HUMAN FACTORS CONSIDERATIONS REGARDING THE ADVANCED NOTICE OF PROPOSED RULEMAKING "MINIMUM CAB SPACE DIMENSIONS"

(BMCS Docket No. MC 79: Notice No. V77-10)
F.R. 43 (31): 6274-6275

Prepared for:

The International Brotherhood of Teamsters
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16. Abstract

This document was prepared to provide the International Brotherhood of Teamsters material in the preparation of their response to a notice of proposed rulemaking on minimum cab size of highway trucks. The study summarizes previous research that has been performed in determining truck driver anthropometric measurements. It details interior dimensions of some typical truck cabs and discusses places where the dimensions appear to be inadequate for the 95th percentile drivers.

A section discusses problems in entering and exiting truck cabs. Another section discusses the interrelationships that exist between vehicle controllability and vehicle exterior dimensions.

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FOREWORD

This document was prepared to provide the International Brotherhood of Teamsters with technical information relevant to a Notice for Proposed Rulemaking (NPRM) by the U.S. Department of Transportation. A draft copy was prepared and submitted directly by the authors to the sponsor so that they might have the benefit of the information before the expiration of the deadline for the NPRM. The Teamsters submitted this draft without change into the NPRM docket, and to a Committee of the U.S. Senate to support their position on some legislation. Subsequently, the draft was reviewed by the Highway Safety Research Institute, and changes have been made, primarily in writing style, from the original draft prepared by the authors. The reader should be aware that this report is slightly different in several places than the draft copies, which have also been placed in circulation.

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I. INTRODUCTION

These comments have been prepared for The International Brotherhood of Teamsters (IBT) who are concerned with the safety and health of its members who drive regulated commercial vehicles. This is in response to the ANPR of February 14, 1978, regarding a safety regulation which would specify the minimum size for the cab portion of regulated commercial vehicles.[1] The information herein primarily addressed and provides guideline design criteria for four of the problem areas cited in the ANPR. These problems areas are:

1. "Deterioration of driver comfort and safety,"
2. "Unsafe and uncomfortable sleeping accommodations for driver relay teams,"
3. "Difficulty in entering and exiting the cab," and
4. Vehicle controllability versus short wheelbases and fifth wheel offsets.

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[1] See Attachment 1.

II. DETERIORATION OF DRIVER COMFORT AND SAFETY

The design dimensions of the cab interior workspace can have an impact on driver comfort and safety. If the driver has to assume cramped or awkward postures due to inadequate space, he may tend to fatigue more quickly. If there is insufficient room to operate steering wheel, foot pedals, and other controls, the driver may not perform at his best. This affects his safety and the safety of others on the road.

Another design consideration is the cab's interior environment to which the driver is constantly exposed. Such things as the interior noise level, amount of vibration, and interior air temperature may all affect the driver's performance and the rate at which he fatigues. Regulations for the cab's interior should require designs which ensure a minimum safety, health, and comfort level and which reduce the severity of the deterioration in the driver's performance capability over time. A reduction in the driver's alloted space in the cab is certainly a trend in the wrong direction to achieve these objectives.

Three areas for potential regulations affecting operator work space designs are of particular concern. These are:

1. Minimum dimensions based on normal operational requirements,
2. Minimum dimensions based on space required to protect occupants in case of collision, and
3. Design standards involving environmental factors.

NORMAL OPERATIONAL REQUIREMENTS

If the driver is to safely operate his vehicle he must first be able to fit into the cab without being forced into awkward postures. He must then be able to reach and operate all controls without undue hindrance. For example, the driver's abdomen should not rub against the steering wheel nor should his knee be obstructed by the steering wheel or column when he is operating the foot-pedals.

Reasonable space for the majority of truckers could be ensured if their cabs were designed to fit up through the 95th percentile driver. In essence this means that the cab needs to be designed around the operator. While we are primarily talking about minimum dimensions, it is important to note that male and female maximum dimensions also must be considered when designing for the smaller drivers. Thus, such things as control reaches, seat depths, and seat heights must be small enough to comfortably accommodate lower percentile male and female drivers.

Cab dimension recommendations based on anthropometric measurements have been provided by McFarland et al. (1955). These are summarized in Table 1 and appear in full in Attachment 2. Figure 1 (from McFarland) contains a drawing of a truck cab with the corresponding dimension recommendations labeled by number. The sample 5th, 50th, and 95th percentile driver dimensions for McFarland's study are presented in Attachment 3.

