UM-HSRI-78-20

A BIOMECHANICAL EVALUATION OF NOTICE OF PROPOSED RULE-MAKING "STEP, HANDHOLD, AND DECK REQUIREMENTS ON COMMERCIAL MOTOR VEHICLES"

[BMCS Docket No. MC-58-1: Notice 78-311].
F.R. 43(32):6637-6640. February 15, 1978

By: Richard G. Snyder, Ph.D.
Head, Biomedical Department
Professor of Anthropology
Highway Safety Research Institute
The University of Michigan
Ann Arbor, Michigan 48109

Prepared for: The International Brotherhood of Teamsters
25 Louisiana Avenue, N.W.
Washington, D.C. 20001

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INTRODUCTION

The various measurements proposed in this NPRM have been evaluated from an anthropometry and biomechanical viewpoint, comparing the proposed specifications to other data where conflicts in design practice appear evident. Several specifications, relating to step height, step clearance and handhold clearance appear to be inadequate. Under some conditions step width may also be inadequate, particularly where steel rung rather than flat type steps are involved.

In researching the various specifications which follow the author had access to most of the known published anthropometric literature as well as the various human engineering design guides. Attached are pertinent sections from other federal or professional standards with which comparisons were made. In addition, because it was difficult to believe that there was so little relative objective data available, professional colleagues in government, industry, and the industrial engineering and anthropology academic community were also consulted to determine if there might be other applicable data. Various collations of measures taken in major studies were reviewed and the USAF AMRL anthropometric data bank of 21 population surveys including 309 variables were also cross-checked for applicable data. It was disappointing to find that the 1977 BMCS sponsored study of truck driver anthropometry did not apparently address a single one of the specifications proposed in this NPRM.

It appears that the specifications provided have evolved subjectively and have not considered the female driver nor adverse environmental factors such as snow, ice or mud debris accumulation effects upon the specifications. To objectively document the proposed specifications these measurements must be taken on a sample representative of male and female truckers.

DISCUSSION AND CONCLUSIONS

393.201 Cab Entry and Exit

(b) General rule. "Any person entering or exiting the cab of a high profile COE truck tractor shall be afforded sufficient steps and handholds to allow the user to have at least 3 limbs in contact with the tank tractor at any time."

Comment: This should be a useful safety requirement.

(c.1.i) Vertical height from ground level. "The first step shall be no more than 609 mm (24.0 in.) from ground level."

Comment: It should be noted that SAE Recommended Practice J185 (Access Systems for Construction and Industrial Equipment - 1970) which provides criteria for vehicle steps, grabrails, etc., states "5.1 The maximum height of the first step from the ground to the machine should not exceed 30 inches when the machine is in the normal parked condition. The preferred height of this step 16 in."

The attached copy of RCCC Recommended Practice RF-404 includes a Figure 7. "Vertical Ladder and Grabrail System" which lists as a source the U.S. Army MERADCOM, Fort Belvoir, Va. This also lists a "range of 16 to 23" inches and notes "(16 preferred)". This reference appears to be identical with Figure 14 "vertical ladder and grabrail system" found in Military Specification Sheet Body, Van, Vehicle-Mounted 150 Size 10, MIL-B-13207/1 (ME) dated 12 August 1976, and approved for use by the USA Mobility Equipment Research and Development Command (MERADCOM)" and is available for use by all Departments and Agencies of the Department of Defense."

OSHA apparently has not addressed first step height as yet in any of their standards.

Human factors engineering rule of thumb at Ford Motor Company is that step height should not exceed knee height, about 18", however I am unaware of any studies of step height involving measurement of male or female subjects at any of the MVMA companies.

The recent "Anthropometric Survey of Truck and Bus Drivers" sponsored by the Bureau of Motor Carrier Safety (attachment) not only did not consider step height, but also did not include any of the measurements proposed in this NPRM. Since that study was completed in February, 1977, it would seem to reflect very poor planning to have conducted a study which did not address such important measurements prior to issuing this NPRM.

This is particularly unfortunate since other than in the three specifications referenced above (SAE J185; PP-404 Fig. 7; MIL SPEC-13207/1 (ME)) no step height data appears to be available in the literature, with one exception. The recent University of Michigan study,of which I was principal investigator, "Anthropometry of Infants, Children, and Youths to Age 18 for Product Safety Design" under contract to the Consumer Product Safety Commission (Final report, May 31, 1977) did report on step height for 1200 children and youth from age 2 to 19 years. However these data cannot be considered representative of truckers.

Further, there is no indication that female physical measures or biomechanical capabilities have been considered in step height. Here the criteria should be to accommodate the lower range of step capabilities (within the ability of the female). These data appear to have been based upon the male maximum step height capabilities, but the female trucker also must be considered. At present objective measurements of such capabilities do not appear

to be in the published literature, but the subjective 24.0" step requirement appears more to accommodate the designer than the user and in my judgement would be difficult for the female and some older male drivers to reach safely. From the viewpoint of safely accommodating both male and female drivers the maximum first step height should probably be less than 24" and closer to 18". However, in the absence of objective tests, Army Mil. Spec. and SAE J185 recommendations stating that "16 inches is preferred" should be noted, and at least this statement should be added to the requirement, so that it reads:

"The first step shall be no more than 609 mm (24.0 in.) from ground level, but 406 mm (16.0 in.) is preferred."

(c,1,ii) Vertical height between steps. "The vertical height between steps up to and including the sill step shall comply with the "Step Spacing Chart" shown below":

Horizontal step offset	Vertical spacing between steps
0 mm (0 in) - 406 mm (16.0 in)	305 mm (12.0 in)
406 mm (16.0 in)-508 mm (20.0 in)	203 mm (8.0 in)
508 mm (20.0 in)-610 mm (24.0 in)	102 mm (4.0 in)
610 mm (24.0 in) or greater	0 mm (0 in)

Comment: OSHA standard (Title 29, XVII, Subpart D, No. 1910.27 b ii) specifies "The distance between rungs, cleats, and steps shall not exceed 12 inches and shall be uniform throughout the length of the ladder." OSHA also requires a 12" distance between steel rungs on individual-rung access ladders.

The Human Engineering Guide to Equipment Design Revised edition, 1972 (section attached pp. 457-46;) states only that "the optimum height between treads is from 11 to 12 in." (p. 459).

RCCC RP-404 Figure 7, and Mil. Spec. MIL-B-13207D(ME) (12 August, 1976) Figure 14, both state that "step vertical spacing range 10 to 16 (12 preferred)". RCC RP-404, in Section 4.2 notes "The maximum distance between steps of vertical ladders on machines shall not exceed 400 mm (16.0 in). The optimum distance between steps based on human factors is 300 mm (12 in.)."

The specifications proposed are not referenced as to what data they are based upon, however appear reasonable based upon the above information. Again, step and climb data for females have not been found, and until such measurements are taken on a representative population sample to determine their statistical step height capabilities the above specifications remain objectively undocumented.

(iv) Step Tread Depth. "Each step shall have a tread depth of at least 102 mm (4.0 in)."

RCCC RF-404, Figure 7, and Mil. Spec. MIL-B-13207D (ME) (12 August, 1976) Figure 14, both state "typical depth range for each step 5 to 7 in. serrated grating step surfaces". RF-404, section 4.6 stated more strongly "The desirable dimension for toe clearance from the outside edge of the step is 180 mm (7 in), and in no case shall it be less than 125 mm (5 in)."

Relative to stair depth, the Human Engineering Guide to Equipment Design (p. 461) states "The optimum tread depth is 9.5 to 10.5 in. plus a 1 to 1.5 in. overhang."

It is not clear why the 5-7" depth indicated in RCC RP-404 was reduced to 4" in the proposed rule, or what new data applies to this. While no information has been found to document that 4" is unsafe, human factors data referenced indicate that a larger tread depth is preferable.

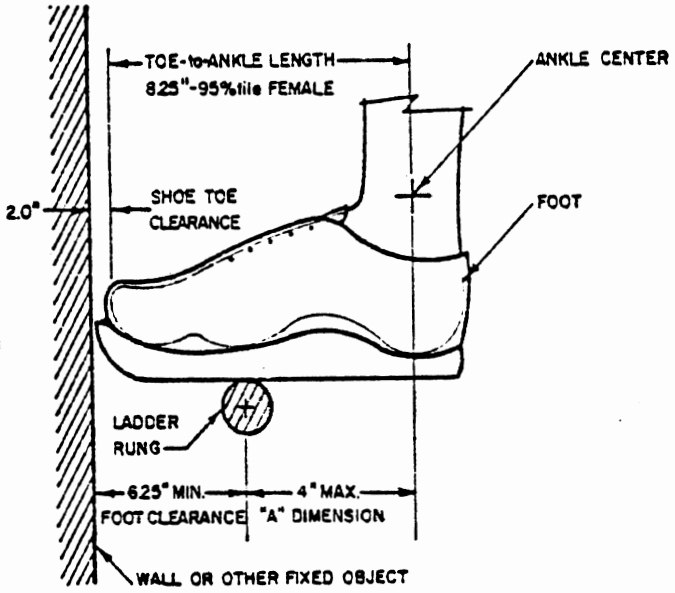
(v) Step Clearance. "There must be at least 51 mm (2.0 in) clearance between the back edge of the step and any part of the truck tractor to allow the user to step on the ball of his or her foot."

This clearance distance is much less than that specified in SAE 185 (SAE Recommended Practice. Access Systems for Construction and Industrial

Equipment (1970), which states" 5.6 The minimum toe clearance from the outside edge of the step should be 5 in. The preferred distance in 7 in.

Similarly, OSHA standard 29CFR Part 1919 Subpart D - walking and working surfaces - (5) relative to ladders specifies that in new ladders constructed after 1979 "the minimum shall be seven (7) inches (17.8 cm) unless physical limitations make a lesser distance, not less than four (4) inches (10.2 cm), necessary".

An unpublished study by Chaffin (1978) recommends that toe clearance for ladder rungs be 6.25 in. (based on a large (95th percentile) female foot length. The rationale for this relates to the biomechanics of maintaining the foot in a horizontal orientation when climbing. Muscle fatigue in climbing could lower a person's capability to maintain the desired foot orientation over time, given a 4" movement arm for 95% of women, and 7.5" for 95% of males from the ankle. Dempster (1963) has estimated that the ankle joint lies about 80% of the distance from the top of the greater toe to the most posterior aspect of the heel. This indicates that 95% of women would have toe to ankle lengths no greater than 8.25" (10.3 x .80), and 95% of men would be no greater than 9.0" (11.2 x .80). Randall (1946) has found that wearing a heavy work boot or shoe requires an additional 2" clearance. Thus the minimum foot clearance recommended would be 6.25" based upon a large (95th percentile) female foot length. While this analysis is based upon a steel ladder rung, this would apply directly to cab access steps of similar construction. This analysis assumes the male ankle strengths are sufficient to compensate for their larger moment arms caused by their larger feet. It has been found that a males's plantar extension strength averages twice that of the female (Chaffin, 1978).



(FOOT CLEARANCE DIMENSIONS (after Chaffin et al, 1978)

The proposed standard does not support why the RP-404 minimum of 5" has been further reduced, and what new data would support a change.

It is concluded that where rails or rungs are used as steps a 2.0 inch clearance is insufficient, and from the sources above 6 1/4 to 7" should be specified.

(A) Exception. "Any step with a tread depth of at least 153 mm (6.0 in) or more is not required to have step clearance."

The comments under iv (step tread depth) apply here. Consider to be marginally adequate but minimal.

(B) Exception. "A sill step with a tread depth of 102 mm (4.0 in) or more is not required to have step clearance."

No data available to evaluate this.

(vi) Step Width. "The first step shall have a tread width of at least 153 mm (6.0 in)...." "If the sill step is not at least 407 mm (16.0 in) wide with a tread depth of at least 153 mm (6.0 in) a step immediately below the sill step is required. This step shall be at least 305 mm (12.0 in) wide...."

This step width appears to be sufficient for one foot for the 99th percentile* population when street shoes or boots are worn. It may be inadequate in the case of a 99th percentile male wearing heavy boots when mud or snow caked. In addition, snow or ice debris accumulation may decrease the available foot space. Since normal design standards accommodate the 95th percentile for a particular measure, the minimum width of 6" appears to be reasonable under most conditions for a single foot, but totally inadequate for both feet.

Discussion: Neither the 1977 anthropometric survey of truck and bus drivers (Sanders, 1977), nor the HEW survey of the U.S. civil population (Stoudt et al, 1965), included foot breath. However review of 15 male U.S. military studies indicate a range of the width of the nude foot as ranging from 10.4 to 11.0 cm (4.0-4.3 inches) for the 99th percentiles. A factor of 0.3 inches for men's shoes, and boots or 1.2 inches or more for heavy boots is added to the bare measures (Van Cott et al, 1972, pp. 419). Thus the following shoe widths are indicated for the 16 populations:

4.3 to 4.6"	95th percentile, street shoes or boots
5.2 to 5.5"	95th percentile, heavy winter boots (flight type)
4.6 to 5.1"	99th percnetile, street shoes or boots
5.5 to 6.0"	99th percentile, heavy winter boots (flight type)

*Percentiles are values corresponding to 100 persons lined up from least to greatest in any given respect. Thus the 95th percentile is that value which exceeds 94 percent of the population and is exceeded by only 5 percent. Percentiles provide a basis for the designer to estimate the proportions of a group accommodated or inconvenienced by any specific design (Damon et al, 1968).

For the 95th percentile male (represented by these 15 studies) 0.5 to 1.8" clearance is available with a 6 inch step when wearing either street shoes or boots or even heavy flying type boots. A 0.5 inch clearance has been recommended in a recent OSHA study of ergonomic aspects of walking and working surfaces (29CFR Part 910, D).

Considering foot width at the 99th percentile level, 1.4 to 0.9" is available with a 6" wide step when street shoes or military style boots are worn, and 0.5 to 0" foot clearance when heavy winter flight type boots are worn. These data indicate that the 6 inch minimum step width is sufficient for 99 out of 100 truckers, for one foot, even when heavy winter boots are worn. This assumes that the foot width of truckers corresponds to that of the 15 military studies. While the BMCS anthropometry study did not measure foot width, this survey of truck and bus drivers found them to be "larger than the general civilian or military population and truck drivers measured 25 years before" (Sanders, 1977, i).

Additional consideration where steel rung type ladders are used anywhere on the vehicle is the effect of wind gusts. The mechanics of wind gusts in climbing have been described by Chaffin et al (1978) and Garg and Chaffin (1976). The wind load creates a pivoting action which must be compensated for by the hand and arm strength moment. It was concluded from these analysis that ladders which may expose the climber to high winds should be wider than the minimal anthropometric dimensions would indicate. A ladder rung width of about 16 inches is required in winds of 45 mph to provide an adequate lever-arm through which a person can exert sufficient arm strength to stabilize the body against rotation.

Where the trucker may have both feet on a step, a total lateral width of 12.7 inches is required to allow for both shoes and 1/2" for clearance. This

would not allow any tolerance for mud, snow, or ice (debris accumulation). ANSI standard A14, 3-1973 advocates a minimum lateral width of 16 inches, which would leave 3.3" for clearance.

In comparison, SAE J185 (5.4) states "It is preferred that all steps have the width capacity to hold both feet. The minimum width for such design is 12 in. The preferred width is 15 in."

Mil. Spec. MIL-B-13207D (ME), Figure 14, specifies for a 7.5" minimum width first step, 12" minimum step width for the second step, and 15" minimum width above that.

In view of these data, a proposed step tread width of 6" appears to be too narrow. Trucks following this minimum specification would not be acceptable for military procurement, since 7.5" minimum is required. It appears that 16" would be the best width, to allow for both feet, with 12" a minimum. This would also follow the 3-point contact rule where one hand must be used in some task.

These comments also apply to 393.202ve, rear of cab access, and 393.20 iv front of cab access, relative to step width.

(vii) Step Strength. "Each step must withstand the vertical static load, produced by the weight of a person of at least 204.1 Kilograms (450 pounds),...."

No available data found to indicate that this is not reasonable at this time. 95th percentile weight for male truckers (BMCS study) was 235 lbs. We have weighed one 505 lb. driver, but this would be beyond normal design range.

(ii) Height from Ground Level. "The dual handholds shall start no more than 1,524 mm (60.0in) from the ground level, One of the dual handholds nearest to the swinging edge of the cab door shall extend at least 1,219 mm (48.8 in) vertically from the door sill."

RCCC RP-404, (section 5.8) states "Grab rails or grab handles for access purposes shall begin at a maximum height of 1500 mm (58 in) above the ground when the machine is in a normal parked position. It is desirable that the grab rail continue to at least 900 mm (36 in) above the final step." Section 5.11 adds, "The desired grab rail height vertically above any step or inclined ladder is 900 mm (36 in)."

There is no justification provided to determine why the proposed specification goes to 60" minimum, rather than the 58" specified in RP-404.

Although the measurement is not strictly comparable, since it was measured from floor level with the right arm extended directly overhead (attachment), overhead reach measurements for 1905 Air Force females (Anthropometry of Air Force Women Clauser, C. et al, 1972, pp. 126-127) provide the following:

95th percentile overhead reach 213.28 cm (83.97")
50th percentile overhead reach 199.18 cm (78.42")
5th percentile overhead reach 185.19 cm (72.91")

These data suggest that the female, in this population at least, could easily reach one handle 60" from ground level. However, the measurements are not strictly compatible and the diameter of the grip object was only pencil diameter. Moving to a frontal overhead reach posture, with larger diameter grip demands, would reduce the reach capabilities listed.

The criteria for this specification should at least be designed about the 5th percentile male and female for reach/grip capability, as 95% of the population would then be expected to reach the handholds. A 1% criteria would include 99% of the truckers. But this is a measurement which also should be

taken on a representative sample in order to objectively determine the specifications needed.

(iii) Exterior Mounting Specifications. "Each handhold, affixed exterior of the vehicle, shall have at least 51 mm (2.0 in) clearance between the surface on which it is mounted and the handhold."

RCCC RP-404 (Section 5.5) specifies "The minimum hand clearance of all grab rails and grab handles shall be 75 mm (3 in) to all surfaces."

MIL-B-13207D (ME) specifies a minimum hand clearance of 3 inches to all surfaces (Fig. 14).

SAE J925 ("Minimum Access Dimensions for Construction and Industrial Machinery") (attached) provides minimum recommended minimum openings for the hand "95th percentile" as 4.0 inches for the bare ("empty") hand, and 5.5 inches for the gloved hand.

OSHA (1910.27) (5) states "Clearance in back of grab bar. The distance from the centerline of the grab bar to the nearest permanent object in back of the grab bars shall be not less than 4 inches...."

An anthropometric survey of the hand by Garnett (1971) found the extended bare hand thickness at the 3rd metacarpel to be 1.42 in. for 95% of the population. However, for wool or leather gloves 0.2 in. must be added to this value (Van Cott and Kinkade, 1972), increasing hand thickness to 1.62 in. Although no data are available on the increase in thickness as a result of hand flexion, a clearance of 1.62 in. allows the gloved and extended hand to fit between the handrail and wall with no clearance. Chaffin (1978) has estimated that it would require 2.25 in clearance to prevent the knuckles from contacting the wall. However he recommends a finger clearance of 4 5/8" (11.75 cm) from any other object, (1978).

SAE Recommended Practice J185 (6.5) specifies that "the minimum hand clearance of all grab rails and grab irons should be 3 in. to all surfaces" (1970).

It is concluded that the 2.0 in. proposed specification is inadequate particularly for the gloved trucker, and that 4 5/8 to 5.5 in. is more valid. No other recommended guideline found concurs with a 2 in. minimum proposed.

(v) Size and Shape. "Each hand hold shall be free of sharp edges and have a circumference no greater than 119.6 mm (4.71 in) nor less than 59.8 mm (2.36 in).

Military specification MIL-B-13207D (ME) specifies a 3/4 in. diameter minimum and 1 1/2 in. diameter maximum for grab rails - (Fig. 14, attached).

In unpublished work Chaffin (1978) recommends that handrail circumference should be no less than 4.4 in. (11.2 cm), and no greater than 5.2 in. (13.2 cm). For cylindrical rails, he recommends a diameter of 1.4 in. (3.6 cm) and no greater than 1.65 in. (4.2 cm). However these data are relative to stair rails.

It is not known on what data the proposed specification is based, but there seems to be no specific agreement on the optimal measurements for the handholds, with some specifiations involving diameters and others circumferences. More information is needed to make a recommendation.

(vi) Handhold Strength. "Each handhold shall be solidly affixed to withstand the static load, produced by the weight of a person of at least 113.4 kg (250 lbs), in any direction with a deflection of no more than 5 mm (0.2 in) in any direction."

This appears reasonable in view of an estimated 95th percentile truck driver clothed body weight of 235 lbs., but no further judgement can be made without test data.

Part 393.202 Rear of Cab Access, and

Part 393.203 Front of Cab Access

The preceding discussion and conclusions relative to the various measurements also apply to the applicable portions of these two parts of the proposed rules. Three differences should be commented on:

(1) 393.202 Rear of Cab Access. (vi) Step Width

"Each step shall have a tread width of at least 204 mm (8.0 in)...."

This is 2 in. greater than proposed for cab entry and exit and also for front of-cab access, both of which are proposed at 6 in. No reason is given for this, but on what basis of facts were these different specifications promulgated? In any case, the prior comments on step width also apply: 8" is inadequate.

(2) 393.203 Front of Cab Access. (2)(i) Height from Ground Level.

"The lowest part of any handhold shall be no more than 1828 mm (72 in) from ground level".

It is also not clear why this differs from "Cab Entry and Exit" (393.201 (2)(ii) or "Rear of Cab Access" (393.202 (2)(i), both of which propose 1524 mm (60.0 in) from ground level. See previous comments for this specification.

(3) 393.203 Front of Cab Access (B) Step Tread Area.

"Each step must have a bearing surface tread area of at least 7,742 mm^2 (12.0 in^2)."

This appears minimal, but would depend upon type of step whether adequate.

APPENDIX

Attachments:

1. Department of Transportation. Federal Highway Administration, Parts and Accessories Necessary for Safety Operation. "Step, Handhold, and Deck Requirements on Commercial Motor Vehicles" BMCS Docket No. MC-58-1; Notice 78-3. 49 CFR Part 393. Federal Register 43(32):6637-6640. February 15, 1978.

2. RCCC Recommended Practice RP-404 Cab Mounting Steps, developed by the Cab and Driver Study Group of the ATA Regular Common Carrier Conference Maintenance Committee. January, 1976.

3. Pertinent portions of OSHA requirements. Steps and Ladders. Title 29 Labor. Chapter XVII - Occupational Safety and Health Administration, Subpart D - Walking-Working Surfaces, pp. 8-55.

4. Military Specification, Body, Van, Vehicle-Mounted, General Specification for. MIL-B-13207D (ME) superseding MIL-B-13207C (ME) (of 9 July, 1970). 12 August, 1976.

5. Society of Automotive Engineers. SAE Recommended Practice - SAE J185. Access Systems for Construction and Industrial Equipment. July, 1970.

