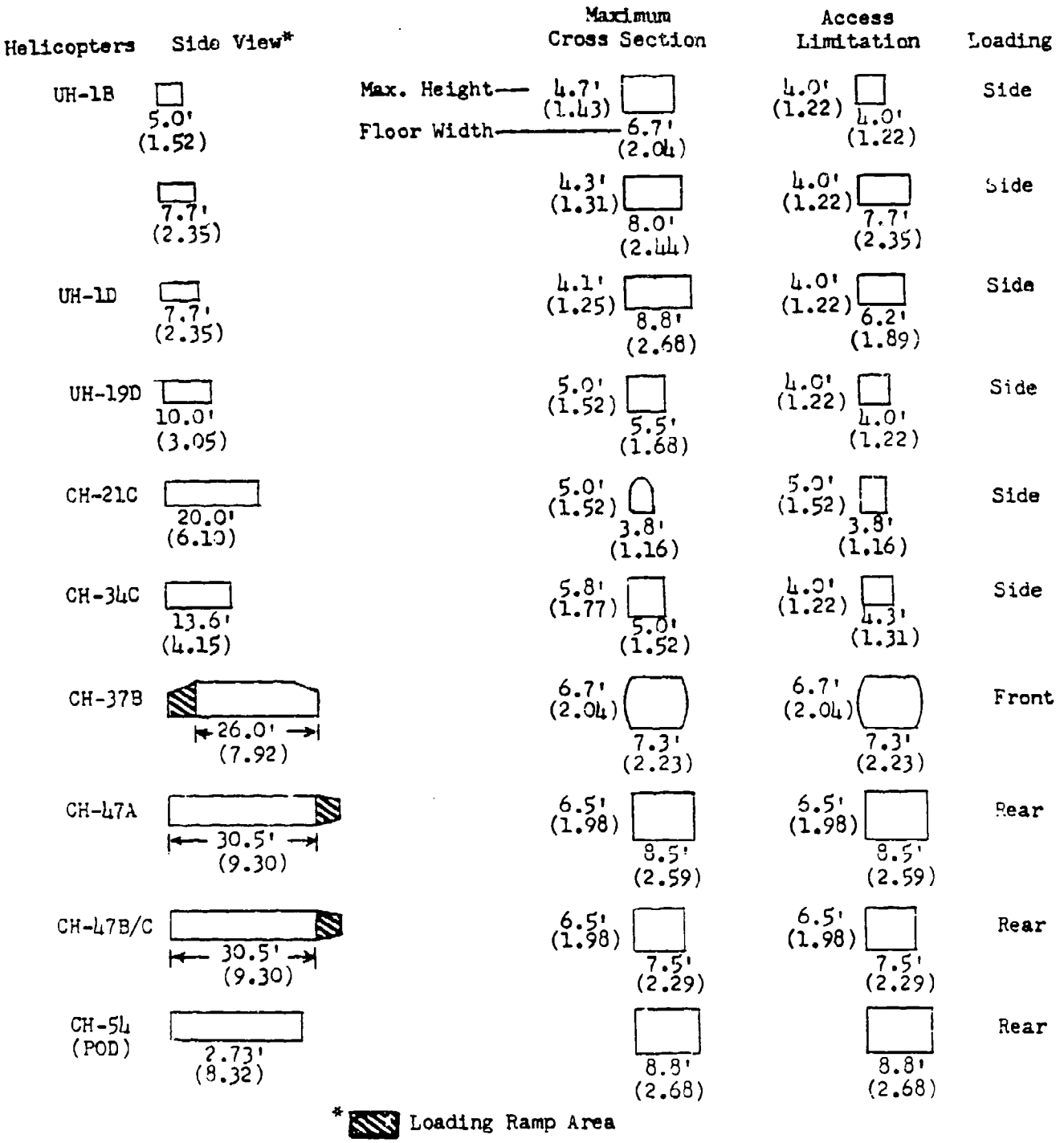


Figure 11. Helicopter Cargo Compartment Envelope and Access Limitations.