Sanders (1977) found that truck and bus drivers tend to be larger now than they were in 1950 when McFarland collected his data. The 5th, 50th, and 95th percentiles for Sander's sample appear in Attachment 4. Therein, the truck-bus driver sample used for

CAB DIMENSION RECOMMENDATIONS BASED ON
ANTHROPOMETRIC MEASUREMENTS (MCFARLAND, 1955)
TABLE 1

1.	Distance from Seat to Roof	minimum	36¼" in highest position 40¼" in lowest position
2.	Distance from Top of Foot Pedals to Lower Edge of Steering Wheel	minimum	26"
3.	Distance (Horizontal) from Lower Edge of Steering Wheel to Seat Back	minimum	15" (at point of range of fore & aft adjustability) in a horizontal line
4.	Distance (Vertical) from Lower Edge of Steering Wheel to Floor	minimun	24½"
5.	Distance Between Dashboard (or other items in this forward area) & Seat Back	minimum	29" with seat-back in rear-most position
6.	Distance from Steering Wheel Rim to Directional Signal	minimum	2½"
7.	Breadth of Cab Seat	minimum	18.8"
8.	Seat Depth	maximum	17"
9.	Height of Seat Back		18"-20"
10.	Breadth of Seat Back	minimum	21"
11.	Height of Seat Front Above Floor	maximum	15½"
12.	Range of Vertical Adjustability	minimum	4"
13.	Range of Fore and Aft Seat Adjustability	minimum	6"

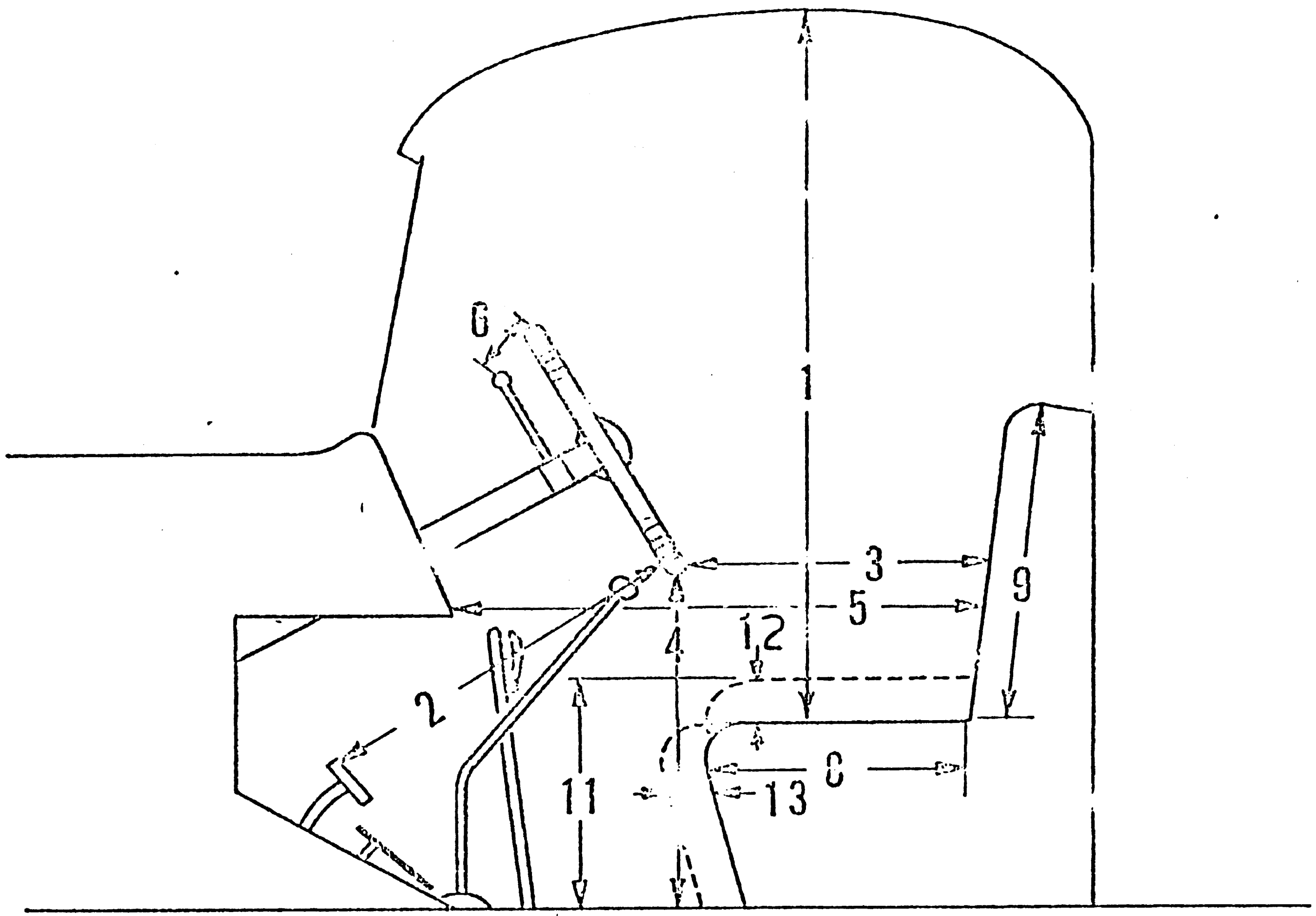


Figure 1. (after McFarland (1955) Truck Cab with McFarland's Dimension Recommendations Labeled by Number (see Table 1)

comparison is taken from McFarland's study. The increase in driver size suggests that recommended dimensions also need to be increased. Therefore, McFarland's recommendations accommodate less of the driver population now than when they were first proposed. Suggested parameters for mock-up of a road vehicle driver position appearing in Figure 2 (VanCott and Kincade, 1972) give an indication of more recent ideas of recommended dimensions based on United States data. Hemmings (1974) provides dimensions based on various European legal requirements and ergonomic considerations. These are shown in Figure 3.