6. Sanders, M.S. Anthropometric Survey of Truck and Bus Drivers: anthropometry, control reach and control force. Final Report, Contract DOT-FH-11-8817, Federal Highway Administration, Bureau of Motor Carrier Safety, Washington, D.C. Prepared by Canyon Research Group, Inc, Westlake Village, Calif. (Executive Summary/selected pages) 1 March, 1977.

7. Society of Automotive Engineers. SAE Recommended Practice - Minimum Access Dimensions for Construction and Industrial Machinery - SAE J925. July, 1965.

8. Clauser, C.E. et al Anthropometry of Air Force Women Aerospace Medical Research Laboratorys, Wright-Patterson Air Force Base, Ohio. Report AMRL-TR-70-S. pp. 126-127. April, 1972.

9. Human Engineering Guide to Equipment Design (Revised edition) H. P. Van Cott and R. G. Kindade (eds). American Institutes for Research, Washington, D.C. pp. 459-463. 1972.

Proponent(s) will be expected to answer whatever questions are presented in initial comments. The proponent of a proposed assignment is also expected to file comments even if it only resubmits or incorporates by reference its former pleadings. It should also restate its present intention to apply for the channel if it is assigned, and, if authorized, to build the station promptly. Failure to file may lead to denial fo the request.

3. *Cut-off procedures.* The following procedures will govern the consideration of filings in this proceeding.

(a) Counterproposals advanced in this proceeding itself will be considered, if advanced in initial comments, so that parties may comment on them in reply comments. They will not be considered if advanced in reply comments. (See § 1.420(d) of Commission Rules.)

(b) With respect to petitions for rule making which conflict with the proposal(s) in this Notice, they will be considered as comments in the proceeding, and Public Notice to this effect will be given as long as they are filed before the date for filing initial comments herein. If they are filed later than that, they will not be considered in connection with the decision in this docket.

4. *Comments and reply comments; service.* Pursuant to applicable procedures set out in § 1.415 and 1.420 of the Commission's rules and regulations, interested parties may file comments and reply comments on or before the dates set forth in the Notice of Proposed Rulemaking to which this Appendix is attached. All submissions by parties to this proceeding or persons acting on behalf of such parties must be made in written comments, reply comments, or other appropriate pleadings. Comments shall be served on the petitioner by the person filing the comments. Reply comments shall be served on the person(s) who filed comments to which the reply is directed. Such comments and reply comments shall be accompanied by a certificate of service. (See § 1.420 (a), (b) and (c) of the Commission Rules.)

5. *Number of copies.* In accordance with the provisions of § 1.420 of the Commission's rules and regulations, an original and four copies of all comments reply comments, pleadings, briefs, or other documents shall be furnished the Commission.

6. *Public inspection of filings.* All filings made in this proceeding will be available for examination by interested parties during regular business hours in the Commission's Public Reference Room at its headquarters, 1919 M Street, NW., Washington, D.C.

[FR Doc. 78-4145 Filed 2-14-78; 8:45 am]

[4910-22]

DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

[49 CFR Part 393]

[BMCS Docket No. MC-58-1; Notice 78-3]

PARTS AND ACCESSORIES NECESSARY FOR SAFETY OPERATION

Step, Handhold, and Deck Requirements on Commercial Motor Vehicles

AGENCY: Federal Highway Administration, DOT.

ACTION: Notice of Proposed Rulemaking.

SUMMARY: Public comments are sought on a proposal to amend the Federal Motor Carrier Safety Regulations applicable to motor vehicles manufactured after January 1, 1981, to require (1) step, deck, and handhold requirements on high profile cab-over-engine (COE) type tractors: (2) step, handhold, and deck requirements on the rear of all other truck tractors; and (3) step, and handhold requirements on the front of trucks as well as all truck tractors. Slips and falls are a substantial problem in the motor carrier industry. The proposal to afford the driver and other personnel with three points of contact on high profile COE truck tractors will serve to provide increased stability and safety. The requirements regarding front and rear access will also provide safe working surfaces in other critical areas.

DATE: Comments must be received on or before May 16, 1978.

ADDRESS: Submit comments (original and 2 copies) to: BMCS Docket No. MC-58-1; Notice No. 78-3, Room 3402, Bureau of Motor Carrier Safety, Federal Highway Administration, Department of Transportation, 400 Seventh Street SW., Washington, D.C. 20590.

FOR FURTHER INFORMATION CONTACT:

Gerald J. Davis, Chief, Driver Requirements Branch, Bureau of Motor Carrier Safety, 202-426-9767; Principal Lawyer, Attorney, Gerald M. Tierney, Motor Carrier and Highway Safety Law Division, Office of Chief Counsel, 202-426-0834; Federal Highway Administration, Department of Transportation, Washington, D.C. 20590. Office hours are from 7:45 a.m. to 4:15 p.m. e.s.t., Monday through Friday.

SUPPLEMENTARY INFORMATION: This Notice of Proposed Rulemaking proposes to issue specific requirements for steps, handholds, and deck plating to afford individuals increased stability and safety while entering and exiting the cab and while performing work-related duties on other areas of the vehicle. The requirements for the high profile COE truck tractors basically set forth details as to the number, location, size and type of steps and handholds to allow a person to have three limbs on the system at all times, including transition between intermediate positions.

The criteria for this proposal is based on the "Recommended Practice 404" developed by the Cab and Driver Study Group of the ATA Regular Common Carrier Conference Maintenance Committee, as well as other prior recommended designs.

NEED FOR IMPROVEMENT

As far back as 1966 and 1967 the high percentage of workmen's compensation cases, attributed to getting in and out of the cab, attracted attention. A study issued in 1967 by Liberty Mutual Insurance Company of Boston, Massachusetts, indicated that falls from tractors amounted to 25.3 percent, 22.2 percent and 16.0 percent of total human on-job injuries for three large motor carriers. Although driver trainers were spending a considerable amount of time training new drivers on proper mounting and dismounting techniques, efforts were not entirely successful because of the poor design of most step and grab-handles, especially on COE models. Information supplied to the Department of Transportation by several motor carriers showed that, slips and falls accounted for 20 percent of all injuries sustained by drivers. In a separate study done by the Transportation Safety Association of Ontario, Canada, it was reported that slips and falls in and around motor vehicles accounted for 40 percent of the total of all types of slip and fall accidents in their association. It was also reported that there was evidence that particular troublesome problems occurred, and were most severe, in the case of trailers and semi-trailers used to haul automobiles and in tank vehicles.

ADVANCE NOTICE OF PROPOSED RULEMAKING

As a result of evidence reported, an Advance Notice of Proposed Rulemaking was issued on May 21, 1974, with the purpose of soliciting comments on whether nonslip surfaces and handholds should be made mandatory on equipment operated in interstate or foreign commerce.

The majority of comments indicated that further proof was needed that slips and falls were occurring frequently enough to warrant a regulation. In an effort to be responsive to these comments, further accident information was sought before developing a mandatory regulation. Several sources were investigated, including State organizations, transportation insurance groups, labor statistics offices and other safety organizations. However,

the information obtained was not detailed. It was concluded, as a result of unsuccessful attempts to obtain precise, specific data, that an actual slip and fall survey and analysis should be conducted.

Slips and Falls Survey

The Bureau of Motor Carrier Safety conducted a "Slips and Falls" survey and analysis during the period of December 1975 to August 1976. A total of 46 carriers were surveyed, centering on four types of vehicles (cargo tanks, car carriers, vans, and flat bed or heavy hauling equipment). The statistics and information were collected for the year 1974. Approximately 22,000 employees' records were reviewed. Detailed information was collected on each slip and fall, including, medical costs, workmen's compensation costs, part of the body injured, person's age, environment, part of the vehicle where injury occurred and type of equipment used. Other areas of concern were also discussed with carrier representatives, namely, various types of non-slip surfaces being used, training and retraining of drivers regarding proper entry/egress, incentive awards for safety practices, workmen's compensation costs for different States, and improvements made as a result of some costly slips and falls. Pictures were also taken of equipment being used.

The results of the survey indicated:

1. Slips and Falls accounted for 14 percent of all driver personal injury accidents and 9 percent of all carriers' personal injury accidents.
2. Slip and Fall medical costs accounted for 11 percent of carriers' total medical costs.
3. Slip and Fall workmen's compensation costs accounted for 10 percent of carriers' total workmen's compensation costs.
4. Approximately 54 percent of the slip and fall incidents happened on the tractor or driver area and 46 percent happened on the trailer or cargo area.
5. Tank carriers had the highest percentage of driver slips and falls (23 percent); followed by auto transporters (14 percent); van-type (11 percent); and flat bed (9 percent).

Costs Associated With Personal Injury Accidents

According to information published by the American Trucking Associations, Inc., employee injuries are up 50 percent from 1968 to 1974; average injury costs have quadrupled since 1970; and the 1973 compensation costs are up 75 percent compared to 1968. Their estimate of an average injury was $1,409.27 for 1975, and that the most frequent cause of injury was falling. The average maximum compensation benefit, nationwide, is now $136.95 per week, compared to $78.82 in 1970—and it is considerably higher in some States. Even heavier compensation expenses are forecasted.

Like the tip of an iceberg, the insured costs of accidents are only a small part of the total costs. Accidents directly affect profit and loss, and may even involve the company's ability to stay in business. Along with the cost of workmen's compensation, there is the loss of employee's services, knowledge and experience and the resulting loss in productivity, as well as the cost of hiring and training replacement labor. An accident also may lower employee morale, which could affect efficiency.

The recent survey indicated the following cost data:

1. Medical costs ranged from 0 to $6.039.15 per individual slip and fall case.
2. Compensation costs ranged from 0 to $8,834 per individual slip and fall case.
3. The combined medical/compensation costs ranged from 0 to $14,873.15 per individual slip and fall case.
4. The average combined medical cost/compensation cost of slip and fall incidents was $290.92.

These costs take into account only the medical and compensation figures paid out. It is reasonable to assume that the actual costs of each slip and fall are considerably more when the other costs mentioned are considered.

Discussion of Proposed Rule

In the preparation of the proposed sections regarding cab entry/exit, rear of cab access and front of cab access, appropriate literature from several sources has been consulted. The references include, (1) Liberty Mutual Study, Driver Falls While Mounting or Dismounting Cab Over Engine Tractor Trailer Cabs, Charles H. Irvine, March 10, 1967; (2) Recommended Practice No. 404, ATA, Regular Common Carrier Conference, Cab and Driver Study Group, January 1976; (3) SAE J185, Access Systems for Construction and Industrial Equipment, Part II SAE Handbook 1977; (4) SAE J833a, U.S.A. Male and Female Physical Dimensions for Construction and Industrial Equipment Design, Part II, SAE Handbook 1977; (5) U.S. Army Specification, Body Van, Vehicle-Mounted, General Specifications For, MIL-B-13207D (ME) CX1966, 12 August 1976; and (6) Human Factors Engineering Guide to Equipment Design, Joint Army-Navy-Air Force Steering Committee, 1972. While the proposed rule does not directly reflect any one of these references exactly, it does represent the most appropriate aspects of all of them. what results is an already proven set of requirements that represents the best design practices the industry can expect.

The requirements are in no way intended to be design restrictive but rather are intended to encourage manufacturers to include in their designs, accommodations for drivers while on the vehicle.

The proposed regulations are, like all the Federal Motor Carrier Safety Regulations, minimum requirements. It is hoped that where more stringent requirements are recommended improvements will be made. The development of RP 404 indicates that need for a better step/handhold system.

The requirements of RP 404 with regard to cab entry/exit have been similarly adopted in our proposed amendment. Our first attempt in the cab entry/exit area is directed at high profile COE truck tractors, as preliminary indications revealed this type vehicle is more prone to driver slips and falls. It is believed that the system proposed, i.e., to have 3 limbs in contact with the truck tractor at any time, including transition between intermediate positions, will insure a safe, stable means for the driver to climb into or descend from the cab of the high profile COE.

Although the vertical height from ground level has been minimally proposed at 610 millimeters (24.0 inches) the 5th percentile group may not comfortably reach this step. However, as mentioned earlier the proposed regulation is minimum.

Access to the rear of the vehicle and the front of the vehicle has not been limited to high profile COE's. There must be a safe access to the front area of all truck tractors and trucks in order to perform such duties as window washing, checking water and oil levels, and to raise the hood on conventional type vehicles.

If electrical and air connections can be reached from the ground level, thereby eliminating the need to climb upon the rear section, the step, handhold and deck plating requirements will be nil.

With regard to construction material, it is believed that self-cleaning material is necessary to prevent element build-up. The material should have no sharp edges, and openings must be such to prevent finger entrapment. Since door sills are used as steps it is being proposed that slip retardant material, commonly used on sill steps, will be acceptable. Although step construction is important, step spacing, depth, and clearance requirements are also necessary.

The proposed handhold requirements are also needed. A person should be able to reach the handhold before ascending. The proposed spacing requirements should provide a balanced comfortable system for any driver.

The proposed strength requirements are needed to ensure that all handholds, steps, and plates will support not only the weight of the individual, but meet certain rigidity requirements for purposes of stability. Without the deflection requirements, the handholds, steps, or plates could flex or

give, thereby jeopardizing the stability of the individual. It should also be noted that the strength requirements have been given in terms of "weight" rather than "mass" that produces a load or force, so as to provide a better understanding to the average individual.

In consideration of the foregoing, it is proposed to amend Chapter III of Subtitle B in Title 49, Code of Federal Regulations by adding a new Subpart J to Part 393 to read as follows:

Subpart J—Step, Handhold and Deck Requirements on Commercial Motor Vehicles

Sec.
393.200 Purpose and scope.
393.201 Cab entry and exit.
393.202 Rear of cab access.
393.204 Front of cab access.

AUTHORITY: Sec. 204, 49 Stat. 546 as amended (49 U.S.C. 304); sec. 6, Pub. L. 89-670; 80 Stat. 937 (49 U.S.C. 1655); 49 CFR 1.48 and 49 CFR 301.60.

Subpart J—Step, Handhold and Deck Requirements on Commercial Motor Vehicles

§ 393.200 Purpose and scope.

This subpart prescribes step, handhold and deck requirements on commercial motor vehicles. These requirements are intended to enchance the safety of motor carrier employees.

§ 393.201 Cab entry and exit.

(a) *Application of the rule in this section.* The section applies to all high profile COE truck tractors (floor height from ground greater than 1.016 millimeters (40.0 inches) manufactured on and after January 1, 1981).

(b) *General rule.* Any person entering or exiting the cab of a high profile COE truck tractor shall be afforded sufficient steps and handholds to allow the user to have at least 3 limbs in contact with the tank tractor at any time. This rule applies to intermediate positions as well as transition between intermediate positions during cab entry and exit.

(c) *Specifications.* All high profile COE truck tractors with seats on both sides of the vehicle shall be equipped on both sides of vehicle with—

(1) Steps of a sufficient number to afford safe and easy access and meet the following minimum requirements:

(i) *Vertical height from ground level.* The first step shall be no more than 609 mm (24.0 in) from ground level.

(ii) *Vertical height between steps.* The vertical height between steps up to and including the sill step shall comply with "Step Spacing Chart" shown below:

STEP SPACING CHART

If horizontal step offset is—*	*The vertical spacing between steps must be no more than—*
At least 0 mm (0 in) but less than 406 mm (16.0 in).	305 mm (12.0 in).
At least 406 mm (16.0 in) but less than 508 mm (20.0 in).	203 mm (8.0 in).
At least 508 mm (20.0 in) but less than 610 mm (24.0 in).	102 mm (4.0 in).
At least 610 mm (24.0 in) or greater.	0 mm (0 in).

*Horizontal step offset equal the horizontal distance between step midplanes.

(iii) *Construction material.* Each step shall be constructed of or covered with a self-cleaning safety material. Openings in the safety material shall be of a size that will prevent finger entrapment and be free of sharp edges. *Exception.* The sill step must be covered with a slip retardant material, but it does not have to be self-cleaning;

(iv) *Step tread depth.* Each step shall have a tread depth of at least 102 mm (4.0 in).

(v) *Step clearance.* There must be at least 51 mm (2.0 in) clearance between the back edge of the step and any part of the truck tractor to allow the user to step on the ball of his or her foot.

(A) *Exception.* Any step with a tread depth of at least 153 mm (6.0 in) or more is not required to have step clearance.

(B) *Exception.* A sill step with a tread depth of 102 mm (4.0 in) or more is not required to have step clearance.

(vi) *Step width.* The first step shall have a tread width of at least 153 mm (6.0 in). The width of succeeding steps shall increase and be located closer to the door sill as you ascend. If the sill step is not at least 407 mm (16.0 in) wide with a tread depth of at least 153 mm (6.0 in) a step immediately below the sill step is required. This step shall be at least 305 mm (12.0 in) wide, with the rear of the step (with respect to the front of the truck tractor) no farther forward than a line drawn vertically from the forward edge of the driver's seat in its rearward most position. This step shall also meet the requirements in subparagraphs (1)(iii), (1)(iv), (1)(v) and (2)(vii) of this section.

(vii) *Step strength.* Each step must withstand the vertical static load, produced by the weight of a person of at least 204.1 kilograms (450 pounds), at any point on the tread with a vertical deflection of no more than 5mm (0.2 in) at any point on the tread and be affixed in such a manner that there will be no horizontal movement of the step or tread.

(2) Handholds of a sufficient number and design to afford safe and easy access and meet the following minimum requirements:

(i) *Location.* Dual handholds must be located directly above the first step to enable a person to reach the handhold before he begin his ascent. Additionally, a handhold must be located at or immediately above the top of the door envelope and extend from the rear of the door envelope forward, at least two-thirds of the door envelope's width.

(ii) *Height from ground level.* The dual handholds shall start no more than 1,524 mm (60.0 in.) from the ground level. One of the dual handholds nearest to the swinging edge of the cab door shall extend at least 1,219 mm (48.8 in) vertically from the door sill;

(iii) *Exterior mounting specifications.* Each handhold, affixed exterior of the vehicle, shall have at least 51mm (2.0 in) clearance between the surface on which it is mounted and the handhold.

(iv) *Unobstructed length.* Each handhold shall be mounted without obstructions or mid-brackets to allow continuous movement to the hand over the entire length;

(v) *Size and shape.* Each handhold shall be free of sharp edges and have a circumference no greater than 119.6 mm (4.71 in) nor less than 59.8 mm (2.36 in). *Exception.* Recessed handholds, pre-formed into the inside of the cab body may be used only if they are designed in a manner that will afford safe and easy use and meet the requirements set forth in subparagraphs (2)(i), (2)(iii), and (2)(v) of this section.

(vi) *Handhold strength.* Each handhold shall be solidly affixed to withstand the static load, produced by the weight of a person of at least 113.4 kg (250 lbs), in any direction with a deflection of no more than 5 mm (0.2 in) in any direction.

§ 393.202 Rear of cab access.

(a) *Application of the rule in this section.* This section applies to all truck tractors manufactured on and after January 1, 1981.

(b) *General rule.* When a person is required to climb upon the rear portion of a truck tractor to couple or uncouple air and electrical connections, the truck tractor shall be equipped with—

(1) Steps of a sufficient number to afford safe and easy access and meet the following minimum requirements.

(i) *Vertical height from ground level.* The first step shall be no more than 609 mm (24.0 in) from ground level;

(ii) *Vertical height between steps.* Vertical distances between steps shall comply with the "Step Spacing Chart" shown in § 393.201 of this chapter;

(iii) *Construction material.* Each step shall be constructed of or covered with a self-cleaning safety material. Openings in the safety material shall be of a size that will prevent finger entrapment and be free of sharp edges;

(iv) *Step tread depth.* Each step shall have a tread depth of at least 102 mm (4.0 in);

(v) *Step clearance.* There must be at least 51 mm (2.0 in) clearance between

the back edge of the step and the vehicle to allow the user to step on the ball of his or her foot. *Exception.* Any step with a tread depth of at least 153 mm (6.0 in) or more is not required to have step clearance;

(vi) *Step width.* Each step shall have a tread width of at least 204 mm (8.0 in); and

(vii) *Step strength.* Each step must withstand the vertical static load, produced by the weight of a person of at least 204.1 kg (450 lbs), at any point on the tread with a vertical deflection of no more than 5 mm (0.2 in) at any point on the tread and be affixed in such a manner that there will be no horizontal movement of the step or tread.

(2) Handholds of a sufficient number number and design to afford safe and easy access and meet the following minimum requirements:

(i) *Height from ground level.* The lowest part of any handhold shall be no more than 1,524 mm (60.0 in) from ground level;

(ii) *Exterior mounting specifications.* Each handhold, affixed exterior of the vehicle, shall have at least 51 mm (2.0 in) clearance between the surface on which it is mounted and the handhold;

(iii) *Unobstructed length.* Each handhold shall be mounted without obstructions of mid-brackets to allow continuous movement of the hand over the entire length;

(iv) *Size and shape.* Each handhold shall be free of sharp edges and have a circumference no greater than 119 mm (4.7 in) nor less than 61 mm (2.4 in). *Exception.* Recessed handholds preformed into the tractor body may be used only if they are designed in a manner that will afford safe and easy use and meet the requirements set forth in subparagraphs (2)(i), (2)(iii), and (2)(v) of this section.

(v) *Handhold strength.* Each handhold shall be solidly affixed to withstand the static load, produced by the weight of a person of at least 113.4 kg (250 lbs), at any point in any direction with a deflection of no more than 5 mm (.2 in) at any point in any direction.

(3) deck plates, mounted on the rear of the truck tractor in all areas where the driver must step or stand in order to provide safe footing and meet the following minimum requirements:

(i) *Construction material.* Each deck plate shall be constructed of, or covered with a self-cleaning safety material. Openings in the safety material shall be of a size that will prevent finger entrapment and be free of sharp edges;

(ii) *Mounting.* Each deck plate shall span the distance between the frame or frame extension brackets in such a manner that it can be held in place with a type of hold down device(s) that will allow ready removal for vehicle service; and

(iii) *Deck plate strength.* Each deck plate must be capable of withstanding the vertical static load, produced by the weight of a person of a least 204.1 kg (450 lbs), at any point with a vertical deflection at any point of no more than 5 mm (.2 in).

§ 393.203 Front of cab access.

(a) *Application of the rule in this section.* This section applies to all trucks and truck tractors manufactured on and after January 1, 1981.