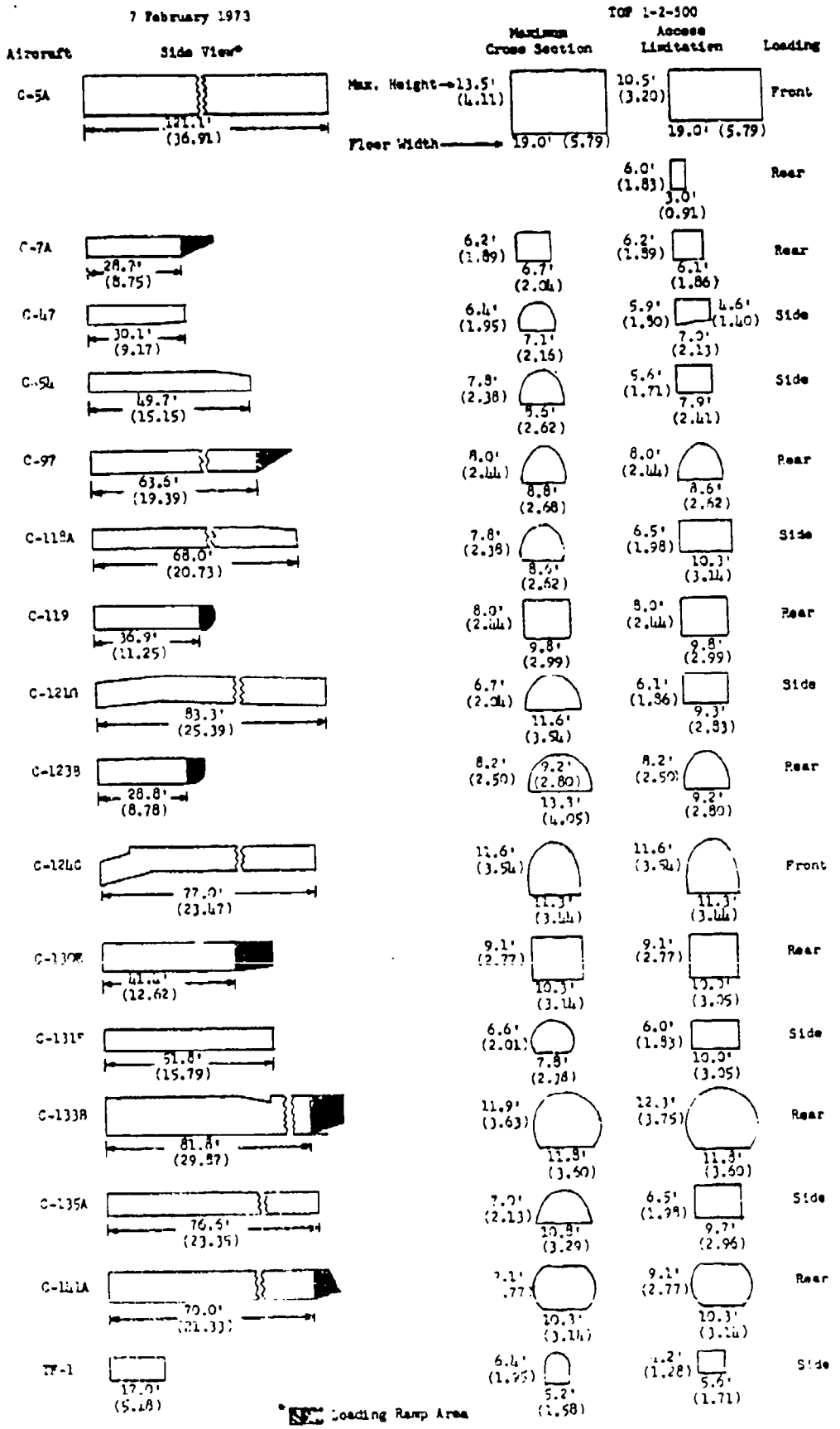
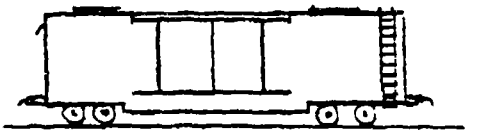
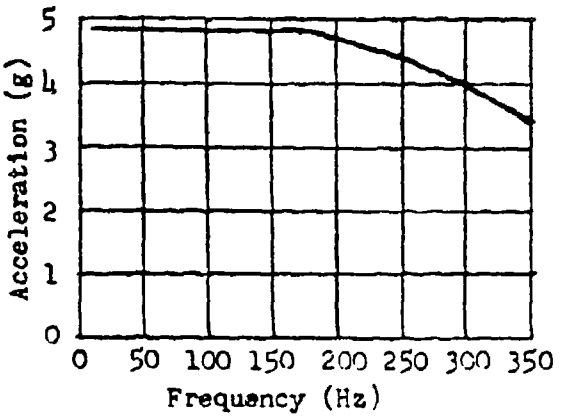


Figure 12. Aircraft Cargo Compartment Envelope and Access Limitations.

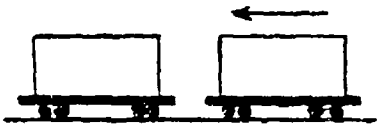
APPENDIX F
SHOCK AND VIBRATION ENVIRONMENTS DURING TRANSPORT BY RAIL, SEA, AND AIR