When current cab dimensions are compared to the various recommended dimensions of McFarland _et al_. or Hemmings, as shown in Table 2, it is obvious that some dimensions of some cabs would not provide adequate room for driver comfort and safety. A number of these, pertaining to anthropometric considerations, appear as Attachment 6 and include:

SAE J941c: Motor Vehicle Drivers Eye Range

SAE J1052: Motor Vehicle Driver and Passenger Head Position

SAE J833a: USA Male and Female Physical Dimensions for Construction Industrial Equipment Design

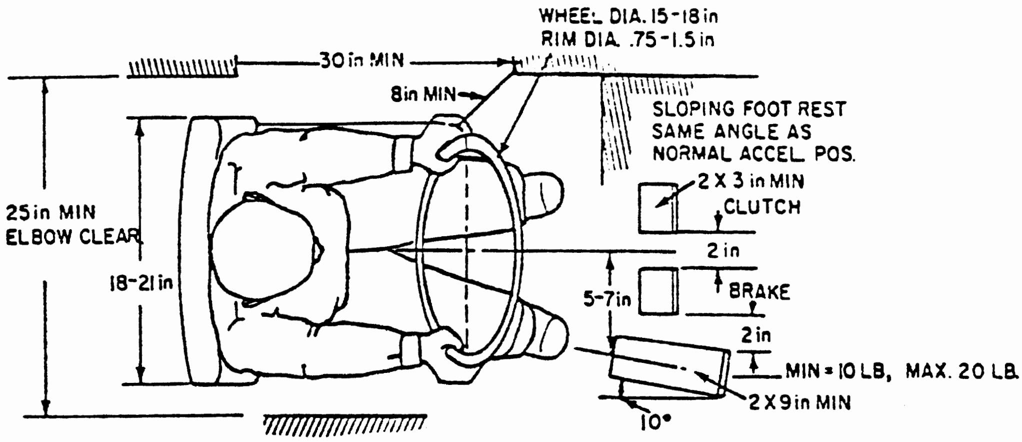
SAE J898a: Control Locations for Construction and Industrial Equipment Design

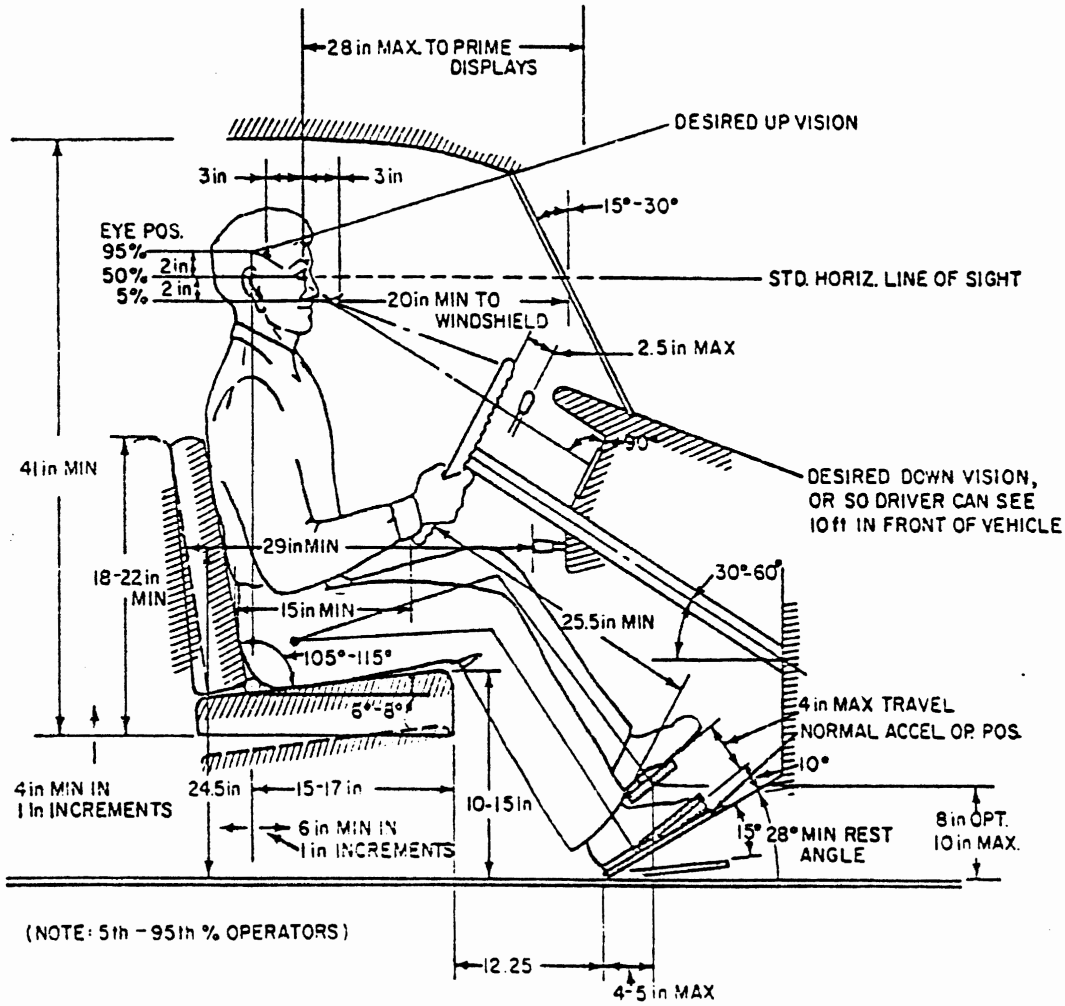
SAE J154: Operator Enclosures (Cabs) - Human Factor Design Considerations