(b) *General rule.* When a person is required to climb upon the front of a truck or truck tractor, the vehicle shall be equipped with—

(1) steps of a sufficient number to afford safe and easy access and meet the following minimum requirements:

(i) *Vertical height from ground level.* The first step shall be no more than 609 mm (24.0 in) from ground level. any succeeding steps shall comply with the "Step Spacing Chart" shown in § 393.201:

(ii) *Construction material* Each step shall be constructed of or covered with an anti-slip material. Any openings in the tread surface shall be of size that will prevent finger entrapment and be free of sharp edges;

(iii) *Steps preformed within bumper*—(A) *Tread width.* Each step shall have a tread width of at least 153 mm (6.0 in);

(B) *Step tread area.* Each step must have a bearing surface tread area of at least 7,742 mm^2 (12.0 in^2);

(C) *Prevention of liquid build-up.* The step tread area must be perforated or sloped downwardly with respect to the horizontal plane no less than .0873 rad (5°) nor more than .1745 rad (10°);

(D) *Step clearance.* There shall be sufficient clearance between the back edge of each step and any other surface to allow any person to place the ball of his or her foot on the step tread area; and

(E) *Step strength.* Each step must withstand the vertical static load, produced by the weight of a person of at least 204.1 kg (450 lbs), at any point with a vertical deflection of no more than 5 mm (.1 in) at any point on the tread and be affixed in such a manner that there will be no horizontal movement of the step or tread;

(iv) *Step preformed or attached to exterior of bumper*—(A) *Tread width.* Each step shall have a tread width of at least 153 mm (6.0 in).

(B) *Step tread area.* Each step must have a bearing surface area of at least 11,613 mm^2 (18.0 in^2);

(C) *Step clearance.* There shall be sufficient clearance between the back edge of the step and any other surface to allow any person to place the ball of his or her foot on the step tread area: *Exception.* Any step with a tread depth of at least 153 mm (6.0 in) or more is not required to have step clearances.

(D) *Step strength.* Each step must withstand the vertical static load, produced by the weight of a person of at least 204.1 kg (450 lbs), at any point on the tread and be affixed in such a manner that there will be no horizontal movement of the step or tread; and

(v) *Bumper.* The top of any bumper that is used as a stepping or standing surface must be covered with an anti-slip material.

(2) handholds of a sufficient number and design to afford safe and easy access and meet the following minimum requirements;

(i) *Height from ground level.* The lowest part of any handhold shall be no more than 1828 mm (72 in) from ground level.

(ii) *Clearance.* Each handhold shall have at least 51 mm (2 in) clearance between the surface on which it is mounted and the handhold;

(iii) *Size and shape.* Each handhold shall be free of sharp edges and have circumference no greater than 119.6 mm (4.71 in) nor less than 59.8 mm (2.36 in).

(iv) *Handhold strength.* Each handhold shall be solidly affixed to withstand the static load, produced by the weight of a person of at least 113.4 kg (250 lbs), in any direction with a deflection of no more than 5 mm (.1 in) in any direction.

Interested persons are invited to submit their views on these proposals. Communications should identify the docket number and the notice number which appear at the beginning of this notice.

All comments received will be available for examination by interested persons at the Bureau of Motor Carrier Safety, Room 3402, Department of Transportation, 400 7th Street SW., Washington, D.C., 20590.

(Sec. 204, 49 Stat. 546 as amended (49 U.S.C. 304); sec. 6, Pub. L. 89-670; 80 Stat. 937 (49 U.S.C. 1655); 49 CFR 1.48 and 49 CFR 301.60.)

NOTE.—It has been determined that this document does not contain a major proposal requiring preparation of an Economic Impact Statement under Executive Order 11821 and 11949 and OMB Circular A-107.

Issued on February 8, 1978.

ROBERT A. KAYE,
Director,
Bureau of Motor Carrier Safety.

[FR Doc. 78-4158 Filed 2-14-78; 8:45 am]

Attachment No. 2

RP-404

CAB MOUNTING STEPS

(With Option "A" And Option "B")

BRIEF BACKGROUND DATA

At the Maintenance Committee meeting held in Indianapolis in 1974, the question was presented to the floor as to how many fleets were dissatisfied with the cab mounting steps on current production vehicles. The vote was several hundred to one. This demonstrated a strong dissatisfaction with supplier mounting steps.

Although substantial data is unavailable, one fleet that experienced one major accident per 396,818 exposures in 1964, 1965, and 1966 changed the cab mounts substantially and now experiences one major accident per 5,500,000 exposures. This employee accident cause appears to have been one of the worst three. The other two were lifting and lowering and falls and slips.

The design criteria will be as follows: "To allow the Person to Have Three Limbs on the System at One time".

CAB ENTRY STEPS

1. All cabs that have a door sill more than 29" off the ground will be equipped with at least one step. That step can be mounted on fuel tanks, battery boxes, or other normal fixtures as long as it meets the remaining design criteria.
2. Normally when more than 38" exists from the ground to the door sill a second step will be added (44" will be the maximum allowable when entry can be made vertically, that is — no step offsets). Additional steps will be provided as the height increases. The first step will normally not be more than 24" from the ground with 27" the maximum allowable. The remaining steps should be spaced taking into consideration step offset as indicated in the following chart.

		Step Spacing					
Step Offset Horiz.	0"	4	8	12	16	20	24
Step Spacing Vert.	24"	20	16	12	8	4	0
Step Center to Center	24"	20.4	17.9	17.0	17.9	20.4	24

3. As the number of steps increase (typical C.O.E. would probably have 3 or 4 steps plus the door sill) the design should indicate whether a left or right foot start is preferred. If either foot can be used, the step should be at least 12" wide. The first step should be between 6" and 8" wide and be located under or nearly under the left hand hold if a left foot start is necessary, and under the right hand hold if a right foot start is necessary. The width of the steps should increase or be located closer to the door sill as you ascend. This, of course, applies to vehicles where interference with tires, etc., does not allow direct entry. The top step may have to be as much as 16" to 20" long; if this is not possible an additional step should be installed under the sill to allow easy access. The additional step, if required, should be at least 12" long and the rear of the step no farther forward than a line drawn vertically from the forward edge of the driver's seat in its most rearward position.

4. The steps will be solidly affixed. On tilt cabs, the preference is to have two steps affixed to the frame or frame fixtures. This is to allow maintenance men to work on or around engine without hitting protruding steps with their head.

5. The steps will be constructed of, or covered with a self-cleaning safety material (i.e., expanded or pierced metal, grating, etc.). Openings in the safety material should not allow finger entrapment. The steps will be at least 4" deep and where possible, provide toe clearance so as to allow the user to step on the ball of his foot. Toe clearance measured from the outside edge of the step should be 6". Rung type steps will be allowed if they are substantially constructed and have non slip material attached. Step materials should be free from sharp edges.

HAND HOLDS

1. At least one grab handle will be affixed to the cab of all vehicles. This allows every entry to have at least three points for entry and exit stability, a door window post, a grab handle, and a step.

2. As the number of steps increase and if an offset ladder arrangement is used two hand holds (not necessarily two separate pieces) will become necessary as the door window post will be out of a driver's normal reach. The hand holds will not begin over 75" from the ground and the handle nearest the cab door opening will not terminate less than 48" from the door sill. If hand holds begin at or near 75" or if mounted lower than 75", they would interfere with a cargo door; a horizontal grip should be provided for use while mounting the first step. (Exhibit 3).

3. The spacing for the hand holds is to be: a minimum distance out from the cab body of 1½" , with 2" to 3" being recommended; and when possible, hand holds should be continuous and without mid brackets.

   Excellent grab handles are available for shorter entries. These handles are approximately ½" in diameter. Where ladder or similiar arrangements are used, for strength and ease of grabbing, pipe and tubing with extremes of ¾" to 1½" in diameter will be used.

DECK PLATES

On vehicles where it is necessary to hook up electrical and air connections on center positions on trailers, and where it is impossible to stand on the ground close enough to make these hook ups, deck plate will be provided as shown on Exhibit 2, item H. This deck plate will be constructed of the same material as specified on the steps. This deck plate will saddle the frame or frame extension brackets in such a manner that it can be held in place by battery box lid type hold downs and be removed for service in a 3 minute interval.

LOW PROFILE C.O. (Additional Requirements)

All cabs where the front axle sits back approximately 50" from front face of cab and where cab floor height does not exceed 45" above the ground shall have an open door envelope of 20" measured from the door hinge to the seat riser (normally mounted on cab floor). When the cab door is opening to the left of the centerline of the front axle (on drivers side), the door will open a minimum of 80°. A grab handle will be provided on the left side in the hinge area unless the steering wheel is available and within easy reach of the driver as he stands on the ground before he makes the first step.

DRAFT INTERNATIONAL STANDARD ISO/DIS 2867

EARTHMOVING MACHINERY – ACCESS SYSTEMS

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the criteria for steps, ladders, walkways, platforms, grab rails (handrails), grab handles, guardrails, and entrance openings as they relate to aiding the operator and servicemen in performing their functions on the equipment.

It does not include criteria for the floor of the operating compartment.

This International Standard is intended as a guide when designing access systems to the operating station and service points on all types of earthmoving machinery, primarily to aid in preventing accidents, and reducing injury to personnel getting on, off, or moving about on vehicles while servicing and preparing to operate them.

2 DEFINITIONS

For the purposes of this International Standard, the following definitions apply :

2.1 step : A device designed for foot placement.

2.2 ladder : A system consisting of a series of steps that are uniformly spaced and will accommodate either one foot or both feet.

2.2.1 vertical ladder : A ladder slanted not less than 75° from the horizontal.

2.2.2 inclined ladder : A ladder slanted less than 75° from the horizontal.

2.3 walkway : A surface designed for personnel to move about on the vehicle.

2.4 platform : A surface on which personnel are required to perform a service function, or a machine function other than operating.

2.5 grab rail (handrail) and grab handle : Devices that may be grasped by the hand for body support.

2.5.1 grab rail (handrail) : A device designed specifically to permit movement of the hand to a different location without removing the hand from the device. (Figure 4).

2.5.2 grab handle : A device designed specifically for single placement of a hand. (Figure 3).

2.6 guardrail : A rail above the outside edge of a walkway or platform (Figure 6).

2.7 entrance opening : The opening providing entry to the operating compartment. (See also ISO . . .[1]).

1) In preparation.

3 GENERAL CRITERIA

3.1 The design of these devices and the means of attachment shall provide adequate strength for the purpose intended.

3.2 The designer shall design for body dimensions for both the 95th percentile group and the 5th percentile groups. "The 95th percentile group represents the large person and only 5 % of the population is larger than this. The 5th percentile represents the smaller person and only 5 % of the population is smaller than this." See ISO . . .[1].

3.3 The designs and attachment means shall be such as to minimize the probability of the user being inadvertently restrained; for example, the catching or holding of a finger, hand, foot, or wearing apparel.

3.4 Devices designed for hand contact shall be free of roughness, such as sharp corners or protrusions.

a) The design and placement of these devices shall be such as to minimize protrusions that could increase injury in case of a fall.

b) These devices may be portable to provide convenient storage on the vehicle but, when in the use position, they shall not move under load.

3.5 Steps, ladders, and grab rails to, on, and from platforms and walkways shall be designed to permit the person using them to have three points of support on the system at all times (two hands and one foot, or two feet and one hand).

4 STEPS AND LADDERS

4.1 The height of the first step from the ground to the machine shall not exceed 700 mm (28 in) when the machine is in the normal parked condition.

Based on principal human factors the optimum height of the first step is 400 mm (16 in).

4.2 The maximum distance between steps of vertical ladders on machines shall not exceed 400 mm (16 in). The optimum distance between steps based on human factors is 300 mm (12 in).

4.3 Where lateral movement is necessary from a top step of a vertical ladder to a walkway or a platform, the vertical distance shall not exceed 300 mm (12 in).

4.4 It is preferred that all steps be wide enough to accommodate both feet. The desirable width for such design is 380 mm (15 in) and in no case shall it be less than 300 mm (12 in).

4.5 In those cases where only one foot is used on a step, the desirable width is 190 mm (7.5 in) and in no case shall it be less than 150 mm (6 in). The use of such steps dictates that they be co-ordinated with properly positioned grab rails or grab handles to enforce the use of the proper foot.

4.6 The desirable dimension for toe clearance from the outside edge of the step is 180 mm (7 in), and in no case shall it be less than 125 mm (5 in). (See Figure 1.)

4.7 The desirable clearance height at the instep is 190 mm (7.5 in) but in no case shall it be less than 150 mm (6 in). (See Figure 1.)

4.8 Wherever a foot may contact a moving part by protruding through the step, a shield shall be provided between the step and the moving part.

4.9 Where steps are in series to form an inclined ladder, they shall be spaced such that twice the rise (vertical distance), Y, plus the stride distance (the horizontal distance from the leading edge of one step to the leading edge of the next step), X, is no more than 750 mm (30 in) (Figure 2).

For the indeterminate zone around 75° inclination where the requirements of 4.2 or 4.9 might apply, the vertical distance between steps shall conform to 4.9 (Figure 2a).

1) In preparation.

4.10 The tread surface of a step should not be designed for use as a grab handle. The leading edge of steps should have no protrusions capable of snagging a finger, ring or clothing.

4.11 The design of steps should minimize the accumulation of debris. The tread surface should be of high slip resistance and should aid in the cleaning of mud and debris from the shoe sole.

4.12 Flexibly mounted steps should be avoided whenever possible. Where ground clearances dictate, the first step from the ground may be so mounted. However, only one step in a series may be so mounted.

4.13 The desirable headroom clearance above all ladders and steps is 1 900 mm (75 in).

5 GRAB RAILS (HANDRAILS) AND GRAB HANDLES

5.1 Grab rails appropriately spaced to provide continuous support to a moving man shall be placed within convenient reach.

5.2 The preferred cross-section of a grab rail and grab iron is circular. However, a square or rectangular cross-section with round corners is permissible but it shall be free from sharp edges.

5.3 For circular cross-section grab rails and grab handles the maximum diameter shall be 38 mm (1.5 in). The minimum diameter shall be 19 mm (3/4 in). The desirable dimension is 25 mm (1 in). For square or rectangular cross-sections, these dimensions apply across flats (axially between parallel surfaces).

5.4 Grab handles shall have an accessible minimum length between the bend radii of the support legs of 150 mm (6 in). The desirable length is 250 mm (10 in) to all surfaces. (Figure 3.)

5.5 The minimum hand clearance of all grab rails and grab handles shall be 75 mm (3 in) to all surfaces. (Figure 3.)

5.6 Grab rails and successive grab handles shall be placed parallel to the path of motion of the user. Grab handles may be oriented vertically or horizontally but shall be consistent within a given system.

5.7 Any grab rail or grab handle on which the hand surface extends beyond the support shall have a change of shape at the end of the hand surface to help prevent the hand from slipping off the end.

5.8 Grab rails or grab handles for access purposes shall begin at a maximum height of 1 500 mm (58 in) above the ground when the machine is in a normal parked position. It is desirable that the grab rail continue to at least 900 mm (36 in) above the final step.

5.9 The vertical grab rails or grab handle shall be spaced no more than 200 mm (8 in) to the side of the nearest edge of the step surface. The desirable spacing between parallel grab rails is 400 mm (16 in). The maximum spacing between parallel grab rails is 750 mm (30 in).

5.10 On inclined ladders, where hip clearance is a factor, the desirable spacing between parallel grab rails is 600 mm (24 in).

5.11 The desired grab rail height vertically above any step or inclined ladder is 900 mm (36 in). (Figure 4.)

5.12 When grab rails or grab handles are placed above walkways, they shall be located 850 mm (34 in) to 1 500 mm (58 in) above the walkways. (Figure 5.)

5.13 The use of grab rails in a ladder system is preferred to grab handles. Where grab rails are used, the spacing shall correspond to the step spacing.

5.14 Control levers and pedals shall be so designed that they are not used unconciously as grab handles or grab rails.

6 GUARDRAILS

6.1 A rigid guardrail shall be placed above the edge of walkways and platforms when a grab rail has not been provided.

6.2 The desirable guardrail height is 1 070 mm (42 in) above the walkway or platform. A second rail shall be spaced midway between the walkway and the top rail (Figure 6).

6.3 Where an opening has been provided, other than at the end of a guardrail to provide ladder or step access, a safety bar or chain should be provided across the opening.

7 WALKWAYS AND PLATFORMS

7.1 Tread surfaces of all walkways and platforms shall have high slip resistance as well as self-cleaning properties.

7.2 All walkways and platforms shall have a minimum width of 380 mm (15 in).

7.3 The edge of a walkway or platform adjacent to a step or ladder shall have no protrusions capable of snagging a finger, ring, or clothing.

8 VERTICAL ENTRANCE OPENINGS

8.1 The desirable entrance opening width is 680 mm (27 in). The minimum opening width is 450 mm (18 in).

8.2 The desirable door height of sit-down type cabs is 1 300 mm (52 in) or more from the floor. The desirable height of doors in stand-up cabs is 1 800 mm (72 in) or more from the floor.

8.3 An alternative exit for emergency purposes shall be provided in a cab surface different from the entrance door wall. The exit dimensions shall be equal to or larger than the dimensions given in ISO . . .[1].

8.4 The cab door shall be accessible directly from the access steps or from a walkway or platform.

8.5 The door shall not sweep the area of the platform or the steps on which the man must stand to open the door.

8.6 The external door handle shall be located from 600 to 1 200 mm (24 to 48 in) above the place on which the man must stand to open the door. The recommended height is 900 mm (36 in). On machines where the door is opened from the ground, the door handle height shall not be less than 1 780 mm (70 in).

8.7 The internal door handle shall be located from 600 to 750 mm (24 to 30 in) from the floor for the seated man and from 800 to 970 mm (32 to 38 in) from the floor for the standing man.

1) In preparation.

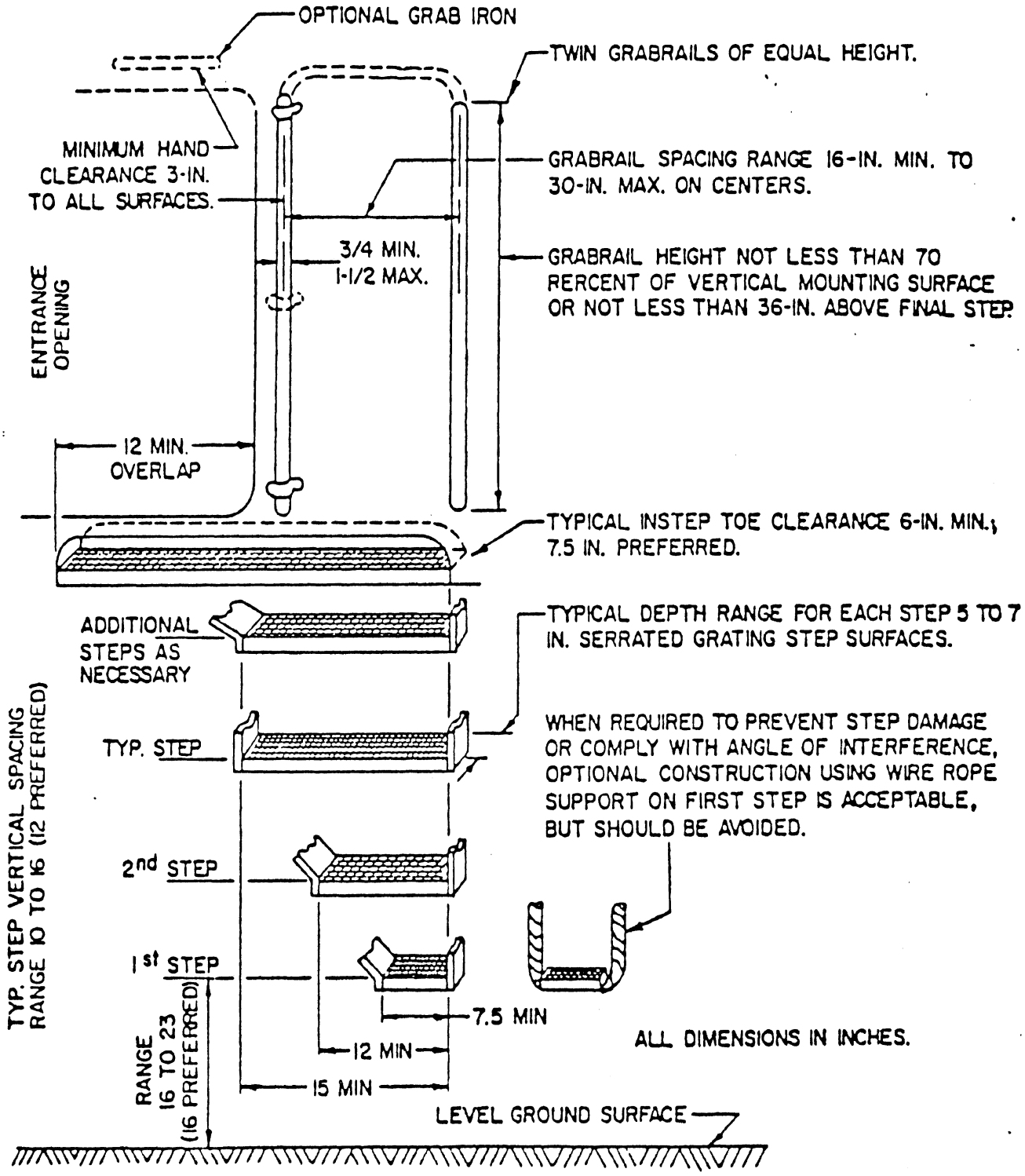


Figure 7. VERTICAL LADDER AND GRABRAIL SYSTEM.

CX1966

Source: US Army MERADCOM
Fort Belvoir, VA 22060

ACCESS SYSTEMS FOR CONSTRUCTION AND INDUSTRIAL EQUIPMENT—SAE J185

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved July 1970.

1. Purpose—This recommended practice is intended as a guide for designing access systems to the operating station and service points on all types of machines used in construction, material handling, mining, logging, and other similar industries, primarily to aid in preventing accidents and reducing injury to personnel getting on, off, or moving about on vehicles while servicing and/or preparing to operate them.

2. Scope

2.1 This recommended practice covers the criteria for steps, ladders, walkways, platforms, grab rails (handrails), grab irons, guardrails, and entrance openings as they relate to aiding the operator and/or servicemen in performing their functions on the vehicle.

2.2 This recommended practice does not include any criteria for the floor of the operating compartment.

3. Definitions

3.1 Step—A device designed for foot placement.

3.2 Ladder—A system consisting of a series of steps that are uniformly spaced and will accommodate either/or both feet.

3.2.1 Vertical Ladder—A ladder slanted not less than 75 deg from horizontal.

3.2.2 Inclined Ladder—A ladder slanted less than 75 deg from horizontal.

3.3 Walkways—A surface designed for personnel to move about on the vehicle.

3.4 Platform—A surface on which personnel are required to perform a service function, or a machine function other than operating.

3.5 Grab Rail (Handrail) and Grab Iron—Devices that may be grasped by the hand for body support.

3.5.1 Grab Rail (Handrail)—A device designed specifically to permit movement of the hand to a different location without removing the hand from the device (Fig. 1).

3.5.2 Grab Iron—A device designed specifically for single placement of a hand (Fig. 2).

3.6 Guardrail—A rail above the outside edge of walkways or platforms (Fig. 6).

3.7 Entrance Opening—The opening providing entry to the operating compartment. (See also SAE J923.)

4. General Criteria

4.1 The design of these devices and the means of attachment should provide adequate strength for the purpose intended.

4.2 The designer should design for both the 95th percentile group and the 5th percentile groups. (See SAE J833.)

4.3 The designs and attachment means should be such as to minimize the probability of the user becoming lodged inadvertently, for example, the lodging of a finger, hand, foot, or wearing apparel.