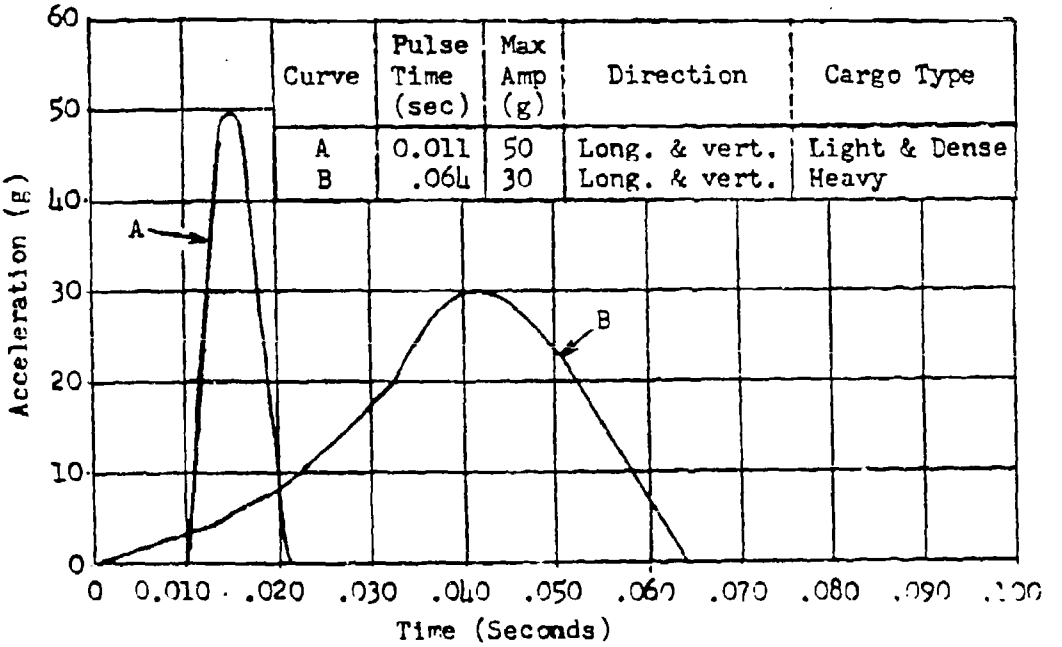
Over-the-Road Schematic



a - Vibration, Vertical and Lateral

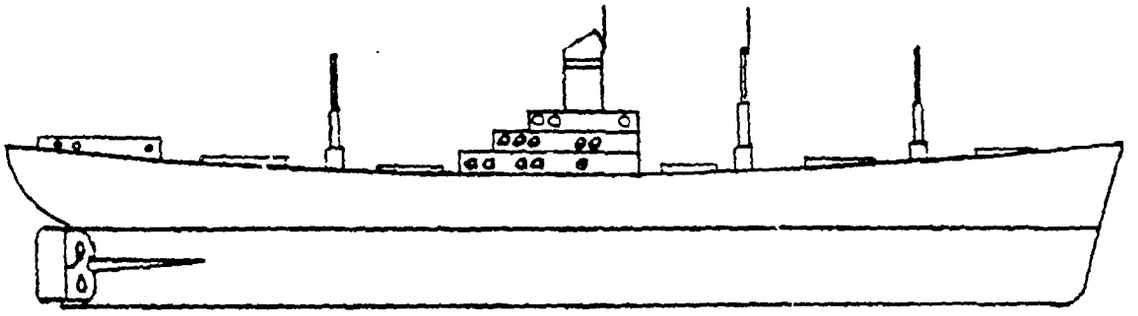


Schematic of Rail Impact

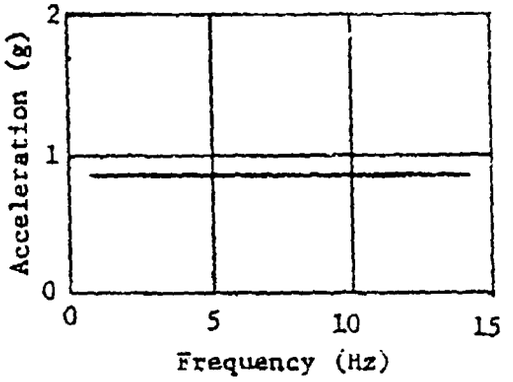


b - Shock

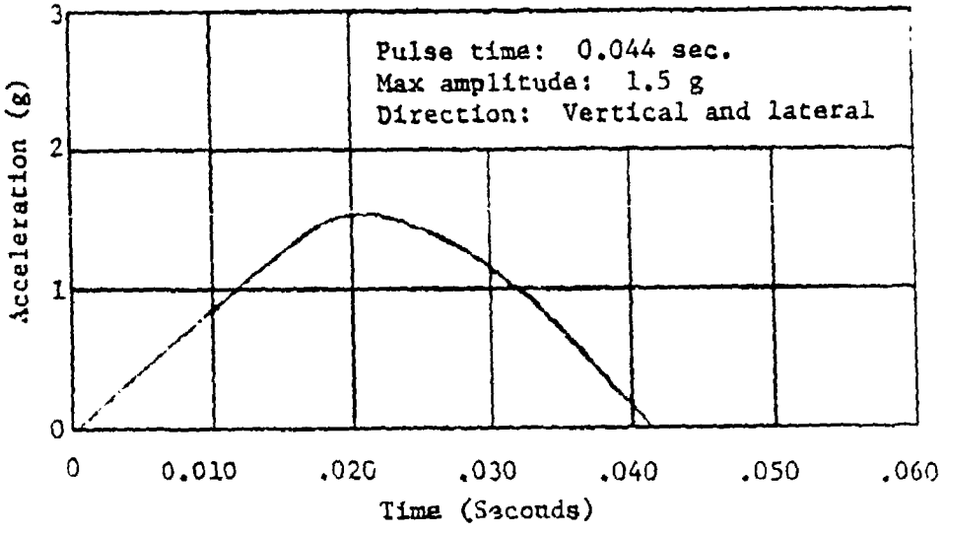
Figure 13. Cargo Environments for Rail Transport.