SAE J209: Instrument Face Design and Location for Construction and Industrial Equipment

SURVIVAL SPACE

Another set of dimensions that are important to driver safety are dimensions critical to the survival space. These measurements





Suggested parameters for mockup of a road vehicle driver position (after Dreyfuss, 1959; Hedgcock and Chaillet, 1964; Woodson, 1954; McFarland and Mosley, 1954).

Figure 2. (from Van Cott and Kincade, 1972)

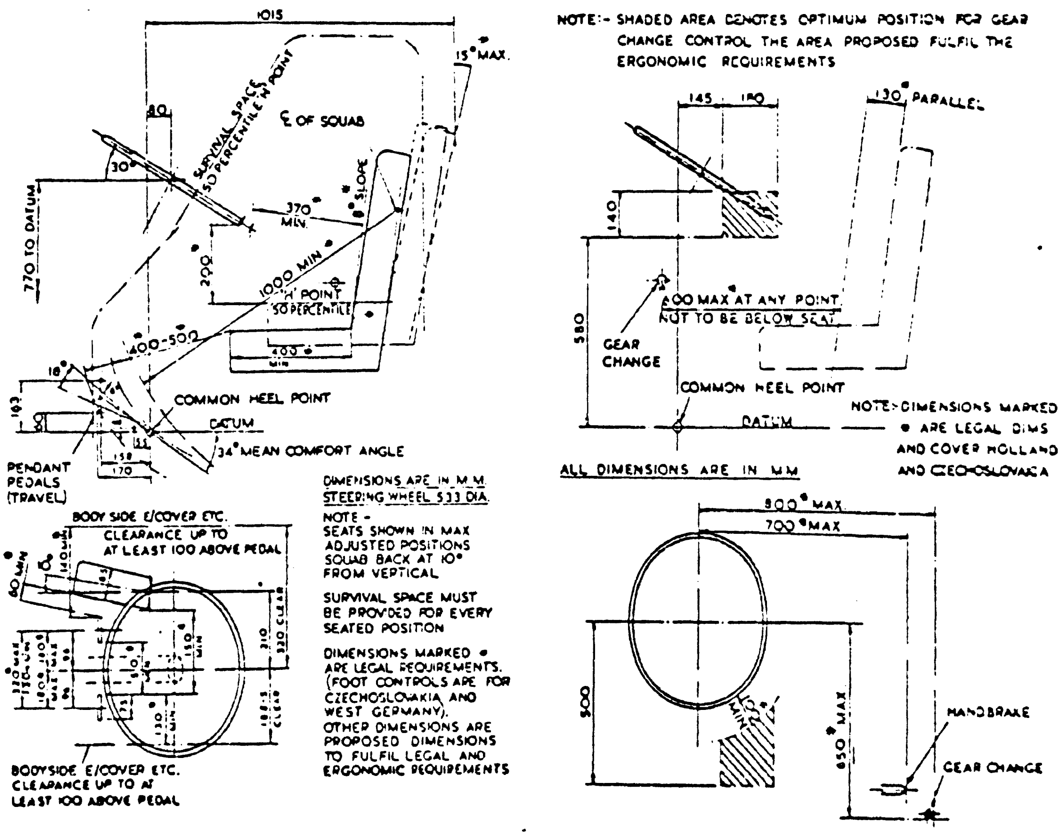


Figure 3. Recommended Dimensions Based on European Practices (from Hemmings, 1974)

TABLE 2

Comparison of Recommended and Actual Truck Cab Dimensions
(Prepared by Miller and Anderson for this report)