4.4 Devices designed for hand contact should be free of roughness, such as sharp corners or weld spatter.

4.5 The design and placement of these devices should be such as to minimize protrusions that could increase injury in case of a fall.

4.6 These devices may be portable to provide convenient storage on the vehicle; but, when in use position, they should not move under load (see paragraph 5.13).

4.7 Steps, ladders, and grab rails to, on, and from platforms and walkways, should be designed to invite the person using them to have three limbs on the system at all times. (Two hands and one foot, or two feet and one hand.)

5. Steps and Ladders

5.1 The maximum height of the first step from the ground to the machine should not exceed 39 in, when the machine is in the normal

...el condition. The preferred height of this step is 16 in.

5.2 The maximum distance between steps of vertical ladders on ...chines is 16 in. The preferred distance between steps is 12 in.

5.3 Where lateral movement is necessary from the top step of a ...ical ladder to a walkway or a platform, the vertical distance should ... no more than 12 in.

5.4 It is preferred that all steps have the width capacity to hold ...th feet. The minimum width for such design is 12 in. The preferred ...th is 13 in.

5.5 In those cases where only one foot is used on a step, that step ...hould be no less than 6 in. wide. Steps 7.5 in. wide are preferred. The ...se of such steps dictates that they be coordinated with properly ...itioned grab rails to force the use of the proper foot.

5.6 The minimum toe clearance from the outside edge of the ...tep should be 5 in. The preferred distance is 7 in. (Fig. 1).

5.7 The minimum clearance height at the instep is 6 in. The pre...rred height is 7½ in. (Fig. 1).

5.8 Wherever a foot may contact a moving part by protruding ...through the step, a shield should be provided between the step and the moving part. (See SAE J907.)

5.9 Where steps are in series to form an inclined ladder, they ...ould be spaced such that two times the rise plus the stride distance ...he horizontal distance from the leading edge of one step to the lead...ing edge of the next step) should be no more than 30 in. (Fig. 2).

5.10 The tread surface of a step should not be designed for use ...a grab iron. The leading edge of steps should have no protrusions ...pable of snagging a finger, ring, or clothing.

5.11 The design of steps should minimize the accumulation of ...debris. The tread surface should be a high slip resistant surface and ...ould aid in the cleaning of mud and debris from the shoe sole.

5.12 Flexibly mounted steps should be avoided whenever possible. Where ground clearances dictate, the first step from the ground may be so mounted. However, only one step in a series may be so mounted.

5.13 The preferred head room clearance above all ladders and steps ...ould be 75 in. (See SAE J833.)

6. Grab Rails (Handrails) and Grab Irons

6.1 Grab rails, appropriately spaced to provide continuous support ...a moving man, should be placed within convenient reach.

6.2 The preferred cross section of a grab rail and grab iron is circu...ar. A square or rectangular cross section with round corners is permissible.

6.3 For circular cross section grab rails and grab irons, the maxi...mum diameter should be 1½ in. The minimum diameter should be ...¼ in. The preferred dimension is 1 in. For square or rectangular cross section, these dimensions apply across flats.

6.4 Grab irons should have a minimum accessible length over and ...bove the bend radii of the support legs of 6 in. The preferred length ...s 10 in. (Fig. 3).

6.5 The minimum hand clearance of all grab rails and grab irons should be 3 in. to all surfaces (Fig. 3).

6.6 Grab rails and successive grab irons should be placed parallel ...to the path of motion of the user. Grab irons may be oriented vertically or horizontally but should be consistent within a given system.

6.7 Any grab rail or grab iron on which the hand surface extends beyond the support should have a change of shape at the end of the hand surface to help prevent the hand from slipping off the end.

6.8 Grab rails or grab irons for access purposes should begin at a maximum height of 58 in. above the ground when the machine is in a normal parked position. It is preferred that the grab rail continue to at least 36 in. above the final step.

6.9 The vertical grab rails or grab irons should be spaced no more than 8 in. to the side of the nearest edge of the step surface. The preferred spacing between parallel grab rails is 16 in. The maximum spacing between parallel grab rails is 30 in.

6.10 On inclined ladders, where hip clearance is a factor, the preferred spacing between parallel grab rails is 21 in.

6.11 The preferred grab rail height vertically above any step or inclined ladder is 36 in. (Fig. 4).

6.12 When grab rails or grab irons are placed above walkways, they should be located 34-58 in. above the walkways (Fig. 5).

6.13 The use of grab rails in a ladder system is preferred to grab irons. Where grab irons are used, the spacing should correspond to the step spacing.

7. Guardrails

7.1 A rigid guardrail should be placed above the edge of walkways and platforms when a grab rail has not been provided.

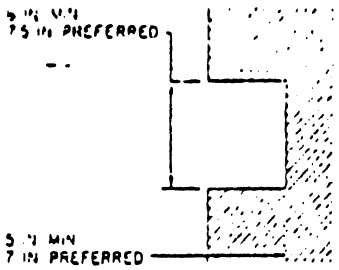


FIG. 1

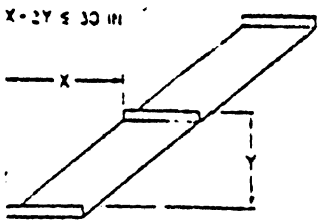


FIG. 2

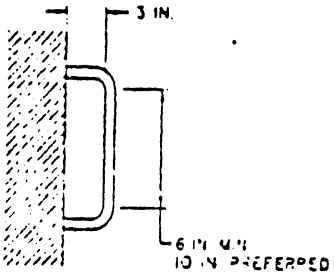


FIG. 3

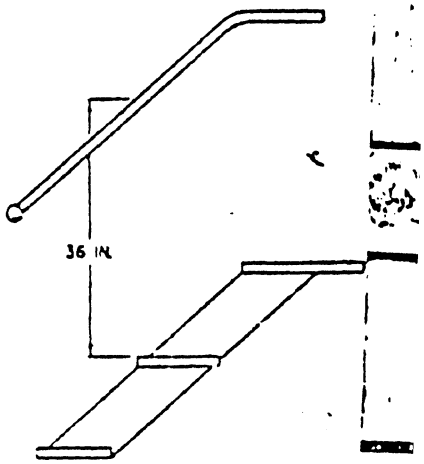


FIG. 4

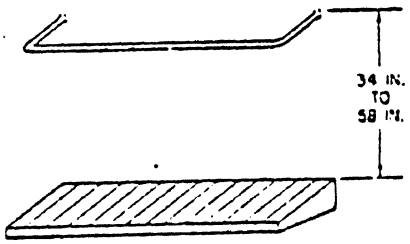


FIG. 5

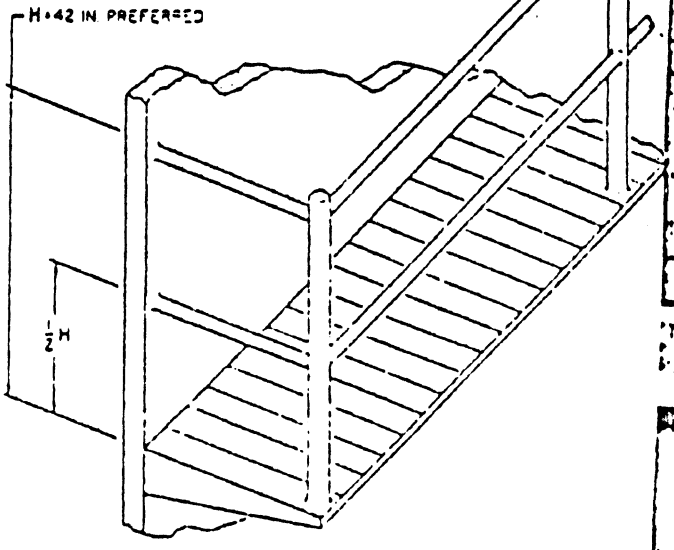


FIG. 6

pl form. A second rail should be spaced midway between the walkway and the top rail (Fig. 6).

7.3 Where an opening has been provided, other than at the end of guardrail to provide ladder or step access, a safety bar or chain should be provided across the opening.

8. Walkways and Platforms

8.1 Tread surfaces of all walkways and platforms should have high si resistance as well as self-cleaning properties.

8.2 All walkways and platforms should have a minimum width of 13 in.

8.3 The edge of a walkway or platform adjacent to a step or ladder should have no protrusions capable of snagging a finger, ring, or clothing.

9. Vertical Entrance Openings

9.1 The preferred entrance opening width is 27 in. The minimum opening width is 13 in.

9.2 The preferred door height of sit down type cabs is 52 in. or more from the floor. The preferred height of doors in stand up type cabs is 72 in. or more from the floor.

9.3 An alternate exit for emergency purposes should be provided in a cab surface different from the entrance door wall. The exit dimensions should be equal to or larger than the dimensions given in SAE J995.

9.4 The cab door should be accessible directly from the access steps or from a walkway or platform.

9.5 The door should not sweep the area of the platform or the steps on which the man must stand to open the door.

9.6 The external door handle should be located 21-45 in. above the step or platform on which the man must stand to open the door. The recommended height is 36 in.

9.7 The internal door handle should be located 24-30 in. from the floor for the seated man and 32-33 in. from the floor for the standing man.

10. Other Considerations

10.1 It is recognized that some shoe sole materials are more slip resistant than others. Operating and servicing personnel should be encouraged to wear footwear with a high slip resistant sole material.

10.2 In the design of equipment it is preferred that the location of service points minimize the movement of service personnel on the machine.

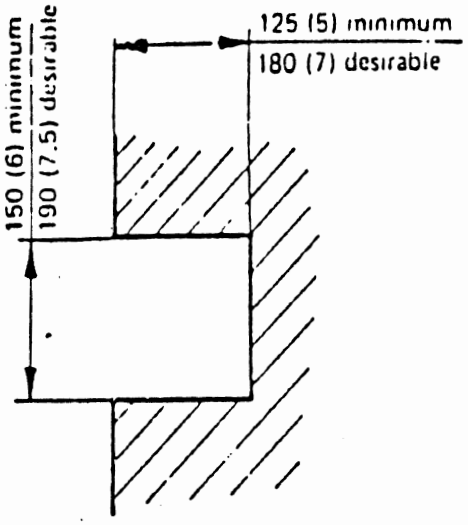


FIGURE 1 – Step

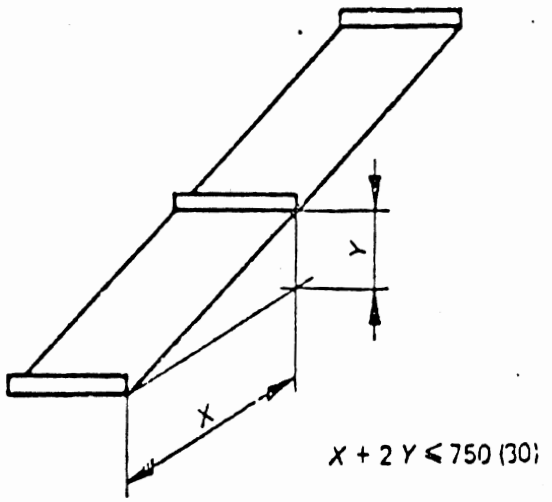


FIGURE 2 – Ladder

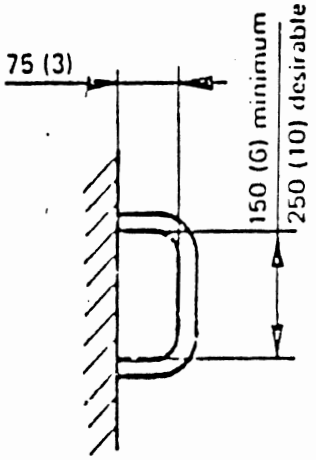


FIGURE 3 – Grab handle

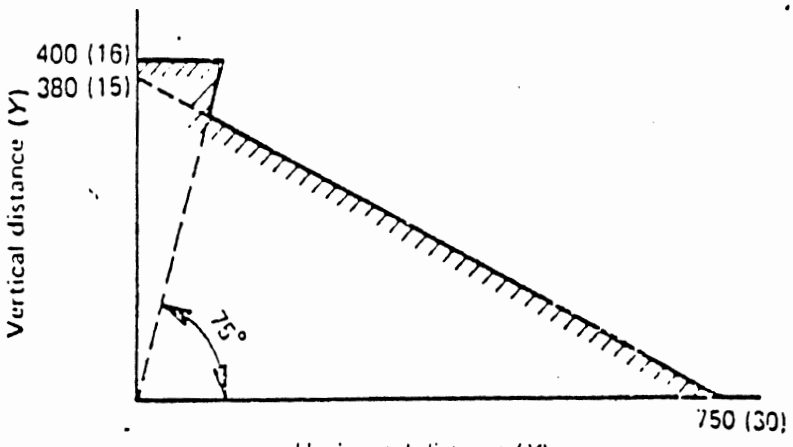


FIGURE 2a

The maximum distance between steps of all kinds of ladders shall be spaced in the hatched area.

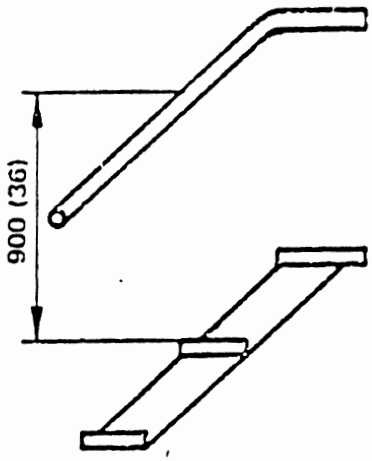
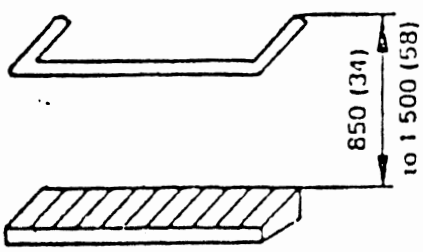


FIGURE 4 – Handrail



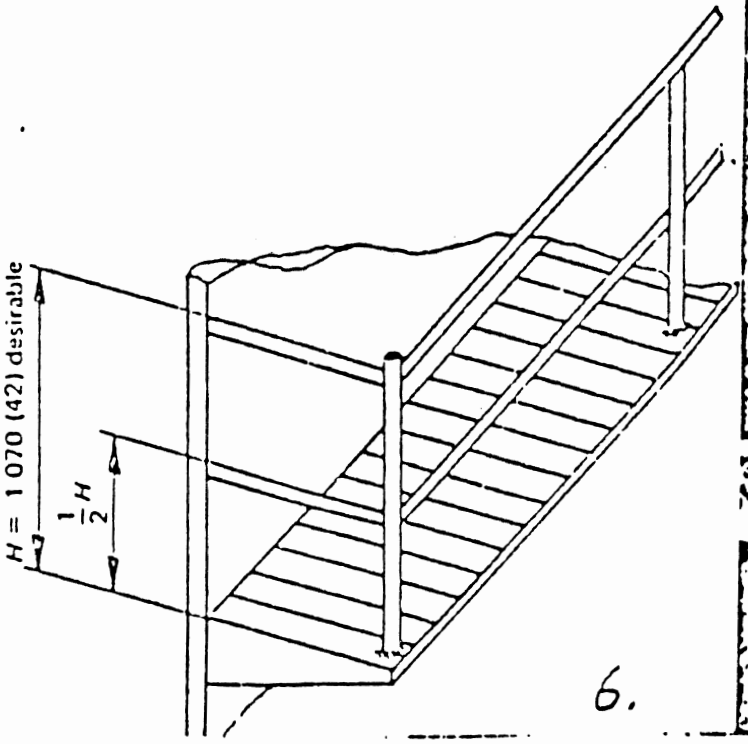


Exhibit 1

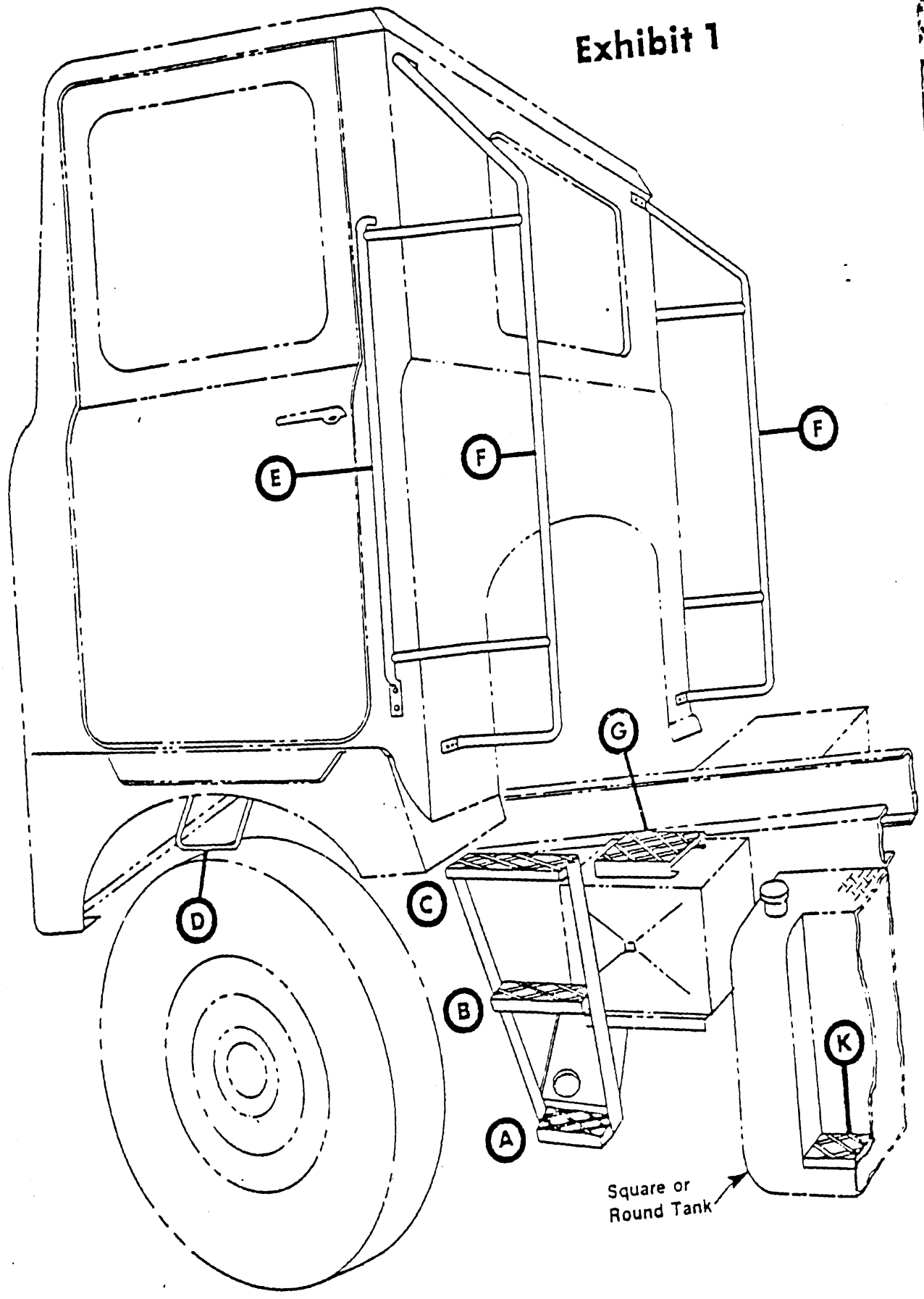
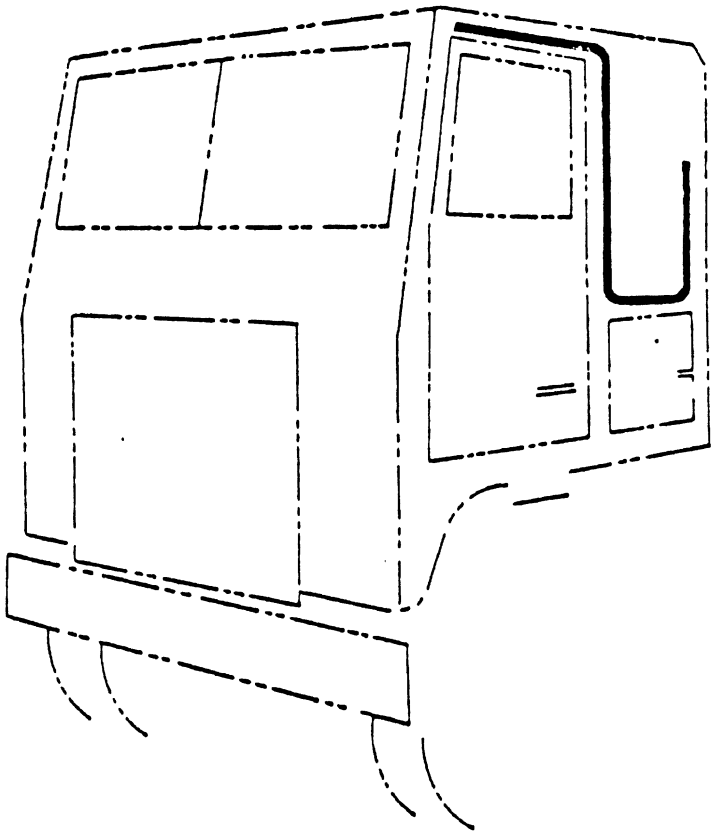