Schematic (C-2 Class)

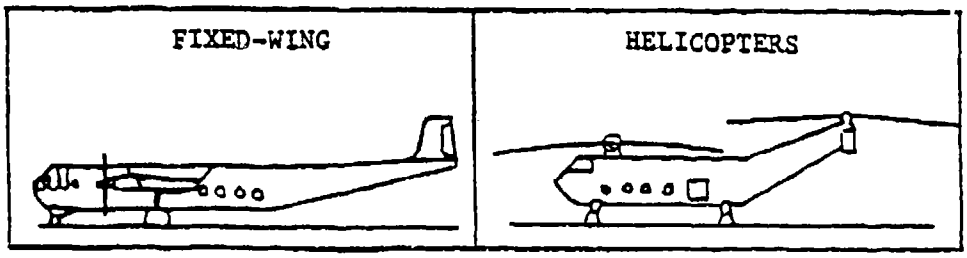


a - Vibration, Vertical and Lateral

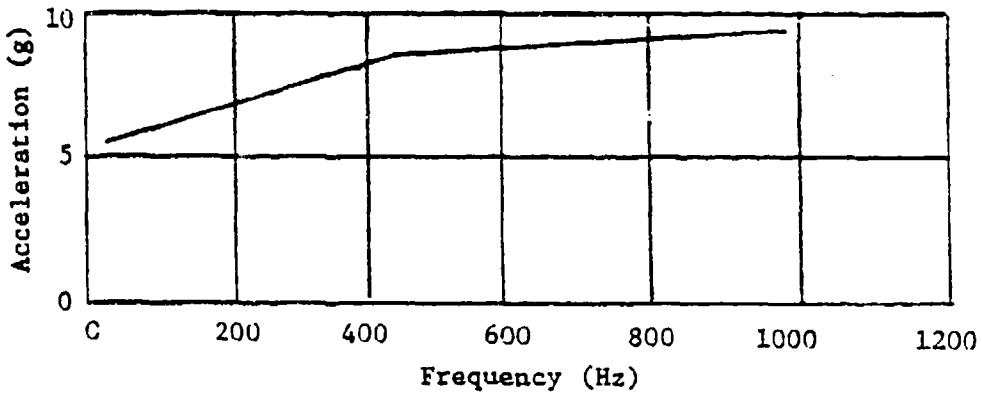


b - Shock

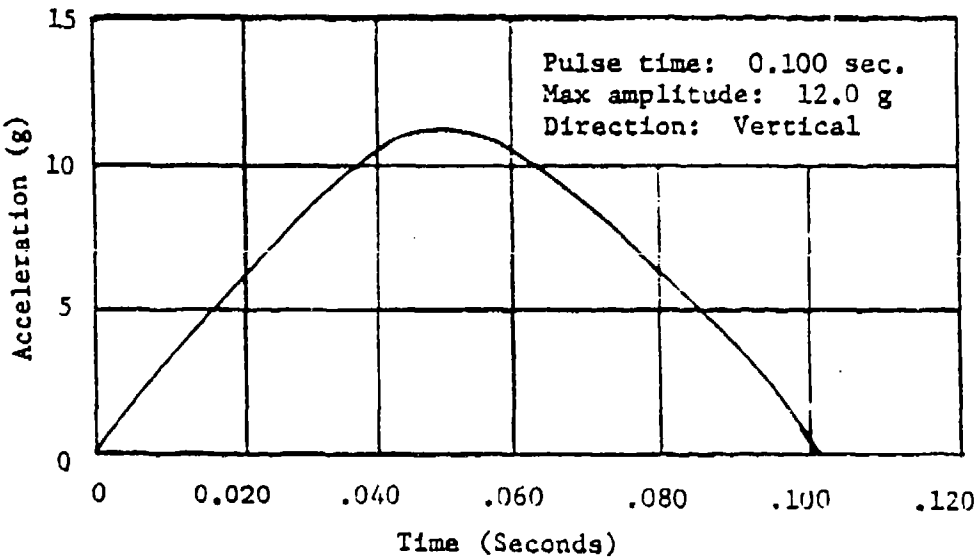
Figure 14. Cargo Environments for Sea Transport.