	Distance from Lower Edge of Steering Wheel to Seat Back in Rear-Most Position	Distance from Top of Highest Foot Pedal to Lower Edge of Steering Wheel	Vertical Distance from Seat to Roof (Seat in Lowest Position)	Height of Seat Front Above the Floor (Seat in Lowest Position)	Distance Between Lower Edge of Steering Wheel and Top of Seat (Seat in Lowest Position)	Distance Between Lower Edge of Steering Wheel and the Floor	Seat Depth	Range of Vertical Adjustability	Range of Horizontal (Fore-and-Aft Adjustability)
McFarland's Recommendations	[1] 17.8"	26"	40¼"	15½"		24½"	17"	4"	6"
Hemming's Recommendations	14.6"	[2] 27.7"			7.9"	25.1"	15.7"		5.1"
FORD TRUCKS									
*"C" Series '73,'76,'78	15.21"	24.6"	38.9"	18.68"	7.05"	25.73"	17.34"	-	4"
*"L" Series (min.)'73,'76,'78	[3] 10.16"	25.4"	41.5"	19.5"	9.1"	28.6"	17"	-	6"
*"L" Series (max.)	[4] 13.92"	25.4"	41.5"	19.5"	7.6"	27.1"	17"	-	3"
*"W" Series '73,'76	13.54"	24.7"	40.8"	20.42"	6.92"	27.34"	18.2"	-	4"
*CL & CLT 9000 '78	16.63"	24.88"	38.92"	18.9"	8.93"	28.34"	17"	-	6.1"
International Trucks									
*Fleetstar A 1977	14.25"		34"	16"	8"	24"	17.5"	-	4"
**Cargostar 1950B 1978	13"	30.6"	36.5"	19.2"	9.75"	28.8"	17"	2.5"	4"
**COF 4000 D 1969	14.75"	24.5"				27.5"	16.5"	4.5"	4"
GMC TRUCKS									
**1978 6500 Diesel(Bench Seat)	15"	24.4"	36.6"	15.6"	5.75"	21.6"	18"	-	4"
**1978 6000 Diesel(Bucket Seat)	18.5"	24.3"	36.1"	15"	6.6"	21.6"	17"	2.5"	4"

1 Modified to represent distance perpendicular to seat back with seat in rear-most position given 15" horizontal distance, 6" fore-and-aft traverse and 8^0 angle for seat-back.

2 Based on a 21" diameter steering wheel.

3 Based on 22" steering wheel and a bucket seat. (22" wheel is an optional item)

4 Based on 20" steering wheel and a bench seat.

* Drawings appear in Attachment 5.

** Manufacturer's dimensions not available for these thus approximate direct measurements taken by authors.

define the minimum size envelope that should still exist after impact. The shape of the interior volume after deformation due to collision is highly dependent on the truck design and the direction and size of the forces. While further testing is needed in this area, a profile view of a recommended survival space for trucks suggested by Franchini (1969) is shown in Figure 4.

ENVIRONMENTAL FACTORS

The dimensions of the work space are not the only concerns with regard to the safety and health of the driver. His alertness is also of utmost importance. We need to consider the extent to which fatigue can be reduced by control of noise, vibration, and ambient interior environment. Miller (1976) has noted the hazardous effects of each of these stresses in conjunction with the driving task. It would seem useful to consider design standards that deal with these and other related safety hazards. Reproduced in Attachment 7 are the following SAE recommended practices:

- SAE J336a: Sound Level for Truck Cab Interior
- SAE J1013: Measurement of Whole Body Vibration of the Seated Operator of Agricultural Equipment
- SAE J169: Design Guidelines for Air Conditioning Systems for Construction and Industrial Equipment Cabs
- SAE J1129: Operator Cab Environment for Heated, Ventilated, and Air Conditioned Construction and Industrial Equipment

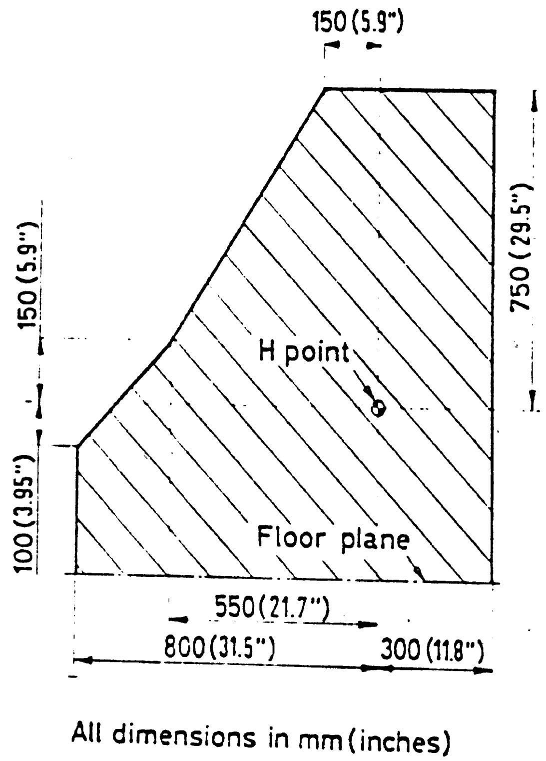


Figure 4. (from Franchini (1969)
Survival Space for Trucks as Recommended by Franchini