Exhibit 3



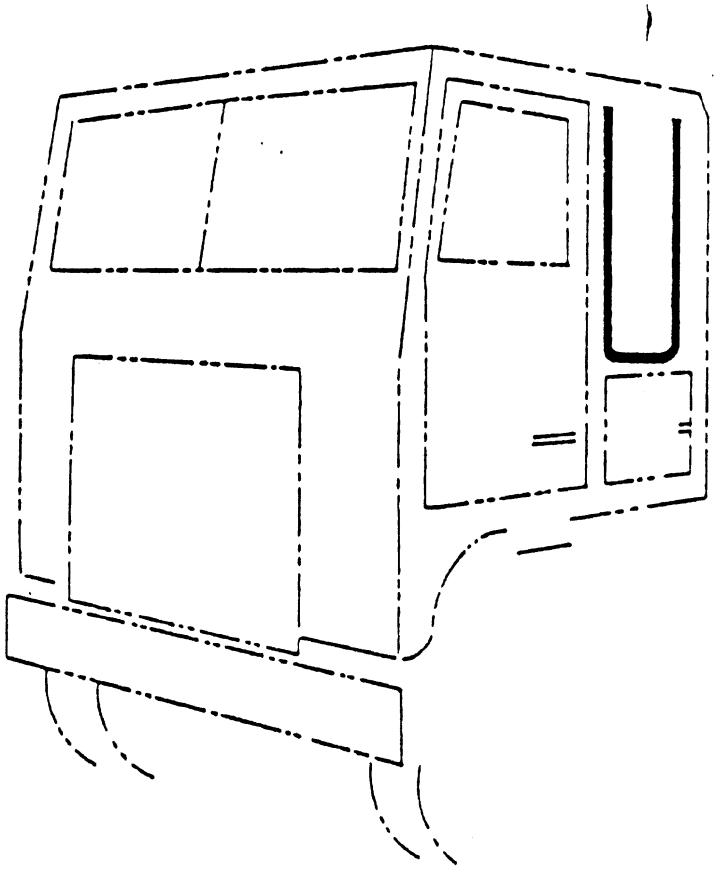
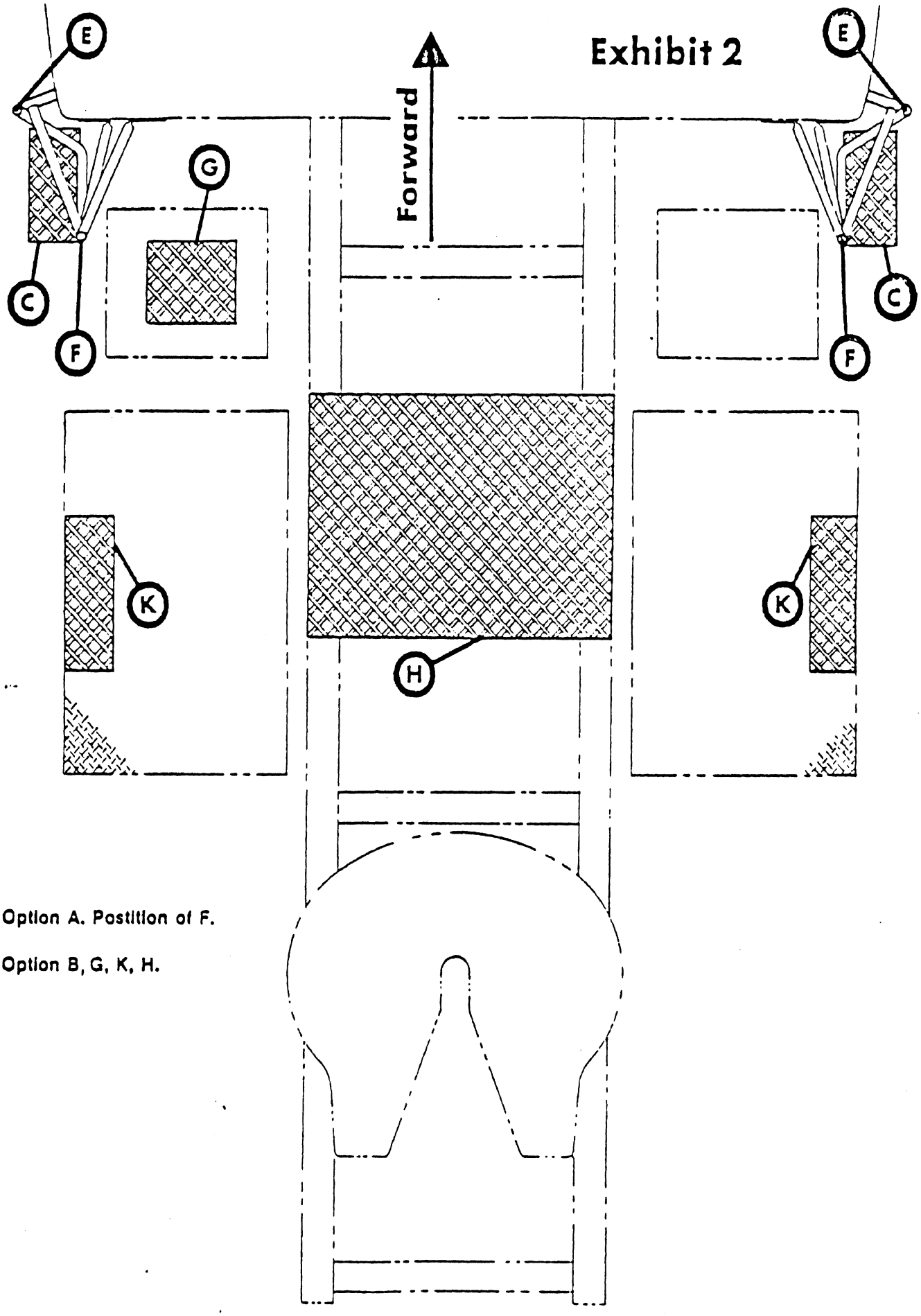


Exhibit 2



Option A. Postition of F.

Option B, G, K, H.

OPTION "A"

This option applies only to short 50" cabs where it is possible to swing around the back of the cab without having to climb down to the ground and back up where fleets are using centrally located air and hose connections. This adds little expense but eliminates danger of injury since many injuries result from irregular surfaces at ground level. This option has only one criteria and that is that the right hand hold on the driver's side will be mounted to the rear of the short cab and inward to allow the driver to dismount from his seat, step out on the highest step and then swing to the deck plate to make his hook ups. (Exhibits 1 & 2). This option would be impractical where interferences exist such as exhaust pipes.

OPTION "B"

This is a deck plate and step arrangement to be used by drivers and or maintenance personnel to mount and dismount from the rear frame area.

The same design criteria will apply on the steps, but since no grab handles can be made available, the step should be a minimum of 12" long so that they can be stepped on easily when dismounting. The same toe clearance applies as does the type of material. Typical installations would be on battery boxes, fuel tanks, etc. This step is added because maintenance personnel work on units mostly with cab tilted where the narrower steps near the cab are impractical.

Attachment No. 3

REVIEW OF OSHA REQUIREMENTS: Steps And Ladders

Source: TITLE 29 - Labor

Chapter XVII - Occupational Safety and Health Administration

Subpart D - Walking-Working Surfaces, pages 8-55.

Para 1910.21 Definitions

1910.22 General Requirements

This section applies to all permanent places of employment, except where domestic, mining, or agricultural work only is performed. Measures for the control of toxic materials are considered to be outside the scope of this section.

Application to road vehicles is not specifically made.

1910.23 Guarding floor and wall openings and holes.

(c) *Protection of open-sided floors, platforms, and runways.* (1) Every open-sided floor or platform 4 feet or more above adjacent floor or ground level shall be guarded by a standard railing (or the equivalent as specified in paragraph (c) (3) of this section) on all open....

Subparagraph (e) describes a 42 inch high railing.

1910.24 Fixed industrial stairs.

(a) *Application of requirements.* This section contains specifications for the safe design and construction of fixed general industrial stairs. This classification includes interior and exterior stairs around machinery, tanks, and other equipment, and stairs leading to or from floors, platforms, or pits.....

Stairs have 3 or more steps and are installed at angles to the horizontal of between 30° and 50°.

1910.25 Portable wooden ladders.

1910.26 Portable metal ladders.

1910.27 Fixed ladders.

(see attached sheet for comments pertaining to fixed ladders)

1910.28 Safety requirements for scaffolding.

1910.29 Manually propelled mobile ladder stands and scaffolds (towers).

1910.30 Other working surfaces.

1910.31 Sources of standards.

The source referenced for subparagph 1910.27 Fixed ladders, is ANSI A14.3-1956.

1910.32 Standards organizations.

note:

Subpart E - Means of Egress specifically excludes the application of subpart E to vehicles

were intended, unless specifically recommended for use by the manufacturer.

(viii) Users are cautioned to take proper safety measures when metal ladders are used in areas containing electric circuits to prevent short circuits or electrical shock.

§ 1910.27 Fixed ladders.

(a) *Design requirements*—(1) *Design considerations.* All ladders, appurtenances, and fastenings shall be designed to meet the following load requirements:

(i) The minimum design live load shall be a single concentrated load of 200 pounds.

(ii) The number and position of additional concentrated live-load units of 200 pounds each as determined from anticipated usage of the ladder shall be considered in the design.

(iii) The live loads imposed by persons occupying the ladder shall be considered to be concentrated at such points as will cause the maximum stress in the structural member being considered.

(iv) The weight of the ladder and attached appurtenances together with the live load shall be considered in the design of rails and fastenings.

(2) *Design stresses.* Design stresses for wood components of ladders shall not exceed those specified in § 1910.25. All wood parts of fixed ladders shall meet the requirements of § 1910.25(b).

For fixed ladders consisting of wood side rails and wood rungs or cleats, used at a pitch in the range 75 degrees to 90 degrees, and intended for use by no more than one person per section, single ladders as described in § 1910.25(c)(3)(ii) are acceptable.

(b) *Specific features*—(1) *Rungs and cleats.* (i) All rungs shall have a minimum diameter of three-fourths inch for metal ladders, except as covered in subparagraph (7)(i) of this paragraph, and a minimum diameter of 1⅛ inches for wood ladders.

(ii) The distance between rungs, cleats, and steps shall not exceed 12 inches and shall be uniform throughout the length of the ladder.

(iii) The minimum clear length of rungs or cleats shall be 16 inches.

(iv) Rungs, cleats, and steps shall be free of splinters, sharp edges, burrs, or projections which may be a hazard.

(v) The rungs of an individual-rung ladder shall be so designed that the foot cannot slide off the end. A suggested design is shown in figure D–1.

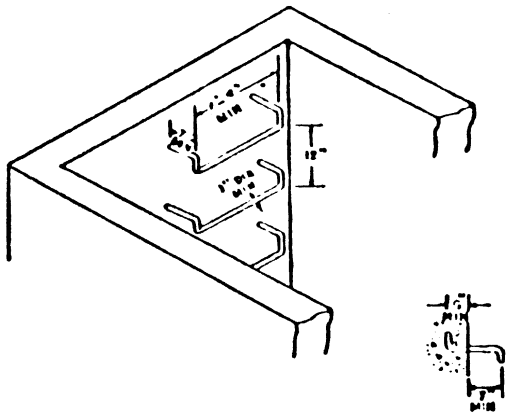


FIGURE D–1.—Suggested design for rungs on individual-rung ladders.

(2) *Side rails.* Side rails which might be used as a climbing aid shall be of such cross sections as to afford adequate gripping surface without sharp edges, splinters, or burrs.

(3) *Fastenings.* Fastenings shall be an integral part of fixed ladder design.

(4) *Splices.* All splices made by whatever means shall meet design requirements as noted in paragraph (a) of this section. All splices and connections shall have smooth transition with original members and with no sharp or extensive projections.

(5) *Electrolytic action.* Adequate means shall be employed to protect dissimilar metals from electrolytic action when such metals are joined.

(6) *Welding.* All welding shall be in accordance with the "Code for Welding in Building Construction" (AWSD1.0–1966).

(7) *Protection from deterioration.* (i) Metal ladders and appurtenances shall be painted or otherwise treated to resist corrosion and rusting when location demands. Ladders formed by individual metal rungs imbedded in concrete, which serve as access to pits and to other areas under floors, are frequently located in an atmosphere that causes corrosion and rusting. To increase rung life in such atmosphere, individual metal rungs shall have a minimum diameter of 1 inch or shall be painted or otherwise treated to resist corrosion and rusting.

(ii) Wood ladders, when used under conditions where decay may occur, shall be treated with a nonirritating preservative, and the details shall be such as to prevent or minimize the accumulation of water on wood parts.

(iii) When different types of materials are used in the construction of a ladder, the materials used shall be so treated as to have no deleterious effect one upon the other.

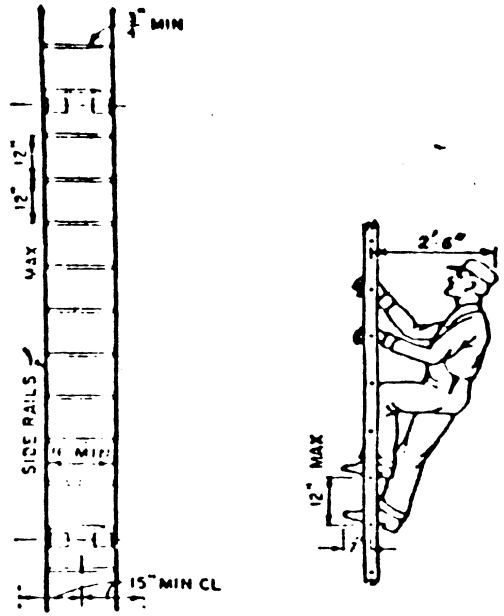
(c) *Clearance*—(1) *Climbing side.* On fixed ladders, the perpendicular distance from the centerline of the rungs to the nearest permanent object on the climbing side of the ladder shall be 36 inches for a pitch of 76 degrees, and 30 inches for a pitch of 90 degrees (fig. D–2 of this section), with minimum clearances for intermediate pitches varying between these two limits in proportion to the slope, except as provided in subparagraphs (3) and (5) of this paragraph.

(2) *Ladders without cages or wells.* A clear width of at least 15 inches shall be provided each way from the centerline of the ladder in the climbing space, except when cages or wells are necessary.

(3) *Ladders with cages or baskets.* Ladders equipped with cage or basket are excepted from the provisions of subparagraphs (1) and (2) of this paragraph, but shall conform to the provisions of paragraph (d)(1)(v) of this section. Fixed ladders in smooth-walled wells are excepted from the provisions of subparagraph (1) of this paragraph, but shall conform to the provisions of paragraph (d)(1)(vi) of this section.

(4) *Clearance in back of ladder.* The distance from the centerline of rungs, cleats, or steps to the nearest permanent object in back of the ladder shall be not less than 7 inches, except that when unavoidable obstructions are encountered, minimum clearances as shown in figure D–3 shall be provided.

(5) *Clearance in back of grab bar.* The distance from the centerline of the grab bar to the nearest permanent object in back of the grab bars shall be not less than 4 inches. Grab bars shall not protrude on the climbing side beyond the rungs of the ladder which they serve.



RAIL LADDER WITH BAR STEEL RAILS AND ROUND STEEL RUNGS

FIG. D-2

Minimum Ladder Clearances

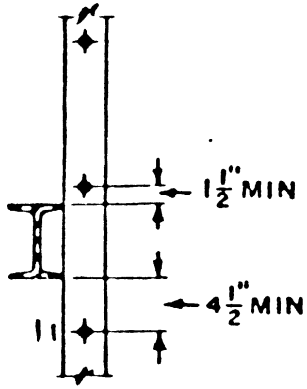


FIG. D-3

Clearance for Unavoidable Obstruction at Rear of Fixed Ladder

(6) *Step-across distance.* The step-across distance from the nearest edge of ladder to the nearest edge of equipment or structure shall be not more than 12

Other items noted that are of interest:

para 1910.23 Holes ect.

(10) Wall opening grab handles shall be not less than 12 inches in length and shall be so mounted as to give 3 inches clearance from the side framing of the wall opening. The size, material, and anchoring of the grab handle shall be such that the completed structure is capable of withstanding a load of at least 200 pounds applied in any direction at any point of the handle.

para 1910.25 and .26 Ladders

(vi) Steps shall be corrugated, knurled, dimpled, coated with skid-resistant materials, or otherwise treated to minimize the possibility of slipping.

(ii) The minimum width between the side rails at the top step shall be 12 inches. The width spread of the side rails shall increase a minimum of 1 inch per foot of length. The width of the step or tread shall not be less than 3 inches.

(ii) Minimum width between side rails at platform level shall be 14 inches. Width spread shall not be less than 1 inch per foot of rise.

para 1910.27 Fixed ladders.

(e) Pitch

(1) Preferred pitch ... in the range of 75° and 90° with the horizontal.

(2) Substandard pitch .... range of 60° and 75° with the horizontal.

(3) Pitch greater than 90 degrees.

" Ladders having a pitch in excess of 90 degress with the horizontal are prohibited."

Attachment No. 4

MIL-B-13207D(ME)
12 August 1976
SUPERSEDING
MIL-B-13207C(ME)
9 July 1970

MILITARY SPECIFICATION

BODY, VAN, VEHICLE-MOUNTED,

GENERAL SPECIFICATION FOR

This specification is approved for use by the Mobility Equipment Research and Development Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE.

1.1 Scope. This specification covers various sizes of intermodal container van bodies intended for the installation of a variety of operating equipment. The van bodies are modified refrigerated ISO (International Organization for Standardization) containers which feature interior heating and air conditioning and utility electrical systems. The van bodies are capable of international intermodal transport by land and sea, in addition to wheeled vehicle mounted transport. Optional truck and semitrailer mounting provides travel capability between operation sites. When advantageous, a single driver may transport two van bodies, the first mounted on the straight transporter truck and the second mounted on the towed dolly converter and semitrailer.

1.2 Classification. The van bodies shall be of the following sizes, as specified (see 6.2):

Modified Commercial ISO Reefer Container Van Body:

Size 10 - ISO 1D, 10-foot van body - MIL-B-13207/1.
Size 20 - ISO 1C, 20-foot van body - MIL-B-13207/2.
Size 30 - ISO 1B, 30-foot van body - MIL-B-13207/3.
Size 40 - ISO 1A, 40-foot van body - MIL-B-13207/4.

FSC 2510

MILITARY SPECIFICATION SHEET

BODY, VAN, VEHICLE-MOUNTED,

ISO SIZE 10

This specification sheet is approved for use by the USA Mobility Equipment Research and Development Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

The complete requirements for procuring the ISO Size 10 van body described herein shall consist of this document and the latest issue of Specification MIL-B-13207.

REQUIREMENTS:

1. The van body shall be an ISO/ANSI Series 1 reefer freight container, designated 1D, having a nominal length of 3000 mm (10 ft.).

2. The maximum gross weight of both basic van body and its operating equipment payload shall not exceed the ISO/ANSI maximum of 10 Tonnes (SI units) 22,400 lb).

3. Singly or in multiples, the basic van body shall mount on the vehicles selected, when adaptors are employed.

4. The van body shall be air transportable (see 3.9.1) in C-130, C-133, C-141, and C-5A aircraft. When necessary, the van body may be demounted from its vehicle component and air transported in two units.

5. Unless otherwise specified in the contract by the procuring activity, the van body shall not be equipped with any heating or air conditioning units, since its intended use is to house compressors, engine generator sets, and machinery necessary for plant operation without personnel.

FSC 2510

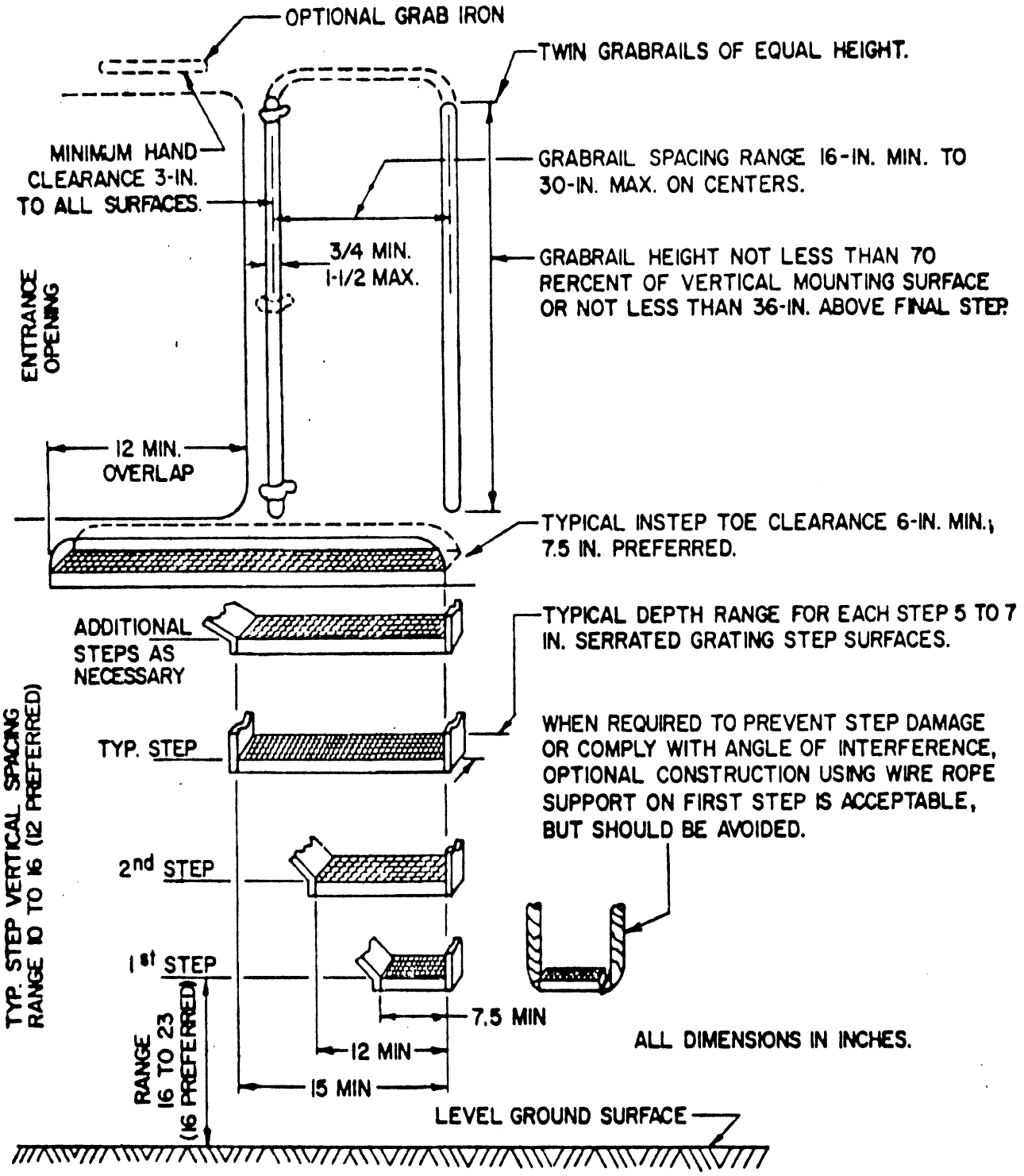


FIGURE 14. VERTICAL LADDER AND GRABRAIL SYSTEM.

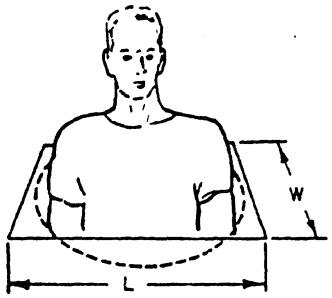
CX1966

TABLE II. Body specifications (Continued).

Feature	Requirements
	Track of industry standard 2-in. size; Antifriction bearing mounted counterbalanced system protected from environment, provide ease of rolling door up to open; twin aircraft quality stainless steel roll-up cables, one cable on each side of the door; Tension adjustment tailored to door weight and height; Handgrips provided for opening and closing; Security door lock to clamp door to bottom door sill with interference fit insuring sealing; Lock prevent door vibration relative to sill and prevent lock loosening during transport; Lock equipped with inside and outside door handles and with provisions for exterior securing with a min. 3/8-in. shackle padlock; During tests, roll-up doors may be externally sealed air-tight for determination of air leakage and thermal transmission rates.
(i) Boarding Ladders -	Per DOT FMCSR, DOL OSHA, and SAE J185; 2-ea. aluminum vehicle boarding type, 1-ea. for rear personnel door and 1-ea. for curbside personnel door; Each ladder equipped with 1-removable handrail installed away from the door hinges and not interfering with the opening swing of the doors; Ladder-mounts of the semi-permanent type preventing ladder instability under heavy traffic; Both ladders and handrails stowed and secured on the front, rear, or underneath during vehicle-mounted road travel and relocated inside van body during transport as an unmounted ISO container.