Schematic



a - Vibration: Vertical, Lateral, and Longitudinal



b - Shock

Figure 15. Cargo Environments for Air Transport.

I Capability For Universal Transport:

A 6' - 2" L x 4' W x 5' H, 4400# (USATEA) _____

B. 18-1/2' L x 6-1/2' W x 7' H, 10,000# (MIL-STD-1366) _____

C. 32' L x 8' W x 8' H, 11,200# (MIL-STD-1366) _____

No Go:	Go:
If restrictions prevail - identify and plan specific tests.	If no restrictions - eliminate all modal tests and concentrate on most restrictive strength and performance parameters.

II Considered For Transport by all Modes: Rail ____ Air ____ Marine ____ Highway ____ Off Road ____ Terminals ____

III Transportability Problem Exists (App A, AR 70-44):

	YES	NO	NOT KNOWN
A. Meets all specified transportability criteria.	____	____	____
B. Is a towed or self-propelled wheeled or tracked vehicle.	____	____	____
C. To be transported in van or stake trucks and exceeds 18-1/2' L x 6-1/2' W x 7' H and 10,000# weight.	____	____	____
D. Exceeds 32' L x 8' W x 8' H and 11,200#.	____	____	____
E. Item is fragile or dangerous.	____	____	____

Consider in planning to determine whether any tests can be eliminated or modifications initiated.	Consider at end of tests in determining whether item is suitable for transport.

IV Specific Data For Transportability Report (AR 70-44):

Data Available _____	Physical Characteristics to be Determined _____

A. Nomenclature and description of items.

B. Modes of transportation.

	Rail	Air	Marine	Highway	Off Road
Required					
Obvious					
Paper Study					
Test					

C. Need for specialized service or equipment (including special MHE).

YES	NO

Identify: _____

_____

_____

D. Configuration of item:

1. Sketch with dimensions and c.g.
2. Weight
3. Unusual dimension or projection.
4. Lifts and tiedowns, location and capacities.

Data Available	Physical Characteristics to be Determined	Test For	Not Applicable

E. Ruggedness:

1. Fragility.
2. Shock.
3. Vibration.

Special Consideration	Most Critical Mode

F. Unusual Characteristics:

Identify:

1. Climatic limits.
2. Performance requirements.
3. Special handling.
4. Other

_____

_____

_____

_____

G. Dangerous Characteristics:

Dangerous	Not Dangerous

REMARKS:

1. DOT class, article, and explosive weight.
2. Venting, protective clothing, or grounding requirements.
3. Disaster response force requirements: security, fire fighter, medical, other.
4. Compliance with applicable codes and regulations.
5. Military quantity-distance class and storage compatibility group.

_____

_____

_____

_____

_____

H. Wheeled or Tracked Configuration: WHEELED _____ TRACKED _____

	Data Available	To be Determined	Not Applicable
1. Footprint data and relative positions of ground contact.			
2. Number of tires, size, location, pressure.			
3. Track ground pressure.			
4. Axle loads, spacing, individual, empty, loaded.			
5. Front and rear overhang, wheelbase.			
6. Ground clearance, component and distance.			
7. Speeds, turning radii, performance data.			
8. Compliance with state and federal regulations.			

I. Safety Compliance:

	Certification Available	Mode	Not Applicable
1. Federal Safety Standards.			
2. Safety Release.			
3. Other.			

J. Sectionalization: Required _____ Feasible _____ Provided For _____

K. Additional Data For Air Loading:

	Data Available	To be Determined	Not Applicable
1. Skid data - diagram showing L, W, distance between, and location of MHE fork entries.			
2. Identity of needed and suitable MHE.			
3. Need for special in-flight power requirements or equipment.			
4. Need for technical escort.			
5. Applicable safety waivers.			
6. Need for sectionalization, reassembly and operational test.			
7. Other limitations.			

V Specific Data for Transportability Guidance Documents:

A. Identify specific aircraft in which transportable.

B. Identify specific highway vehicles in which transportable. Indication limitations, need for special permit or routing.

C. Provide off-road traffic data, vehicle and rating cone indices.

D. Identify specific rail carriers and any limitations.

E. Identify specific rail carriers and any limitations.

F. If sectionalization is required, provide instruction diagram, reduced dimensions and weights.

G. Provide detailed sketches, procedures, and lists of materials for loading, bracing, lashing, and tiedown on various media.