III. UNSAFE AND UNCOMFORTABLE SLEEPING ACCOMMODATIONS FOR DRIVER RELAY TEAMS

For the long-haul driver in particular, minimization of fatigue can also be approached in terms of provision for adequate berthing accommodations. For maximum recovery from fatigue the sleeper berth must be large enough to afford comfortable sleeping postures and room for egress, ingress, and changing positions. Johnson found as early as 1930 that bodily movement is necessary to ensure adequate blood flow, to prevent overheating of skin areas in contact with the bed surface, and prevent localized muscle set.

Adequate berth space is an important determinant in the relay driver's recovery from fatigue. An increase in the minimum sleeper berth width beyond the present 24" standard appears necessary, since Sanders (1977) found that 92% of his sample exceeded this width when adopting a prostrate sleeping posture. Furthermore, 44% of the sample exceeded the current 75" length while in this position. These and other percentages appear in Table 3. The sleep envelope for 95th, 90th, and 80th percentiles in each of these sleeping positions is presented in Table 4. A width of at least 34" would be necessary to support the prostrate sleeping posture of the 95th percentile individual in Sander's sample, and this includes no additional space for changing positions to assume this space. A length of at least 80" would be needed to give uncramped, unrestricted space for the 95th percentile individual in this study.

PERCENTAGE OF SAMPLE THAT EXCEED THE DIMENSIONS OF A BERTH CONFORMING TO FEDERAL REGULATIONS

Federal Regulations (inches)	Length (75)	Width (24)	Height (24)
Preferred Posture	19% exceed	56% exceed	0% exceed
Prostrate Posture	44% exceed	92% exceed	0% exceed
Fetal Posture	(Not Measured)	42% exceed	0% exceed

Table 3. (after Sanders, 1977)

SLEEP ENVELOPE FOR 95TH, 90TH, AND 80TH PERCENTILES FOR EACH SLEEPING POSTURE (INCHES)

	Length	Width	Height
Preferred Posture (N=239)			
95th percentile	77.9	33.0	16.0
90th	76.9	30.6	15.2
80th	75.0	28.5	14.4
Prostrate Posture (N=239)			
95th	80.2	33.8	12.1
90th	78.5	33.2	11.5
80th	77.2	32.5	11.0
Fetal Posture (N=238)			
95th	[Not	27.2	17.0
90th	Mea-	26.5	16.4
80th	sured]	25.0	15.7

Table 4. (from Sanders, 1977)

IV. DIFFICULTY IN ENTERING AND EXITING THE CAB

Due to attempts to increase the cargo space yet stay within length regulations, the bumper-to-back-of-cab (BBC) dimension has progressively shrunk. One result has been the advent of cab-over-engine (COE) configurations. Such tractors have smaller BBC dimensions than cab-behind-engine (CBE) tractors, and can be more difficult to enter and exit. This is because the steps are oftne not directly in line with the door opening, and the doors are normally higher off the ground. Considering that slips and falls accounted for 14 percent of all driver personal injuries in a recent DOT study (BMCS, 1977), attention should be given to the study design, and installation of safe ingress/egress systems. Our comments on the step, hand-hold, and ladder aspects of these systems are contained in A Biomechanical Evaluation of Notice of Proposed Rule-Making, "Step, Handhold, and Deck Requirements on Commercial Motor Vehicles" (Snyder, 1978).

It is also important to consider dimensions of the door opening when studying entry and exit from the cab. The primary guidelines on this issue are given in SAE Recommended Practice J925 "Minimum Access Dimensions for Construction and Industrial Machinery" and SAE Recommended Practice J185 "Access Systems for Construction and Industrial Equipment." (Both of these recommended practices appear in Attachment 8). The minimum door opening width recommended in J185 is 18", with a preferred dimension of 27". The preferred door opening height is 52" from the floor. These dimensions also need to be considered when regulating the minimum size of the cab.

V. VEHICLE CONTROLLABILITY VERSUS SHORT WHEELBASES AND FIFTH WHEEL OFFSETS

The RNPR cited a number of driver-related human factors having an interrelationship with vehicle geometry. On any length wheelbase the result of moving forward the fifth wheel position is that (a) higher steering torques are required, (b) the vehicle may become excessively understeering in its turning behavior, and (c) ride quality will be degraded. A long-wheelbase configuration by itself generally offers superior ride qualities over short-wheelbase tractors, and long-wheelbase tractors are often preferred because of their reduced demand on jackknife control

With respect to the effect of state laws, for example, a market exists in the West for long-wheelbase tractors as a consequence of liberal overall length laws through the Western states. The same tractor would be virtually inoperative in the East because of the ridiculously far forward position of the fifth wheel which would be needed to fit within the shorter Eastern length allowances. Even if such a West Coast tractor were fitted with a short cab, the unit would not be useful in the East because, with its fifth wheel far forward, the front axle would become overloaded at rather small levels of trailer payload. We must conclude that constraints on overall length, especially the tighter constraints found in the Eastern states, cultivate not only shorter cabs but by necessity shorter wheelbases as well.