TABLE V. Transporter truck specifications (Continued).

Feature	Requirements
(5) Rear Bumper -	To the maximum practical extent, provide a rear 2-position retractable hinged bumper as follows: (a) When lowered, comply with DOT FMCSR and TTMA RP No. 10; (b) When retracted, provide clearance for travel over off-road terrain. (c) When retracted and while towing full trailer, provide articulation of the dolly converter towbar through min. 140° horizontal arc about the rear pintle.
(k) Cab -	COE lightweight tilt cab type; Material aluminum or FRP and aluminum; min. 70 degree tilt angle or two stage, min. 55 degree and min. 70 degree tilt; Tilt system electrohydraulic or air-hydraulic power types w/manual hydraulic emergency pump; Safety tilt cab locking system; Shock and vibration reduction mounts; Cab min. 81-in. width by min. 54-in. height interior size; Insulation and deadener furnished in cowl, engine tunnel, roof, rear and quarter panels, doors, and floor to comply with DOT FMCSR, SAE J336, and cab thermal, cold weather protection option.
(1) Steps and Grab Rail System -	Per RCCC RP-406 and SAE J185 on both curb and road sides, similar to Figure 14.
(2) Cab Glazing -	All glazing of flat safety glass, except curved glass is acceptable for windshield only;



MINIMUM DIMENSIONS, IN.	SQUARE		ROUND	RECTANGULAR	
	W	L	D	W	L
NORMAL CLOTHED	18.0	18.0	22.0	12.0	22.0
ARCTIC CLOTHED	20.0	20.0	24.0	14.0	24.0

NOTE: OPTIONAL ON ALL CORNERS, MAX. 1 IN. RADIUS

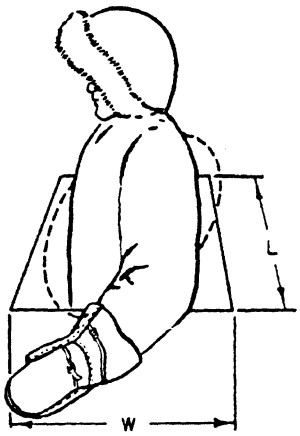
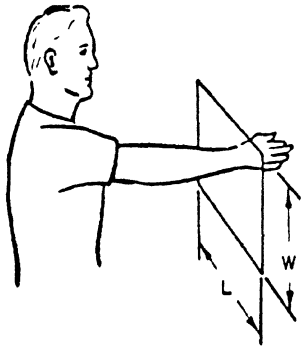


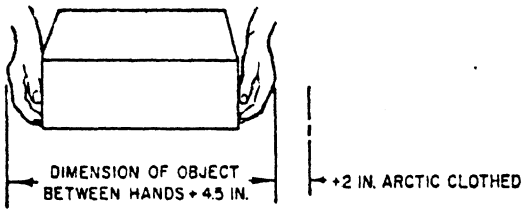
FIG. 3—RECOMMENDED MINIMUM DIMENSIONS FOR BODY ACCESS, 95TH PERCENTILE



MINIMUM DIMENSIONS ONE ARM, IN.	W	L
ARM BARE	6	8
ARCTIC CLOTHED	8	10

NOTE: OPTIONAL ON ALL CORNERS, MAX. 1 IN. RADIUS

FIG. 4—RECOMMENDED MINIMUM DIMENSIONS FOR ARM REACH ACCESS, 95TH PERCENTILE



MINIMUM DIMENSIONS TWO-HANDS	R	W
	REQUIRED REACH	MINIMUM WIDTH
NORMAL CLOTHED	R	3/4 R
ARCTIC CLOTHED	R	3/4 R + 2 IN.

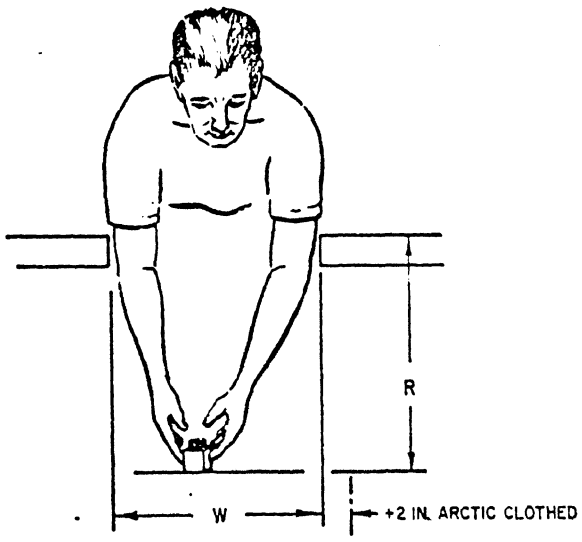


FIG. 5—RECOMMENDED MINIMUM DIMENSIONS FOR TWO-HANDED ACCESS, 95TH PERCENTILE

ACCESS SYSTEMS FOR CONSTRUCTION AND INDUSTRIAL EQUIPMENT—SAE J185

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved July 1970.

1. Purpose—This recommended practice is intended as a guide for designing access systems to the operating station and service points on all types of machines used in construction, material handling, mining, logging, and other similar industries, primarily to aid in preventing accidents and reducing injury to personnel getting on, off, or moving about on vehicles while servicing and/or preparing to operate them.

2. Scope

2.1 This recommended practice covers the criteria for steps, ladders,

walkways, platforms, grab rails (handrails), grab irons, guardrails, and entrance openings as they relate to aiding the operator and/or servicemen in performing their functions on the vehicle.

2.2 This recommended practice does not include any criteria for the floor of the operating compartment.

3. Definitions

3.1 Step—A device designed for foot placement.

3.2 Ladder—A system consisting of a series of steps that are uniformly spaced and will accommodate either/or both feet.

3.2.1 VERTICAL LADDER—A ladder slanted not less than 75 deg from horizontal.

3.2.2 INCLINED LADDER—A ladder slanted less than 75 deg from horizontal.

3.3 Walkways—A surface designed for personnel to move about on the vehicle.

3.4 Platform—A surface on which personnel are required to perform a service function, or a machine function other than operating.

3.5 Grab Rail (Handrail) and Grab Iron—Devices that may be grasped by the hand for body support.

3.5.1 GRAB RAIL (HANDRAIL)—A device designed specifically to permit movement of the hand to a different location without removing the hand from the device (Fig. 4).

3.5.2 GRAB IRON—A device designed specifically for single placement of a hand (Fig. 3).

3.6 Guardrail—A rail above the outside edge of walkways or platforms (Fig. 6).

3.7 Entrance Opening—The opening providing entry to the operating compartment. (See also SAE J925.)

4. General Criteria

4.1 The design of these devices and the means of attachment should provide adequate strength for the purpose intended.

4.2 The designer should design for both the 95th percentile group and the 5th percentile groups. (See SAE J833.)

4.3 The designs and attachment means should be such as to minimize the probability of the user becoming lodged inadvertently, for example, the lodging of a finger, hand, foot, or wearing apparel.

4.4 Devices designed for hand contact should be free of roughness, such as sharp corners or weld spatter.

4.5 The design and placement of these devices should be such as to minimize protrusions that could increase injury in case of a fall.

4.6 These devices may be portable to provide convenient storage on the vehicle; but, when in use position, they should not move under load (see paragraph 5.13).

4.7 Steps, ladders, and grab rails to, on, and from platforms and walkways, should be designed to invite the person using them to have three limbs on the system at all times. (Two hands and one foot, or two feet and one hand.)

5. Steps and Ladders

5.1 The maximum height of the first step from the ground to the machine should not exceed 30 in. when the machine is in the normal parked condition. The preferred height of this step is 16 in.

5.2 The maximum distance between steps of vertical ladders on machines is 16 in. The preferred distance between steps is 12 in.

5.3 Where lateral movement is necessary from the top step of a vertical ladder to a walkway or a platform, the vertical distance should be no more than 12 in.

5.4 It is preferred that all steps have the width capacity to hold both feet. The minimum width for such design is 12 in. The preferred width is 15 in.

5.5 In those cases where only one foot is used on a step, that step should be no less than 6 in. wide. Steps 7.5 in. wide are preferred. The use of such steps dictates that they be coordinated with properly positioned grab rails to force the use of the proper foot.

5.6 The minimum toe clearance from the outside edge of the step should be 5 in. The preferred distance is 7 in. (Fig. 1).

5.7 The minimum clearance height at the instep is 6 in. The preferred height is 7½ in. (Fig. 1).

5.8 Wherever a foot may contact a moving part by protruding through the step, a shield should be provided between the step and the moving part. (See SAE J907.)

5.9 Where steps are in series to form an inclined ladder, they should be spaced such that two times the rise plus the stride distance (the horizontal distance from the leading edge of one step to the leading edge of the next step) should be no more than 30 in. (Fig. 2).

5.10 The tread surface of a step should not be designed for use as a grab iron. The leading edge of steps should have no protrusions capable of snagging a finger, ring, or clothing.

5.11 The design of steps should minimize the accumulation of debris. The tread surface should be a high slip resistant surface and should aid in the cleaning of mud and debris from the shoe sole.

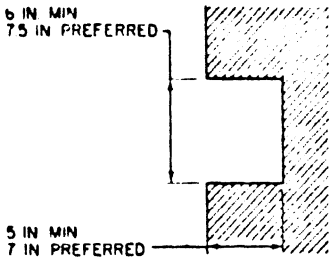


FIG. 1

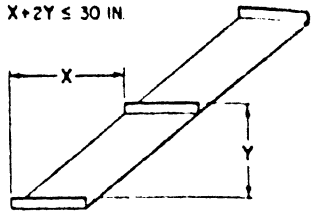


FIG. 2

5.12 Flexible mounted steps should be avoided whenever possible. Where ground clearances dictate, the first step from the ground may be so mounted. However, only one step in a series may be so mounted.

5.13 The preferred head room clearance above all ladders and steps should be 75 in. (See SAE J833.)

6. Grab Rails (Handrails) and Grab Irons

6.1 Grab rails, appropriately spaced to provide continuous support to a moving man, should be placed within convenient reach.

6.2 The preferred cross section of a grab rail and grab iron is circular. A square or rectangular cross section with round corners is permissible.

6.3 For circular cross section grab rails and grab irons, the maximum diameter should be 1½ in. The minimum diameter should be ¾ in. The preferred dimension is 1 in. For square or rectangular cross section, these dimensions apply across flats.

6.4 Grab irons should have a minimum accessible length over and above the bend radii of the support legs of 6 in. The preferred length is 10 in. (Fig. 3).

6.5 The minimum hand clearance of all grab rails and grab irons should be 3 in. to all surfaces (Fig. 3).

6.6 Grab rails and successive grab irons should be placed parallel to the path of motion of the user. Grab irons may be oriented vertically or horizontally but should be consistent within a given system.

6.7 Any grab rail or grab iron on which the hand surface extends beyond the support should have a change of shape at the end of the hand surface to help prevent the hand from slipping off the end.

6.8 Grab rails or grab irons for access purposes should begin at a maximum height of 58 in. above the ground when the machine is in a normal parked position. It is preferred that the grab rail continue to at least 36 in. above the final step.

6.9 The vertical grab rails or grab irons should be spaced no more than 8 in. to the side of the nearest edge of the step surface. The preferred spacing between parallel grab rails is 16 in. The maximum spacing between parallel grab rails is 30 in.

6.10 On inclined ladders, where hip clearance is a factor, the preferred spacing between parallel grab rails is 24 in.

6.11 The preferred grab rail height vertically above any step or inclined ladder is 36 in. (Fig. 4).

6.12 When grab rails or grab irons are placed above walkways, they should be located 34–58 in. above the walkways (Fig. 5).

6.13 The use of grab rails in a ladder system is preferred to grab irons. Where grab irons are used, the spacing should correspond to the step spacing.

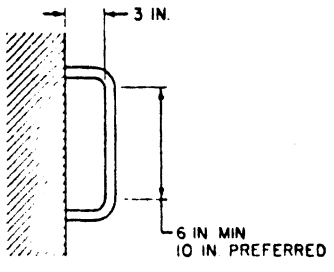


FIG. 3

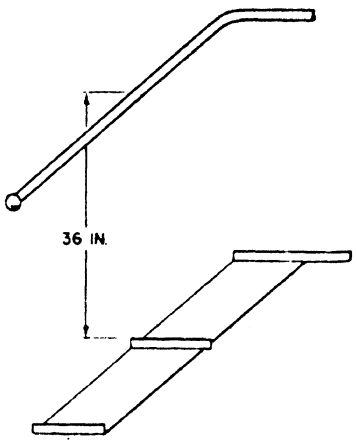


FIG. 4

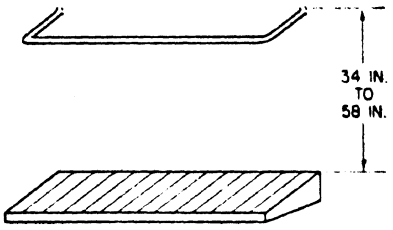


FIG. 5

7. Guardrails

7.1 A rigid guardrail should be placed above the edge of walkways and p forms when a grab rail has not been provided.

7.2 The preferred guardrail height is 42 in. above the walkway or platform. A second rail should be spaced midway between the walkway and the t rail (Fig. 6).

7.3 Where an opening has been provided, other than at the end of a guardrail to provide ladder or step access, a safety bar or chain should be provided across the opening.

8 Walkways and Platforms

8.1 Tread surfaces of all walkways and platforms should have high slip r tance as well as self-cleaning properties.

8.2 All walkways and platforms should have a minimum width of 15 in.

8.3 The edge of a walkway or platform adjacent to a step or ladder s ıld have no protrusions capable of snagging a finger, ring, or clothing.

Vertical Entrance Openings

9.1 The preferred entrance opening width is 27 in. The minimum opening width is 18 in.

9.2 The preferred door height of sit down type cabs is 52 in. or more from floor. The preferred height of doors in stand up type cabs is 72 in. or more n the floor.

9.3 An alternate exit for emergency purposes should be provided in a cab surface different from the entrance door wall. The exit dimensions should be ıal to or larger than the dimensions given in SAE J925.

9.4 The cab door should be accessible directly from the access steps or trom a walkway or platform.

9.5 The door should not sweep the area of the platform or the steps on ıich the man must stand to open the door.

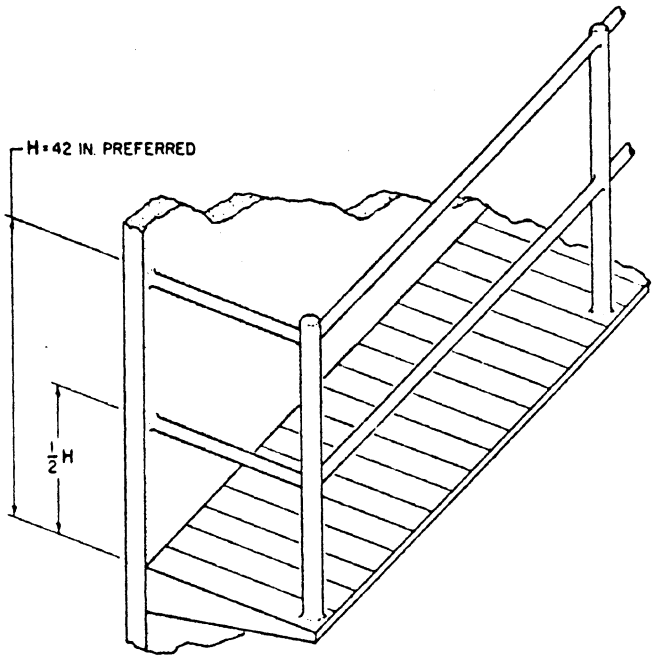


FIG. 6

9.6 The external door handle should be located 24–48 in. above the step or platform on which the man must stand to open the door. The recommended height is 36 in.

9.7 The internal door handle should be located 24–30 in. from the floor for the seated man and 32–38 in. from the floor for the standing man.

10. Other Considerations

10.1 It is recognized that some shoe sole materials are more slip resistant than others. Operating and servicing personnel should be encouraged to wear footwear with a high slip resistant sole material.

10.2 In the design of equipment it is preferred that the location of service points minimize the movement of service personnel *on* the machine.

ORCE-DEFLECTION MEASUREMENTS OF SEAT AND BACK CUSHIONS FOR AGRICULTURAL, CONSTRUCTION, AND INDUSTRIAL QUIPMENT—SAE J1051

SAE Recommended Practice

Report of Tractor Technical Committee and Construction and Industrial Machinery Technical Committee approved January 1974.

1. Scope—This SAE Recommended Practice defines a method of determining the force-deflection characteristics of a finished seat cushion and a finished back cushion of any construction and may be used to help determine seat comfort characteristics and in quality control.

2. Test Apparatus

2.1 An 8 in. (203 mm) diameter, rigid, flat indentor (Fig. 1) with the force applied through a rigid joint or a swivel joint capable of accommodating the angle of the top surface of the test specimen.

2.2 A platform capable of positioning the top surface of the test specimen parallel to and centered with the rigid joint indentor and not to restrict the breathing or normal deformation of the specimen tested (Fig. 2). The indentor with the swivel joint may be preferred for tapered or irregular shaped cushions or for a fixed platform (Fig. 3).

2.3 An apparatus capable of applying forces and measuring the deflection of the indentor into the specimen.

3. Procedure

3.1 The test specimen shall consist of a finished upholstered product seat cushion and/or back cushion in an unused condition (with packaging or protective bag removed).

3.2 Test Conditions—The specimen shall be conditioned, undeflected and undistorted, at 72 ± 5°F (22 ± 2.8°C) and relative humidity of 50 ± 2% for at least 12 h before being tested. It is recommended that all tests be performed 96 h or more after the manufacture of the raw materials used in the test specimen (foam, elastic components other than metal, etc.). In case of question, refer to the applicable SAE or ASTM specification (if available) for the particular material.

3.3 Test Method

3.3.1 Mount the test specimen with the top surface parallel to and centered with the indentor, unless otherwise specified by mutual agreement of the manufacturer and customer. In the case of cushions with unusual shapes or

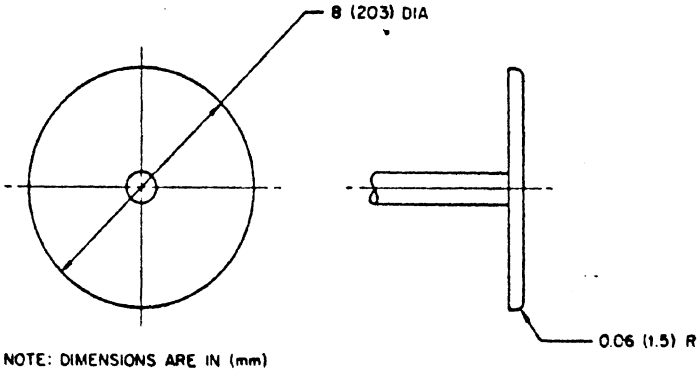


FIG. 1—FLAT INDENTOR

Attachment No. 6

ANTHROPOMETRIC SURVEY OF TRUCK AND BUS DRIVERS:

Anthropometry, Control Reach and Control Force

Mark S. Sanders, Ph.D.

February 1977

Final Report

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

Prepared for:

DEPARTMENT OF TRANSPORTATION
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Bureau of Motor Carrier Safety
Washington, D. C. 20590

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15. Supplementary Notes

16. Abstract

A mobile lab was constructed to collect data on static and dynamic anthropometry, reach envelope, sleep envelope and force production to steering wheel and brake-clutch pedals on 227 truck and 50 bus drivers. There were essentially no differences between truck and bus drivers on the static measures. The drivers were larger than general civilian or military populations and truck drivers measured 25 years before. For all static and dynamic measures, the mean, standard deviation, standard error, 5th, 50th, 95th percentiles, kurtosis and skewness values are presented. The 5th, 10th and 20th percentile values for front, right side, and behind the seat reach envelopes are presented. Wearing a winter jacket restricted reach by approximately 2 inches. Maximum force (torque on wheel) and sustained force (torque) at max plus 5, 10, 15 seconds are presented. Steering wheel torque is compared to torques provided during front tire blowout conditions. From 7 to 12% of the sample would not be able to sustain peak blowout torques. The 95th, 90th, 80th percentiles on height, width and length of sleep envelopes are presented.

17. Key Words		18. Distribution Statement
Anthropometry	Reach Envelope	Unlimited
Truck Driver	Biomechanics	
Bus Driver	Human Engineering	
Force Production	Eye Position	
Sleep	Ergonomics	
	Human Body	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

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EXECUTIVE SUMMARY

A mobile lab was constructed in order to collect anthropometric data on a nationwide sample of truck and bus drivers. Eight cities were visited and data were collected on 227 truck and 50 bus drivers. The sample consisted of 96 percent males and four percent female drivers. The mean age was 40.2 years with a range from 22 to 64 years of age. The majority (62.5%) of drivers were employed in private truck fleets and most (54.7%) drove line haul operations.

Static Anthropometric Data

These measures were made with the subject in a fixed rigid posture. Photographic and direct measurement techniques were used. The following measures were made:

- Stature
- Weight
- Sitting height
- Sitting eye height
- Sitting shoulder height
- Sitting elbow height
- Sitting thigh clearance height
- Sitting knee height
- Head back to eye length
- Sitting arm reach
- Forearm - hand length
- Buttock - knee length
- Buttock - popliteal length
- Shoulder breadth
- Sitting seat breadth

Means, standard deviations, standard error, 5th, 50th, and 95th percentiles, skewness, and kurtosis values are presented for each measure for the total sample and males and females separately. Intercorrelations between the static measures and selected scatter plots are also presented.

There were virtually no differences between bus and truck drivers on static anthropometry and the data were, therefore, combined. Comparing the current data to data collected on 1950

truck and bus drivers revealed that the current sample was larger on all measures but two. In comparison to a cross section of the civilian population, the current sample was again larger on all measures except one. The mean differences, however, are small, all being within two inches of the current sample.

Dynamic Anthropometry

Measures were made while the subject assumed a normal driving posture in a truck mock-up (buck). The following measures were made photographically or manually:

- Sitting height
- Sitting eye height
- Sitting knee height
- Accelerator heel point (AHP) to eye length
- AHP to abdomen length
- AHP to knee length
- Elbow breadth
- Knee breadth

For each measure, for the total sample and males and females separately, the mean, standard division, standard error, 5th, 50th and 95th percentiles, kurtosis and skewness are presented. Scatter plots and correlations between corresponding static and dynamic measure are also presented.

Reach Envelope

The front, right side, and behind the seat reach envelopes were assessed with drivers wearing tee shirts or no shirts in a truck mock-up. The mean standard deviation, 5th, 10th and 20th percentile values are presented for each probe position. Forty-four (44) probes were used to assess front reach, 47 probes for side reach and six probes for behind the seat reach.

The front and behind the seat reach was performed by one-fifth of the subjects wearing a winter jacket. The jacket restricted front reach only for the extreme (high and/or inboard)

scalp as possible, measure from the surface distance in the coronal plane from the left to the right tragion landmark.