H. Provide detailed sketches on vehicle turning radii, obstacle clearance angles, ramp angles, etc.

I. Provide special shipment data - volumes, cubes, areas, weights.

Available	Under Study	Test for	Not Needed

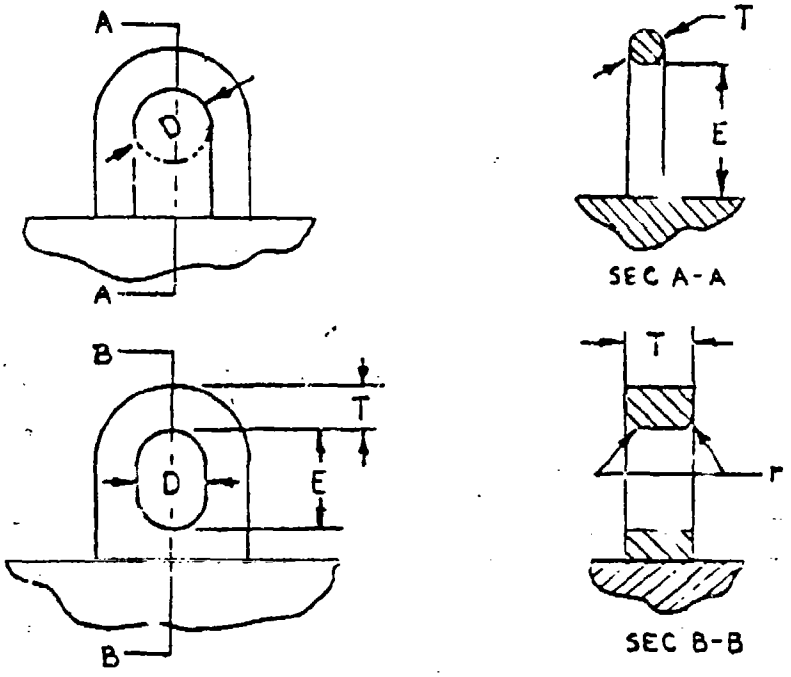
V. Specific Test Data:	MODE					Critical Factors
	Rail	Air	[illegible]	Highway	Off Road	
A. Dimensional:						
Length						6'-8" - Foreign service railroads, 18-1/2' - vans and oversize containers.
Width						6' - Closed foreign service railcar, 6-1/2' - van, 8' - universal limited all mode.
Height						5' - Foreign service rail, 7' - van container, 8' - all [illegible]
Cube						Vans: CONEX - 365 cu ft gross, loaded pallet - 70 cu ft.
Center of gravity						Varies with configuration.
Weight						4400# - Some MHE, 10,000# - all mode, 11,200# - all mode (excluding vans).
No. of lift/tiedowns						Minimum of 4 for vehicles.
Size of lift/tie'owns						Openings 3" to 8' weight dependent, 1-1/16" for aircraft extraction.
Clearance - lift/tiedowns						3" to 20" weight dependent. 2" for aircraft extraction.
Clearance - cargo to [illegible]rier						Varies with media.
Clearance - access						MILVAN - 7'-8" x 7'-3" C5A - 13'-6" x 19'-0" Boxcar - 7'-8" x 5'-6" C130 - 9'-1" x 10'-3" Van truck - 6'-6" x 7'-0" Victory ship - 22'-4" x 15'-4"
Clearance - route						Bridge (US) - 13-1/2' x 8', waterway (worldwide) - 11' x 7'-10", rail - 8'-4" x 8' (for 8' width)
B. Strength and Forces:						
Tiedown						2.5 x maximum shipping weight / No. of eye.
Lift						2.5 MHE/sling legs or 0.625 MSW (MIL-STD-209), 1.5 x working load (yield) (MIL-STD-814).
Suspension						1.65 x working load (yield)
Extraction						Up to 1.75 x working load (ultimate), weight dependent.
Drawbar						Design dependent.

	MODE					
	Rail	Air	Marine	Highway	Off Road	Critical Factors
						[illegible] 30%.
						Design dependent.
						Design dependent.
Floor loading						Varies with carrier: C133 Aircraft - 300-375 #/sq ft, up to 20,000# single axle load.
Stacking						Allow 3" between tiers for MHE access. Allow 6" vertical and 5" lateral in aircraft. Aisle widths for MHE access - 10 to 25 feet.
Environmental:						
Shock						Rail - 50 g @ 0.011 sec, highway - 10 g @ 0.083 sec, air - 12 g @ 0.1 sec, drops to 100 g.
Vibration						Rail - 4.8 g @ 2 Hz, sea - 0.8 g @ 14 Hz, air - 9 g @ 1000 Hz, highway - 9 g @ 7 Hz.
Acceleration						Various; for vehicles at bridge tunnels and RR tracks, 4.8 g @ 2.5 to 150 Hz.
Temperature						Extremes per AR 70-38.
Humidity						To 100% RH.
Altitude						To 100,000 feet.
Rainfall						To 12" per hour
Salt exposure						Salt fog - see MIL-STD-810. Natural seashore environment.
Operational						As specified.
Storage						8 Climatic categories - AR 70-38.
Interface						Specific terminals environments.
Performance:						
Mobility						Varies with media.
Endurance						MIL-STD-810, table 514-V, Vehicles. Rail - 3000-mile mainline haul. Marine - 20 days at sea.