VI. SUMMARY

1. Design standards for the operating space in cabs should be considered. McFarland et. al.'s (1955) recommended cab dimensions (see Table 1) could be a starting point for such an endeavor.

2. Maximum dimensions are also important for the accommodation of the lower-percentile male and female drivers.

3. The survival space should be taken into account when designing cabs. This would mean ensuring adequate space for the occupants of the vehicle after deformation due to impact.

4. Because of their potential effect on fatigue, safety, health, and comfort, design standards for environmental factors such as interior noise, vibration, temperature, humidity, and ventilation should be considered.

5. Even with limited research information it appears fair to conclude that the minimum sleeper berth width and length requirements should be increased.

6. Safe entry and exit of the cab are dependent on minimum dimensions for door openings in combination with step and hand-hold designs. These dimensions should thus be candidates for future standards.

7. Constraints on overall tractor-trailer length have apparently led to shorter cabs, shorter wheel bases, and more forward fifth wheel placement.

REFERENCES

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Franchini, E. "The Crash Survival Space" SAE Publication 690005, International Automotive Engineering Congress, Detroit, Michigan, January 13-17, 1969.

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Johnson, H.M., Swan, T.H. and Weigand, G.E. "In What Position Do Healthy People Sleep?" Journal of the American Medical Association. June 28, 1930, p. 2058.

McFarland, R.A., Damon, A., and Stoudt, H.W., "The Application of Human Body Size Data to Vehicular Design" SAE Special Publication 142, 1955.

Miller, J.M. "Efforts to Reduce Truck and Bus Operator Hazards" Human Factors 1976, 18(6), 533-550.

Sanders, M.S., Anthropometric Survey of Truck and Bus Drivers: Anthropometry, Control Reach and Control Force Springfield, National Technical Information Service, 1977.

Snyder, R.G., A Bio-mechanical 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: Washington, D.C., International Brotherhood of Teamsters, 1978.

Van Cott, H.P. and Kincade, R.G. (eds.) Human Engineering Guide to Equipment Design (Revised Edition), Washington, D.C., American Institutes for Research, 1972.

APPENDIX

(d) Frequency loading resulting from the use of secondary signalling will not be considered in whole or in part as a justification for authorizing additional frequencies in the licensees mobile system.

(e) A mobile service frequency may not be used exclusively for secondary signalling.

(f) The output power shall not exceed 30 watts (at the remote site).

(g) All A2, A9, F1, or F9 emission, may be authorized.

(h) The transmitter shall be designed to deactivate automatically after 3 minutes of continuous carrier radiation.

(i) Operational fixed stations authorized under this paragraph are exempt from the requirements of §§ 91.54(e)(2), 91.107(e), 91.152, 91.154.

(j) On frequencies above 25 MHz, base, mobile relay or mobile stations may transmit secondary tone or impulse signals to receivers, as provided in this section.

(52) Persons providing a central station commercial protection service may use the frequency, on a secondary basis, to transmit information about alarms received by the central station to police or to fire stations or vehicles, if the frequency is also authorized to the licensee and it is used in a base and mobile system offered by that licensee.

* * * * *

[FR Doc. 78-3938 Filed 2-13-78; 8:45 am]

[4910-22]

DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

[49 CFR Part 393]

[BMCS Docket No. MC-79; Notice No. 77-10]

MINIMUM CAB SPACE DIMENSIONS

Advance Notice of Proposed Rulemaking

AGENCY: Federal Highway Administration, DOT.

ACTION: Advance notice of proposed rulemaking.

SUMMARY: This advance notice is being issued to solicit comments on proposed additions to the Federal Motor Carrier Safety Regulations. Consideration is being given to adopting a safety regulation which would specify minimum size for the cab portion of the regulated commercial vehicles manufactured after a certain date and operated in interstate or foreign commerce. There is a need to reassess the safety impact of present restrictions imposed by certain States on overall commercial vehicle length as they influence the driver's operating environment.

DATES: Comments must be received on or before July 14, 1978.

ADDRESSES: BMCS Docket No. MC 79, Bureau of Motor Carrier Safety, Federal Highway Administration, Room 3402, 400 Seventh Street SW., Washington, D.C. 20590. All comments and suggestions received will be available for examination at the above address between 7:45 a.m. and 4:15 p.m. e.s.t., Monday through Friday.

FOR FURTHER INFORMATION CONTACT:

Mr. D.W. Morrison, Chief, Vehicle Requirements Branch, Bureau of Motor Carrier Safety, 202-426-1700; or Mrs. K. S. Markman, Attorney, Office of the Chief Counsel, 202-426-0786, Federal Highway Administration, 400 Seventh Street SW., Washington, D.C. 20590. Office hours are from 7:45 a.m. to 4:15 p.m. e.s.t., Monday-Friday.