37. Bitragion Breadth—Subject sits erect. The horizontal breadth of the head is measured from the right tragion to the corresponding tragion of the left ear using spreading calipers.

38. Tragion to Top of Head—Subject stands under a headboard. Headboard is adjusted so that its vertical and horizontal planes are in firm contact with the back and the top of the head. Measure the vertical distance from the horizontal plane to the right tragion landmark.

39. Tragion to Wall—Subject stands under a headboard. Headboard is adjusted so that its vertical and horizontal planes are in firm contact with the back and the top of the head. Measure the horizontal distance from the vertical plane to the right tragion landmark.

40. Ectocanthus to Wall—Subject stands under a headboard. Measure the horizontal distance from the vertical plane to the right ectocanthus (outer corner) of eye.

41. Weight—With subjects nude or semi-clothed, no shoes, to the nearest kilogram on spring platform scale.

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3. H. T. E. Hertzberg, G. S. Daniels, and E. Churchill, *Anthropometry of Flying Personnel—1950.* WADC Technical Report 52-321, Aero Medical Laboratory, Wright-Patterson Air Force Base, Ohio, 1954.

4. Society of Automotive Engineers, "Male Physical Dimensions for Construction and Industrial Equipment Design," SAE J833. SAE Handbook, New York, 1962.

5. U. S. Dept. of Health, Education and Welfare, *Weight, Height and Selected Body Dimensions of Adults—U. S., 1960-1962.* National Center for Health Statistics, Washington, D. C., 1965.

6. R. M. White, et al., *The Body Size of Soldiers: U. S. Army Anthropometry—1966.* Report AD 743 456, U. S. Army Natick Laboratories, Natick, Massachusetts, 1971.

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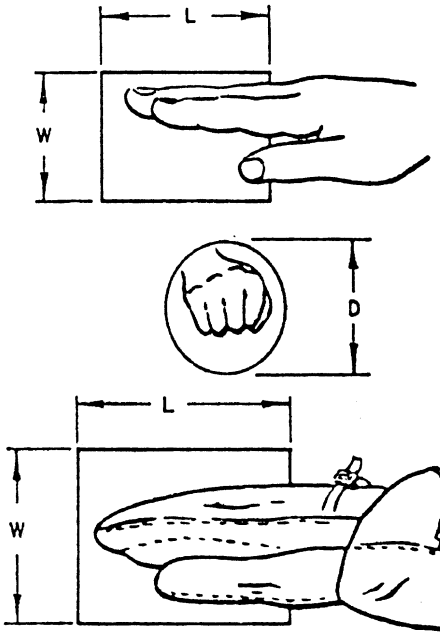
MINIMUM ACCESS DIMENSIONS FOR CONSTRUCTION AND INDUSTRIAL MACHINERY—SAE J925

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved July 1965.

This SAE Recommended Practice is intended to give information to engineers and designers in order that access openings provided in equipment and machinery for purposes of inspection, adjustment, and maintenance are made large enough for efficient performance of the intended function by the man in the field or shop.

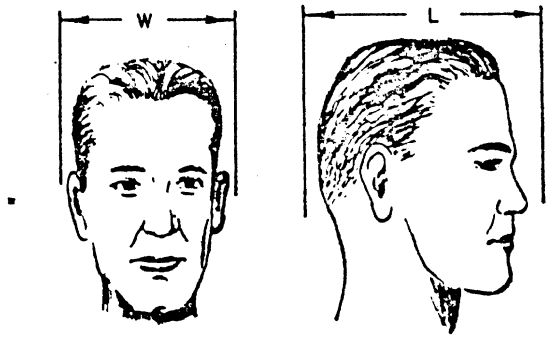
The larger openings for access with arctic clothing are based on military arctic clothing. They are intended for military equipment and also equipment used on civilian construction requiring performance in cold environments. Based on available anthropometric data, the recommended openings are the smallest that will accommodate 95% of the people.



MINIMUM DIMENSIONS, IN.	SQUARE		ROUND	RECTANGULAR	
	W	L	D	W	L
EMPTY HAND	4.0	4.0	4.0	2.25	4.0
ARCTIC MITTEN	5.5	5.5	5.5	3.75	5.5

NOTE OPTIONAL ON ALL CORNERS, MAX. 1 IN RADIUS

FIG. 1—RECOMMENDED MINIMUM DIMENSIONS FOR HAND ACCESS, 95TH PERCENTILE



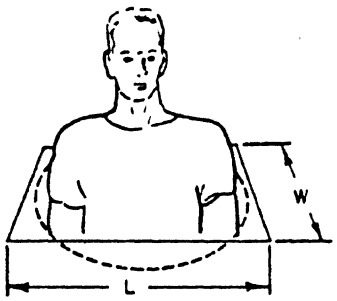
MINIMUM DIMENSIONS, IN.	SQUARE		ROUND	RECTANGULAR	
	W	L	D	W	L
HEAD BARE	9.0	9.0	9.0	6.5	9.0
ARCTIC CLOTHED	10.0	10.0	11.0	9.0	11.0
HAT HELMET	12.0	12.0	12.0	10.0	12.0

FIG. 2—RECOMMENDED MINIMUM DIMENSIONS FOR HEAD ACCESS, 95TH PERCENTILE

In many cases larger openings will be mandatory to perform the specific intended operation. In most cases openings larger than the recommended minimum will be more useful and efficient.

Recommended minimum openings for hand 95th percentile are shown in Fig. 1. Fig. 2 gives recommended minimum openings for head passage 95th percentile and Fig. 3 gives recommended minimum openings for body manhole access 95th percentile. Recommended minimum dimensions for reach access 95th percentile are shown in Figs. 4 and 5.

The dimensions shown are the recommended minimum for limited activity through the opening. Larger openings will be needed in specific instances depending upon nature of task, size and weight of parts, etc. They are based on data from: QM Handbook Series, Human Engineering Guide to Equipment Design, SAE tables, and Product Engineering (Human Engineering Reprints).



MINIMUM DIMENSIONS, IN.	SQUARE		ROUND	RECTANGULAR	
	W	L	D	W	L
NORMAL CLOTHED	18.0	18.0	22.0	12.0	22.0
ARCTIC CLOTHED	20.0	20.0	24.0	14.0	24.0

NOTE: OPTIONAL ON ALL CORNERS, MAX. 1 IN. RADIUS

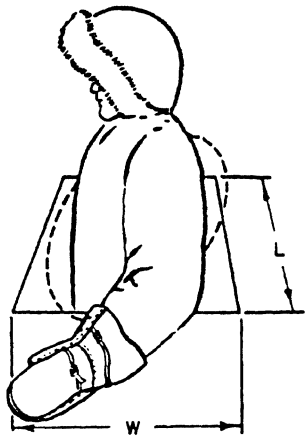
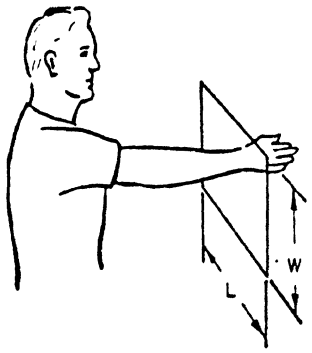


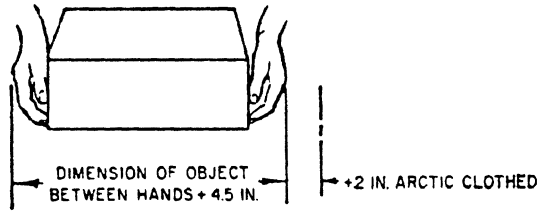
FIG. 3—RECOMMENDED MINIMUM DIMENSIONS FOR BODY ACCESS, 95TH PERCENTILE

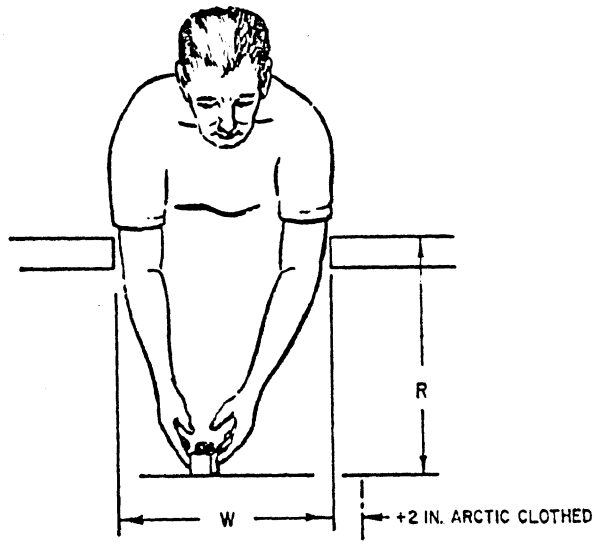


MINIMUM DIMENSIONS ONE ARM, IN	W	L
ARM BARE	6	8
ARCTIC CLOTHED	8	10

NOTE: OPTIONAL ON ALL CORNERS, MAX. 1 IN. RADIUS

FIG. 4—RECOMMENDED MINIMUM DIMENSIONS FOR ARM REACH ACCESS, 95TH PERCENTILE





MINIMUM DIMENSIONS TWO-HANDS	R	W
	REQUIRED REACH	MINIMUM WIDTH
NORMAL CLOTHED	R	3/4 R
ARCTIC CLOTHED	R	3/4 R + 2 IN.

FIG. 5—RECOMMENDED MINIMUM DIMENSIONS FOR TWO-HANDED ACCESS, 95TH PERCENTILE

ACCESS SYSTEMS FOR CONSTRUCTION AND INDUSTRIAL EQUIPMENT—SAE J185

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved July 1970.

1. Purpose—This recommended practice is intended as a guide for designing access systems to the operating station and service points on all types of machines used in construction, material handling, mining, logging, and other similar industries, primarily to aid in preventing accidents and reducing injury to personnel getting on, off, or moving about on vehicles while servicing and/or preparing to operate them.

2. Scope

2.1 This recommended practice covers the criteria for steps, ladders,

Attachment No. 8

AMRL-TR-70-5

ANTHROPOMETRY OF AIR FORCE WOMEN

CHARLES E. CLAUSER
PEARL E. TUCKER, LIEUTENANT COLONEL, USAF, NC
AEROSPACE MEDICAL RESEARCH LABORATORY

JOHN T. McCONVILLE
E. CHURCHILL
LLOYD L. LAUBACH
WEBB ASSOCIATES, INC.

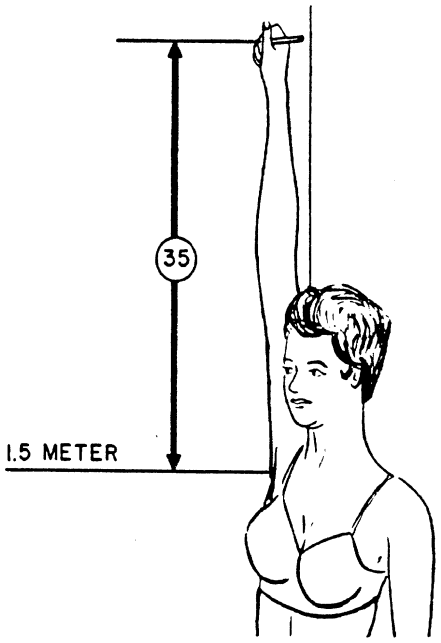
JOAN A. REARDON, LIEUTENANT COLONEL, USAF, BSC
WRIGHT-PATTERSON AIR FORCE BASE MEDICAL CENTER

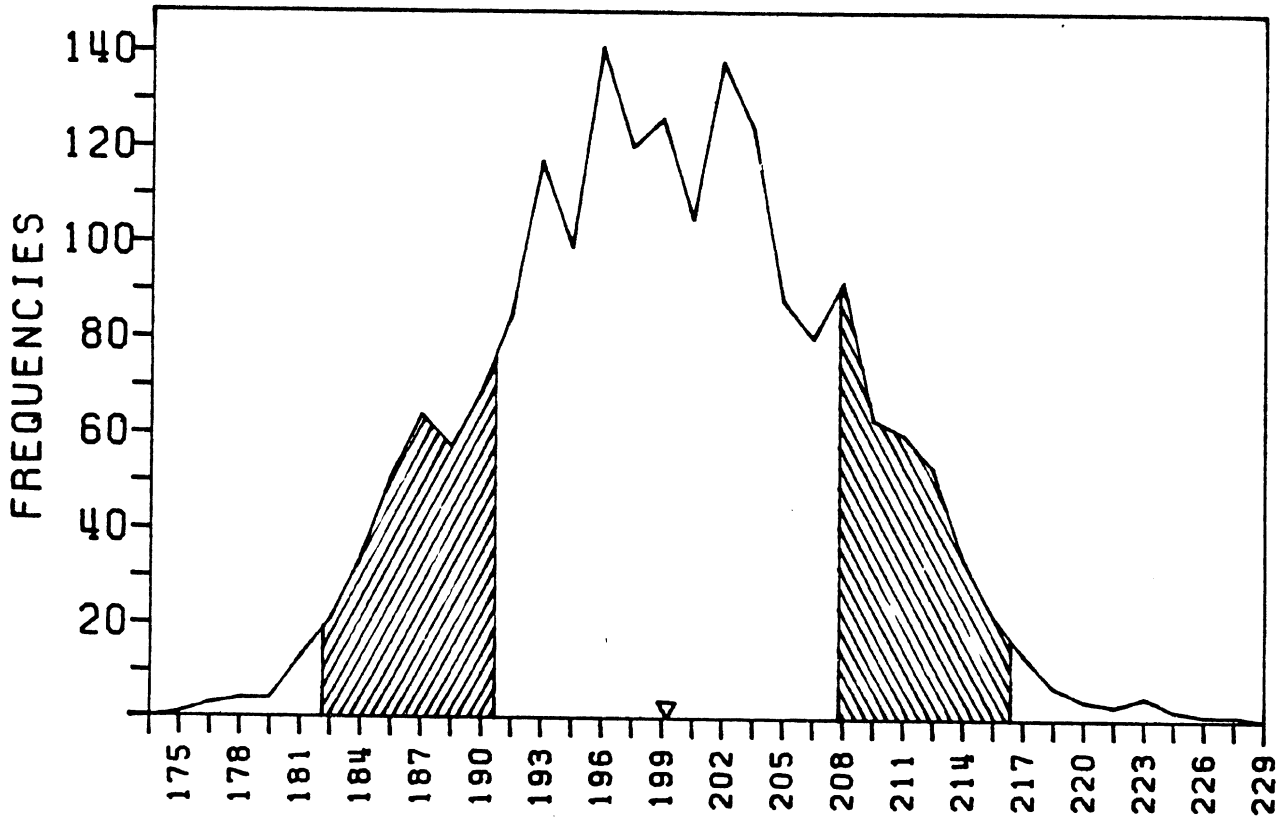
APRIL 1972

AEROSPACE MEDICAL RESEARCH LABORATORY
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

(35) OVERHEAD REACH

Subject stands erect, looking straight ahead, along side of, but not touching, the wall mounted scale. Holding the special pointer in her right fist, she raises the pointer as high as possible while keeping her feet flat on the floor and both the pointer and the proximal phalanges horizontal. Measure on the wall scale the vertical distance from the floor to the tip of the pointer.





RANGES*	F	CUMF	FPCT	CUMPCT
226.75-228.25	1	1905	0.05	100.00
225.25-226.75	1	1904	0.05	99.95
223.75-225.25	2	1903	0.10	99.90
222.25-223.75	5	1901	0.26	99.79
220.75-222.25	3	1896	0.16	99.53
219.25-220.75	4	1893	0.21	99.37
217.75-219.25	7	1889	0.37	99.16
216.25-217.75	14	1882	0.73	98.79
214.75-216.25	22	1868	1.15	98.06
213.25-214.75	34	1846	1.78	96.90
211.75-213.25	53	1812	2.78	95.12
210.25-211.75	60	1759	3.15	92.34
208.75-210.25	63	1699	3.31	89.19
207.25-208.75	92	1636	4.83	85.88
205.75-207.25	80	1544	4.20	81.05
204.25-205.75	88	1464	4.62	76.85
202.75-204.25	124	1376	6.51	72.23
201.25-202.75	138	1252	7.24	65.72
199.75-201.25	105	1114	5.51	58.48
198.25-199.75	126	1009	6.61	52.97
196.75-198.25	120	883	6.30	46.35
195.25-196.75	141	763	7.40	40.05
193.75-195.25	99	622	5.20	32.65
192.25-193.75	117	523	6.14	27.45
190.75-192.25	85	406	4.46	21.31
189.25-190.75	69	321	3.62	16.85
187.75-189.25	57	252	2.99	13.23
186.25-187.75	64	195	3.36	10.24
184.75-186.25	51	131	2.68	6.88
183.25-184.75	34	80	1.78	4.20
181.75-183.25	21	46	1.10	2.41
180.25-181.75	13	25	0.68	1.31
178.75-180.25	4	12	0.21	0.63
177.25-178.75	4	8	0.21	0.42
175.75-177.25	3	4	0.16	0.21
174.25-175.75	1	1	0.05	0.05

*IN CENTIMETERS

CENTIMETERS		INCHES
199.23	MEAN VALUE	78.44
0.20	SE(MEAN)	0.08
8.56	SD DEVIATION	3.37
0.14	SE(SD DEV)	0.05

****

SYMMETRY---VETA I = 0.07
KURTOSIS---VETA II = 2.67
COEF. OF VARIATION = 4.3%

****

NUMBER OF SUBJECTS = 1905

****

THE PERCENTILES

CENTIMETERS		INCHES
218.37	99TH	85.97
216.39	98TH	85.19
215.09	97TH	84.68
213.28	95TH	83.97
210.37	90TH	82.82
208.33	85TH	82.02
206.67	80TH	81.37
205.21	75TH	80.79
203.89	70TH	80.27
202.65	65TH	79.78
201.47	60TH	79.32
200.32	55TH	78.87
199.18	50TH	78.42
198.03	45TH	77.96
196.87	40TH	77.51
195.68	35TH	77.04
194.43	30TH	76.55
193.09	25TH	76.02
191.62	20TH	75.44
189.96	15TH	74.79
187.94	10TH	73.99
185.19	5TH	72.91
183.61	3RD	72.29
182.57	2ND	71.88
181.18	1ST	71.33

Attachment No. 9

HUMAN ENGINEERING GUIDE TO EQUIPMENT DESIGN

(Revised Edition)

Sponsored by

Joint Army-Navy-Air Force Steering Committee

Edited by

Harold P. Van Cott, Ph. D., and Robert G. Kinkade, Ph. D.

American Institutes for Research
Washington, D.C.

1972

10.7.4 Watertight Doors and Armored Hatches

Heavily constructed hatches must be as small as possible to reduce weight and preserve the structural integrity of the bulkhead or deck in which they are to be mounted. Figure 10–45 shows recommended and minimum dimensions for bulkhead-mounted hatches. The 76-in. height permits the helmet-wearing 95th-percentile man to remain erect. If men must pass through a bulkhead-mounted hatch carrying heavy loads, the risk of muscular strain is less for stepping over a high coaming than for stooping excessively. For such situations, a 68-in. minimum is recommended for the top of the hatch, with the height of the coaming being 10 in. (and not over 14 in.). Bulkhead-mounted hatches should be designed for the range of the population that will use the hatch and not just the average man. In any event, the coaming should not be higher than 20 in. (at least 10 in. below the crotch height of the 5th-percentile man).

Horizontal, deck-mounted opening armored hatches (battle tanks, armored decks which raise and lower by hand) have particular maximum weight restrictions which depend on whether the hatch must be raised with:

1. One arm (about 40 lbs. force can be exerted);
2. Rigid arm with lift provided by torso (60 lbs. force); or
3. Two hands (80 lbs.).

If more than one person can simultaneously apply force, these forces can be additive provided the positions of the lifting personnel are not out-of-balance and strain-producing. In these cases, the actual action required should *always* be tested in a full-scale mockup which *fully duplicates* the intended production arrangement in dimensions and weight. This will avoid difficult and harmful situations in which the operator is required to exert a force from a strained position. Hundreds of thousands of military man-hours are lost annually because ruptures, hernias, or torn and strained ligaments or muscles have resulted from poor workplace and work-area design. Maximum forces to be applied are discussed in Chapter 11. The guidelines given should never be substituted for a live test in a faithfully reproduced design mockup, however.

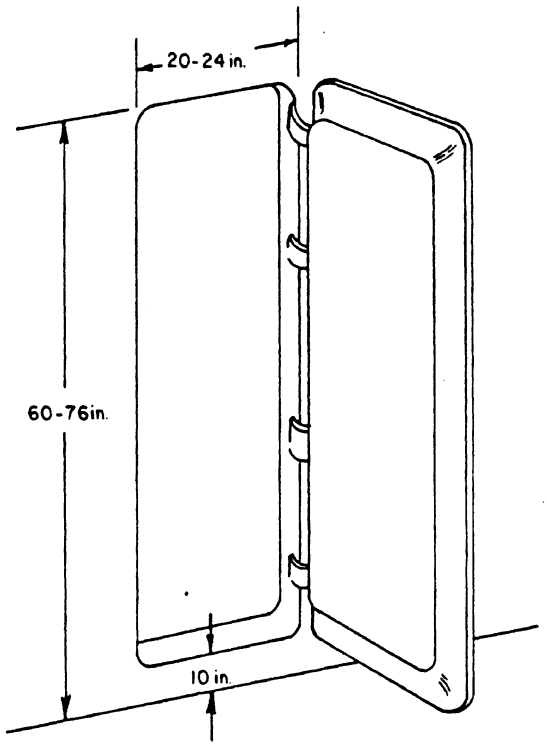


FIGURE 10–45. Armored door dimensions (Thomson et al., 1958).

Figure 10–46 shows mimimum and recommended dimensions for deck-mounted (horizontal) hatches. The actual depth of the hatch depends on the angle X of the ladder leading up to the hatch. The greater the angle X, the greater must be the depth of the hatch to provide head clearance. A usable rule of thumb is: hatch depth equals 76 (tangent X) in. The minimum depth is 24 in. Greater clearance must be added to this minimum when personnel will wear encumbering clothing, equipment, or harnesses. (See Figure 10–47.) For angled ladders, the minimum recommended vertical distances between the lower front edge of the hatch and ladder tread immediately below this point are shown in Figure 10–48.

10.7.5 Ladders, Stairs, Ramps, and Poles

Ladders

Ladders should be used where the desired rise from the horizontal is at an angle of 50° or more, or where a stairway is not practicable.