	MODE					Critical Factors
	Rail	Air	Marine	Highway	Off Road	
Speed						60 mph maximum (highway).
Mileage						Typical: Rail 400, highway 500, air 4000 marine 2500, offshore 5, in terminals 0.2).
Footprint						Design dependent.
Ground pressure						Design dependent.
Turning radii						Varies with vehicle (26' for a tractor/trailer combination).
Slopes						On highway 11%, Off road - 60% forward 45% side.
Maneuverability						Design dependent.
Operational						As specified.
Actual transport						See "Mileage"
E. Compatibility:						
Ease of loading/unloading						TM instructions. Bed heights of vehicles - 18" to 56"
Towed or towing characteristics						Design dependent.
Mating of lift/tiedown points						Varies with media/modes/weight of cargo.
Intermodal mating						MHE, terminals gear, loading platforms, universal slings.
Adaptability, cargo to carrier						Clearances, effects on c.g., stability.
Personal tolerance						Noise levels, skill level, human factors, handles, grabs, weights.
Ease of operation						Various operating characteristics and conditions.
Ease of maintenance						AR 750-1.
F. Safety:						
Safety to handler						Guards, human factors, posted warnings.

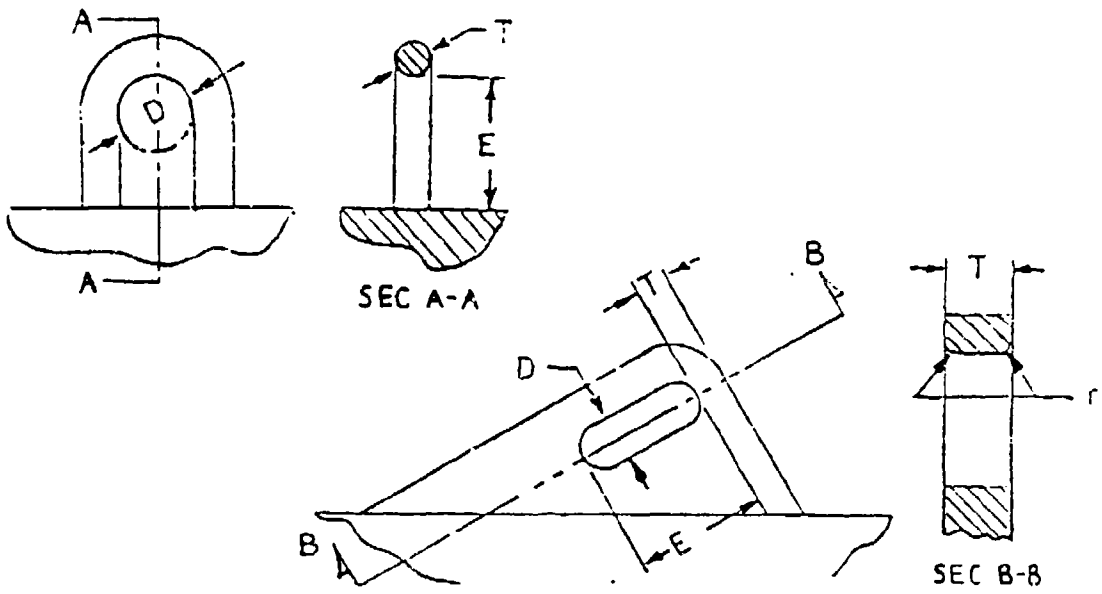
	MODE					
	Rail	Air	Marine	Highway	Off Road	Critical Factors
Safety to public						Lights, brakes, stopping distances.
Hazards						To personnel or to equipment.
Compliance with regulations						Various regulating agencies for each mode.
Safety equipment						Fire-fighting, lifesaving, protective clothing, security, pilferage.
Warnings/instructions						TM's, posted instructions, warning devices.
Safety release						Specialized to media or mode.
Escorts						Highway oversize, dangerous materials, convoy.

APPENDIX H
EXTERNAL HELICOPTER LIFT CRITERIA



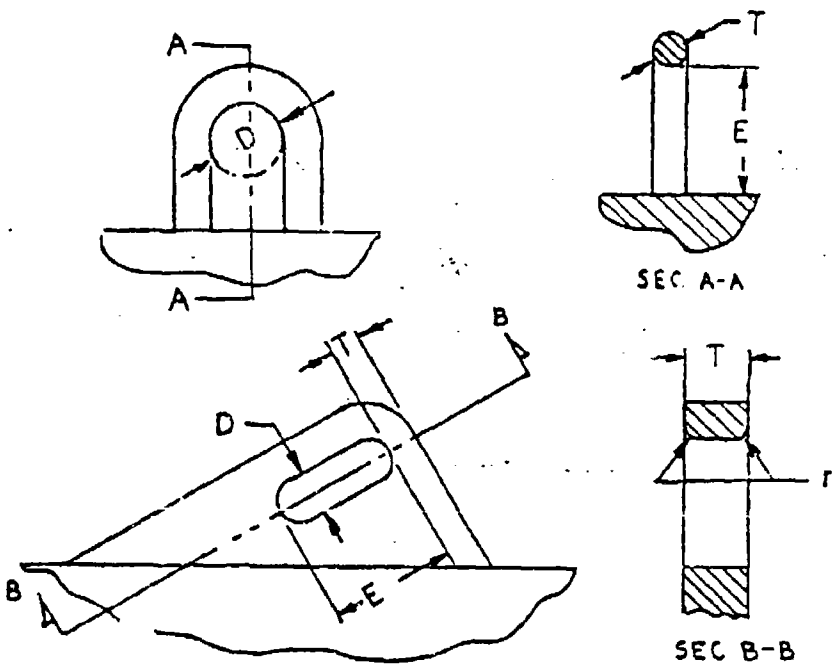
1 Lift Point	Weight Range of Materiel (Pounds)			
	Up to 11,200	11,200 to 22,400	22,400 to 49,280	49,280 to 72,000
D_{min}	2-3/8 in. (0.060 m)	3-7/16 in. (0.087 m)	5-7/16 in. (0.138 m)	5-13/16 in. (0.147 m)
E_{min}	2-9/16 in (0.065 m)	3-15/16 in. (0.100 m)	6-7/8 in. (0.174 m)	7-9/16 in. (0.193 m)
T_{max}	1-7/16 in. (0.036 m)	1-7/8 in. (0.047 m)	3-3/16 in. (0.081 m)	3-13/16 in. (0.096 m)
r_{min}	1/4 in. (0.006 m)	3/8 in. (0.009 m)	5/8 in. (0.016 m)	3/4 in. (0.019 m)

Figure 16. Fitting Dimensional Requirements - Single Point Suspension (1 Lift Point).



4 Lift Points	Weight Range of Materiel (Pounds)			
	Up to 11,200	11,200 to 22,400	22,400 to 49,280	49,280 to 101,000
D_{min}	1-1/4 in. (0.031 m)	1-3/4 in. (0.044 m)	2-7/8 in. (0.073 m)	4 in. (0.102 m)
E_{min}	1-7/8 in. (0.047 m)	2-13/16 in. (0.071 m)	3-3/8 in. (0.085 m)	6 in. (0.152 m)
T_{max}	15/16 in. (0.02[illegible] m)	1-7/16 in. (0.036 m)	1-3/4 in. (0.044 m)	2-7/8 in. (0.073 m)
r_{min}	3/16 in. (0.005 m)	5/16 in. (0.008 m)	3/8 in. (0.009 m)	5/8 in. (0.016 m)
3 Lift Points				
D_{min}	1-3/4 in. (0.044 m)	2 3/8 in. (0.060 m)	3-7/16 in (0.087 m)	4-7/16 in. (0.113 m)
E_{min}	2-1/16 in (0.053 m)	2-13/16 in. (0.071 m)	3-3/4 in. (0.095 m)	6-7/8 in. (0.174 m)
T_{max}	1-1/4 in. (0.031 m)	1-7/16 in. (0.036 m)	1-7/8 in. (0.047 m)	3-1/4 in. (0.082 m)
r_{min}	1/4 in (0.006 m)	5/16 in. (0.008 m)	3/8 in. (0.009 m)	11/16 in. (0.017)
2 Lift Points				
D_{min}	2 in. (0.051 m)	3-1/8 in. (0.079 m)	4-1/8 in. (0.105 m)	6 in. (0.152 m)
E_{min}	2-3/8 in. (0.060 m)	2-3/4 in. (0.070 m)	4 in. (0.102 m)	6 in. (0.152 m)
T_{max}	1-5/8 in. (0.041 m)	1-15/16 in. (0.049 m)	2-7/8 in. (0.073 m)	4 in. (0.102 m)
r_{min}	3/8 in. (0.009 m)	3/8 in. (0.009 m)	5/8 in. (0.016 m)	3/4 in. (0.019 m)

Figure 17. Fitting Dimensional Requirements - Single Point Suspension (2, 3, or 4 Lift Points).



4 Lift Points	Weight Range of Materiel (Pounds)			
	Up to 11,200	11,200 to 22,400	22,400 to 49,280	49,280 to 101,000
D_{min}	1-1/4 in. (0.031 m)	1-3/4 in. (0.044 m)	2-3/8 in. (0.060 m)	3-7/16 in. (0.087 m)
E_{min}	1-1/2 in. (0.038 m)	2-1/8 in. (0.053 m)	3-1/4 om/ (0.082 m)	4-1/2 in. (0.115 m)
T_{max}	7/8 in. (0.022 m)	1-1/8 in. (0.028 m)	1-11/16 in. (0.042 m)	2-9/16 in. (0.065 m)
r_{min}	3/16 in. (0.005 m)	1/4 in. (0.025 m)	3/8 in. (0.009 m)	1/2 in. (0.013 m)

Figure 18. Fitting Dimensional Requirements - Multipoint Suspension (4 Lift Points).