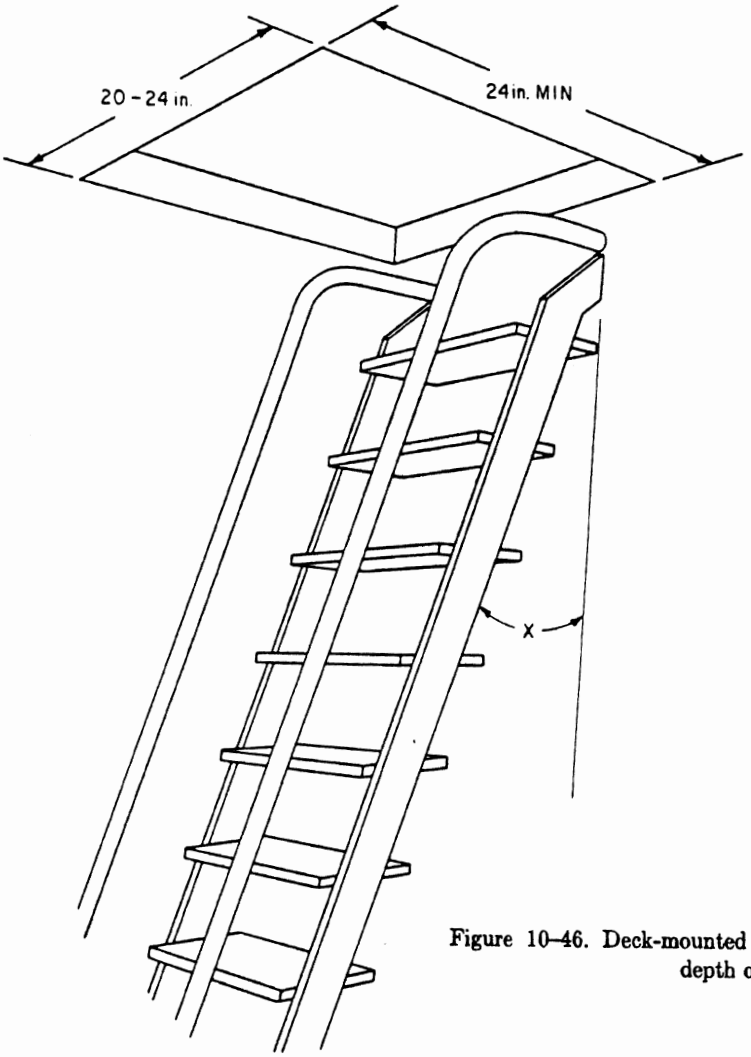


Figure 10–46. Deck-mounted hatch dimensions; as angle X increases, depth of hatch must increase.

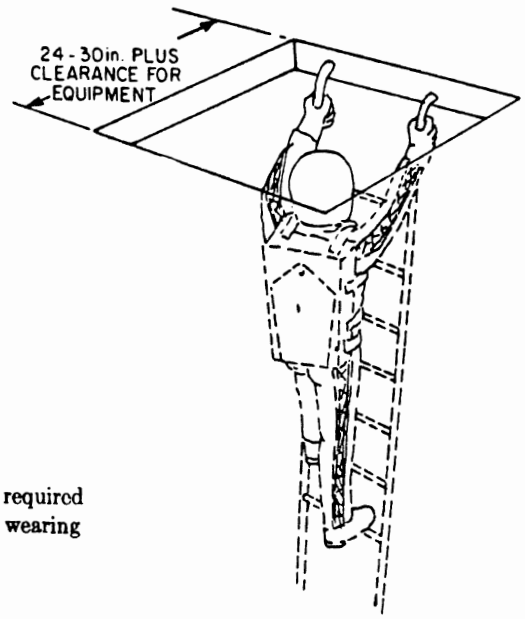


FIGURE 10–47. Added clearance in width required for vertical hatch use by persons wearing equipment.

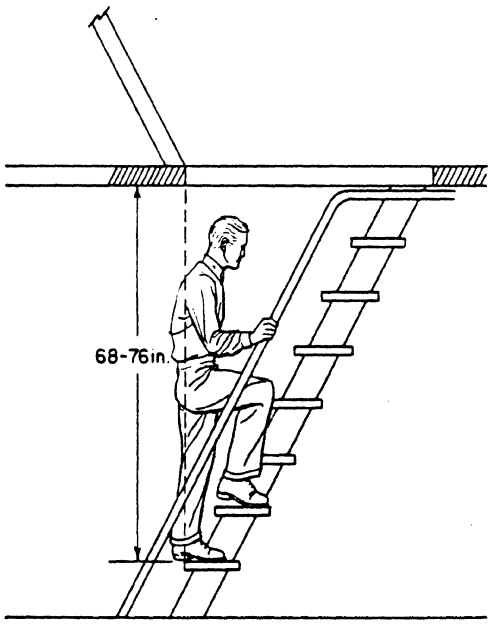


FIGURE 10–48. Minimum hatch edge to ladder tread distance.

The round rung on the vertical ladder is necessary to provide a handgrip. Non-vertical ladders should have flat horizontal treads (as opposed to round rungs) and handrails. The most familiar example of this type is the ship's ladder, which usually rises at an angle of 68° from the horizontal (60° is a preferable angle), with a clearance for only one person. If simultaneous two-way traffic is desired, separate up-and-down ladders are provided, with a maximum tilt angle of 60°, preferably with a double handrail in the center.

Figure 10–49 shows recommended dimensions for this type of ladder. The optimum height between treads is 8.5 to 9 in. Treads should be open (without risers) and provided with non-skid surfacing. Depth of tread depends upon the angle of the ladder. As a rule, the rear of each tread should overlap the front of the tread immediately above, varying from 1 in. for a 70° ladder to 3 in. for a 50° ladder. Although portions of the shoe may extend beyond this point, this design will be in contact with the weight-bearing portion of the shoe sole. Metal screening should be fastened to the underside of the ladder to prevent the foot from slipping through. When two or more flights of such ladders are located one above the other, solid metal sheeting instead of screening will

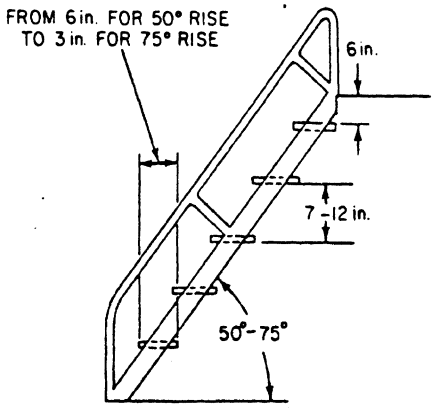


FIGURE 10–49. Ship's ladder dimensions.

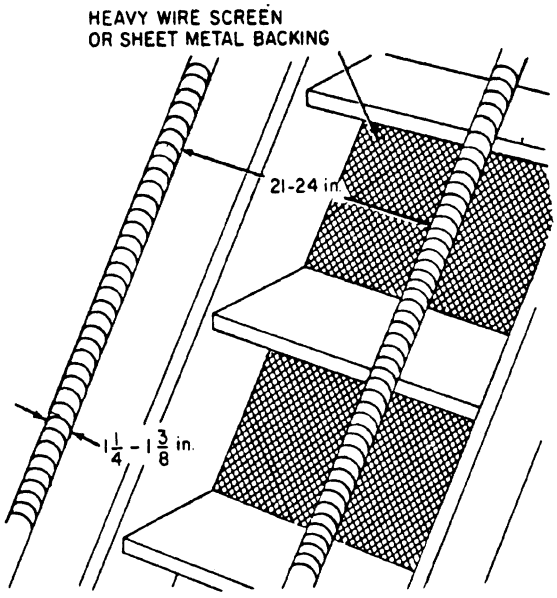


FIGURE 10–50. Handrail arrangements.

protect those on the lower ladder from falling dirt particles, etc. Handrails with a diameter of 1½ to 1⅜ in. and a spacing of 21 to 24 in. (see Figure 10–50) on both sides of the ladder should be covered with a nonslip surfacing.

For vertical ladders, round rungs are used to provide both hand grips and foot supports (for inclines between 75° and 90°). Figure 10–51 shows the recommended dimensions of such a ladder.

The optimum height between treads is from 11 to 12 in. If ladders are used to provide more or less permanent access to several levels, they should be offset at each level and protected by guardrails around the opening at the top of each ladder. (See Figure 10–52.)

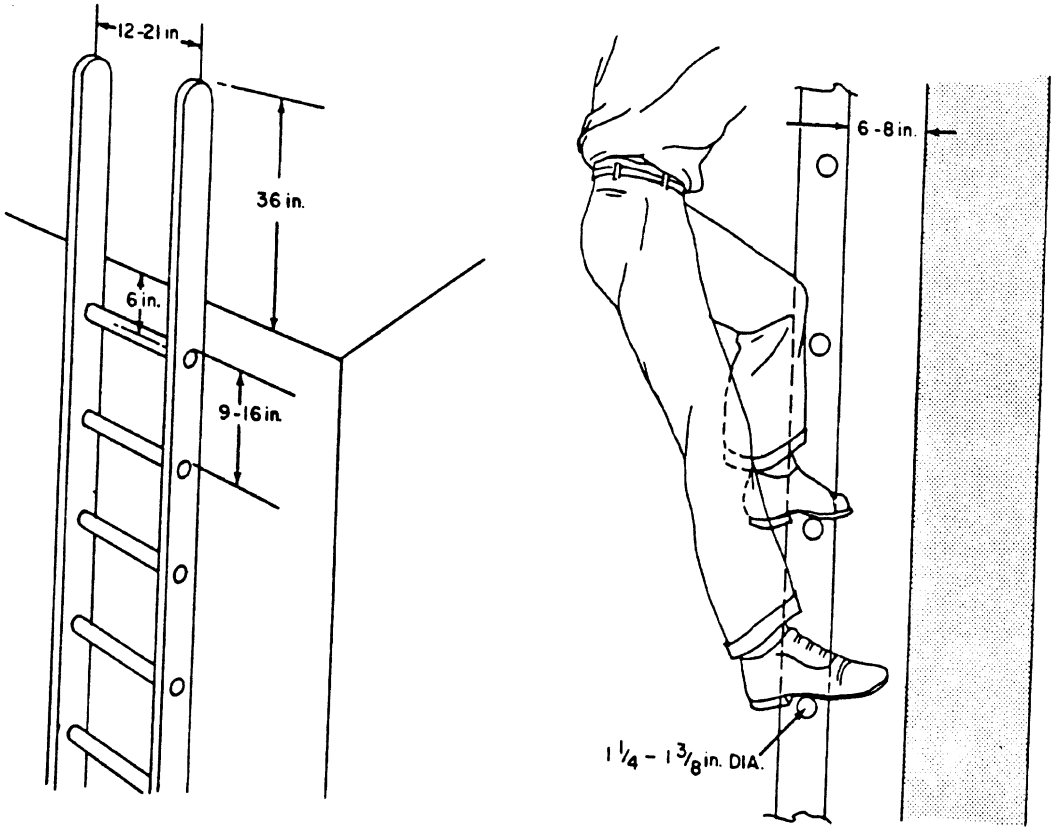


FIGURE 10–51. Vertical ladder design.

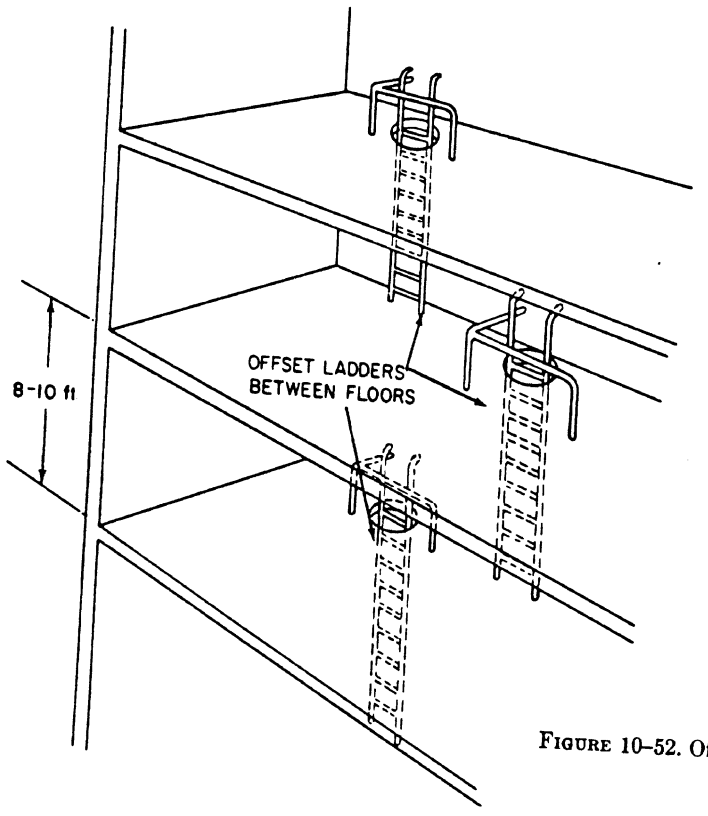


FIGURE 10–52. Offset of ladder between floors is recommended.

Stairs

Stairs should rise from the horizontal at an angle of between 20° and 35°. (See Figure 10–53.) This rise angle automatically determines the ratio of riser height to tread depth, but the minimum riser height should be 5 in. and the maximum 8 in. The optimum tread depth is 9.5 to 10.5 in. plus a 1 to 1.5 in. overhang. (See Figure 10–54.) These dimensions provide depth such that, in descending the stairs, the ball of the foot does not extend beyond the front edge of the tread, and the heel comfortably clears the overhang of the step above.

Long continuous flights of stairs should be avoided. Where space permits, landings should be provided every 10 to 12 treads. In addition, stairs enclosed by walls should have a handrail on at least one side. Recommended height of handrails is shown in Figure 10-55. The width of stairs (between handrails or between wall and handrail) should be as shown in Figure 10–56.

For open stairways and landings, a guardrail should be provided halfway between the handrails and treads. In addition, screen guards should be provided between the guardrail and floor for landings where the stairway is at right angles to the landing. (See Figure 10–57.)

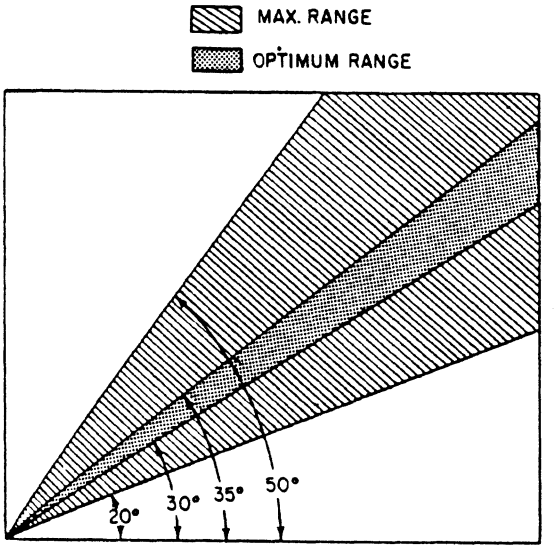


FIGURE 10–53. Stair rise angles (Thomson et al., 1958).

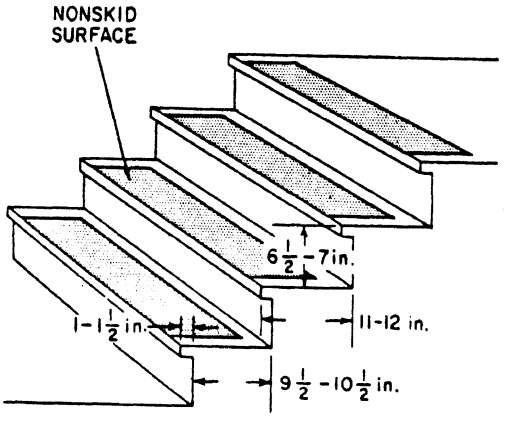


FIGURE 10–54. Stair tread dimensions.

Ramps

Ramps or inclines should be used for grades under 20° where rolling stock must be moved between different levels. For pedestrian traffic only, a stairway is more efficient from the standpoint of space, safety, and speed.

Ramps with a small incline do possess one advantage for pedestrian traffic: they allow elderly persons, or persons in poor physical condition, to expend their energy slowly and to avoid the abrupt raising of the knee required in climbing stairs; the user may shuffle at whatever step length he chooses. In designing for a military population, however, the requirement to provide this type of facility should be clearly justified. When a ramp is to be used for pedestrian traffic, cleats should be provided for slopes of over 15°. Maximum ramp slope may not exceed 20°. For outdoor ramps with slopes in excess of 15°, a non-skid surfacing must be used, and where liquids are likely to be spilled, a similar surface should be applied to indoor ramps as well. Indoor ramps (e.g., the ramps used in the Pentagon building) with slopes of 10° of less may be surfaced with standard materials. Distance between cleats should be 20 in. for slopes of 15°, decreasing as the slope increases to a separation of 14 in. for a maximum slope of 20°. When the ramp is for pedestrian use only, cleats should extend from handrail to handrail at right angles to the slope. (See Figure 10–58.)

Where a smooth (but nonskid) surface or runway for small wheeled vehicles is needed in conjunction with a passage for pedestrians, it should be located in the center of the ramp with the cleated portions on the outside next to the handrail. (See Figure 10–59.)

recommended.

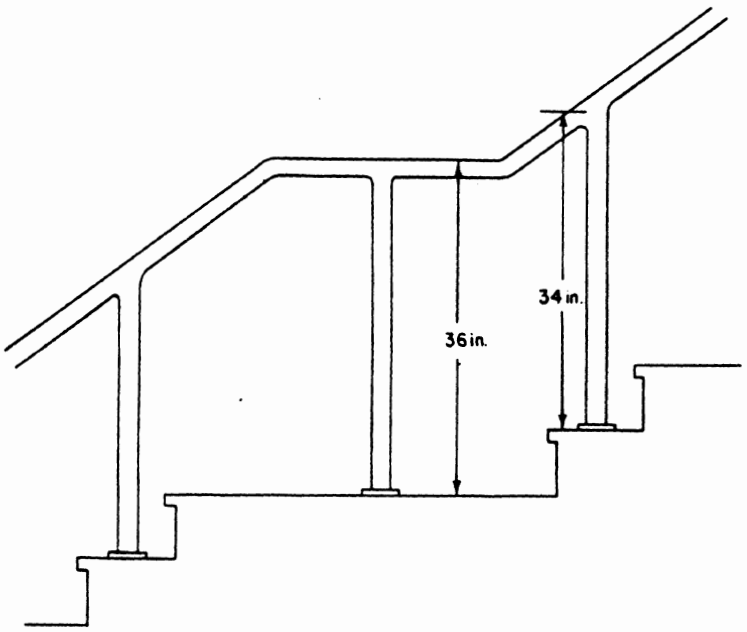


FIGURE 10–55. Recommended handrail heights.

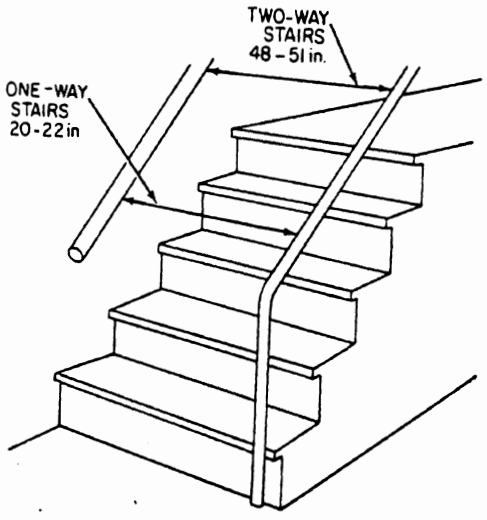


FIGURE 10–56. Recommended stair widths between handrails.

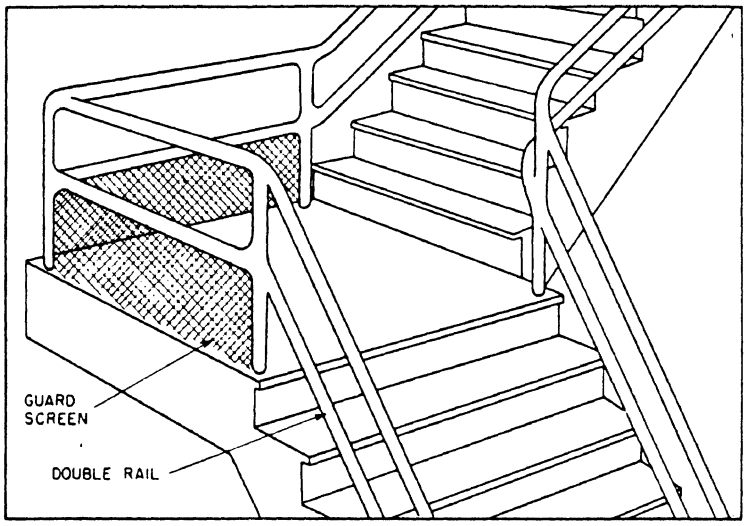


FIGURE 10–57. Use screen guards and guard rail when stair flights are at right angles.

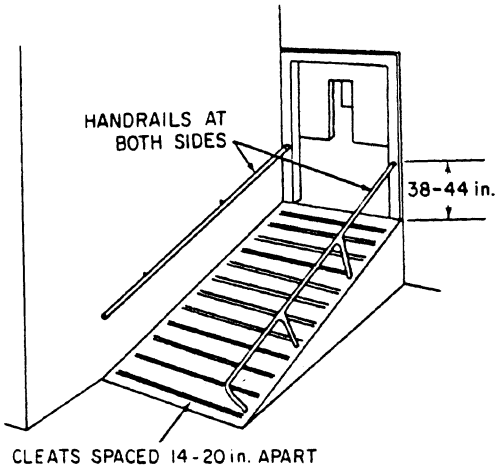


FIGURE 10–58. Ramp design for pedestrian use.

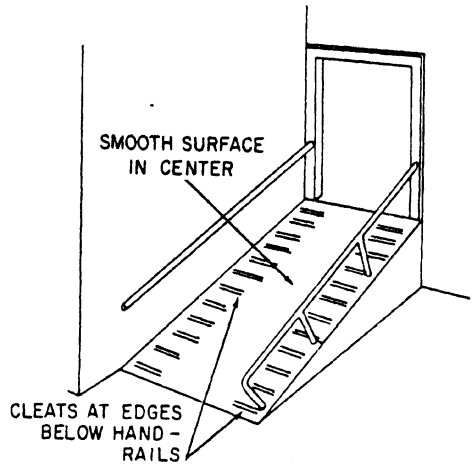


FIGURE 10–59. Ramp design for pedestrian and vehicle use.

Circular Stairs

If they must be used, the space between the handrail and steps of a circular stair or ladder should be enclosed with a metal screen. However, circular stairs are inherently hazardous and are not recommended because:

1. The ratio of tread width to riser height varies continuously across a step.
2. If persons approach in opposite directions, the inside person is forced to step on a very narrow tread. This situation is particularly dangerous if he is descending.

Poles

Vertical poles are used as a means of rapid access from one floor downward to the next. They permit a person in a "ready alert" situation to be transported quickly to another location in a ready-to-operate condition. Since the small possible increment of time saved in comparison to use of stairways is outweighed by the prevalence of accidents, the use of poles is not normally recommended. A survey of fire stations indicates that accidents are frequent. Moreover, fire station architects are discontinuing use of multi-story construction, with the "ready room" (lounge, cots, writing tables) now located adjacent to and on the same level as equipment. This latter practice is recommended here for military and other forms of construction.