SUPPLEMENTAL INFORMATION: The Bureau of Motor Carrier Safety (BMCS), an element of the Federal Highway Administration (FHWA), is considering the problems associated with and which would give rise to the necessity for the specification of a minimun size for the cab portion of regulated commercial vehicles. Such specifications would consider the means of achieving safety-related objectives through the regulation of truck and tractor cab size of commercial motor vehicles manufactured after a certain date and operated in interstate foreign commerce.

There are several reasons for initiating proposed rulemaking at this time. First, the need to reassess the safety impact of present restrictions imposed by certain States on overall commercial vehicle length as they influence the driver's operating environment. Second, the National Highway Safety Advisory Committee's report, Vehicle Length Restrictions, March 1977, noted safety benefits in revised vehicle length restrictions to allow more cab operating space. Third, the issue of truck lengths has become a matter of increasing concern to labor interest groups as it impacts upon working conditions of the drivers. Fourth, the Department of Transportation's Steering Axle Study, July 5, 1977, prepared in accordance with section 210 of the Federal-Aid Highway Act of 1976, discussed the effort required to steer a commercial motor vehicle in relation to steering axle weights, placement of the fifth wheel, and the length of the cargo carrying body.

The Bureau is considering minimum cab size requirements which may have a direct effect on cargo carrying capacity or commercial vehicle lengths within the framework of an overall length limitation imposed by States. At present, the maximum length specified by any State for a tractor semitrailer combination is 75 feet, and most of the States have limits ranging from 55 to 65 feet.

The International Brotherhood of Teamsters (IBT) and the Professional Drivers Council (PROD) have stated that equipment manufacturers, in response to customer requests, have shortened the wheel base and cab dimensions of power units in order to increase, as much as possible, the cargo carrying portion of the vehicle. The following problems have been cited:

Excessive weight on the steering axle.

Improper fifth wheel placement

Deterioration of driver comfort and safety.

Reduced accessibility to the engine for inspection and maintenance.

Increased difficulty in entering and exiting the cab, thereby increasing the likelihood of slips and falls.

Unavailable space to alter the shape of the cab for purposes of reducing wind resistance and improving fuel economy

Unsafe and uncomfortable sleeping accommodations for driver relay teams.

Short wheel bases and high fifth wheel offsets that adversely affect operating safety.

Overloading of front tires.

The Bureau believes that a severly degraded ride may have an indirect impact on safety by increasing driver fatigue level or reducing the driver's concentration. Currently, the effect of ride quality is one phase of a study being conducted for the Department of Transportation. Results of this contract and others will be considered in the formulation of any regulations affecting vehicle or vehicle component lengths.

In order to obtain data, information and views to assist the Bureau for assessing the need for regulations in this area, we are requesting comments on these minimum cab size parameters:

1. Whether any type or weight class of vehicle be exempted and why.
2. Experience with shortened cab and its effect on driver performance.
3. Experience with shortened cab and vehicle controlability and maneuverability.
4. Cab over engines (COE) and their effect on steering axle weights.
5. Fifth wheel placement resulting from COE configurations and its effect on vehicle controlability.
6. Effect of COE placement on accessibility of engine for purposes of inspection and maintenance.
7. Compatability of differing sizes of tractor and trailer and the possible effect on safety.
8. In addition, comments are specifically requested on the feasibility of proposing model advisory standards in lieu of regulations with respect to minimum cab space dimensions, as rec-

ommended by the National Highway Safety Advisory Committee Report of March 1977.

Those desiring to comment on this advance notice of proposed rulemaking are asked to submit in writing 3 copies of their views, data, and arguments. All communications received will be considered before any proposals for rulemaking actions are undertaken.

All comments submitted will be available both before and after the closing date for examination by interested persons in the docket room of the Bureau of Motor Carrier Safety, room 3402, 400 Seventh Street SW., Washington, D.C. 20590. If it is determined to be in the public interest to proceed further after summarizing the comments and considering the available data and comments received in response to this advance notice, a notice of proposed rulemaking will be issued.

(49 U.S.C. 304, 49 U.S.C. 1655, 49 CFR 1.48 and 49 CFR 301.60.)

Issued on February 3, 1978.

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

[FR Doc. 78-4054 Filed 2-13-78; 8:45 am]

[4310-55]

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

[50 CFR Part 20]

MIGRATORY BIRD HUNTING

Proposed 1978-79 Migratory Game Bird Hunting Regulations (preliminary)

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Proposed rulemaking.

SUMMARY: The Service proposed to establish open hunting seasons, daily bag and possession limits, and shooting hours for all designated groups or species of migratory game birds for which hunting seasons are being considered for 1978-79 in the contiguous United States, Alaska, Hawaii, Puerto Rico, and the Virgin Islands. The Service annually prescribes migratory bird hunting regulations. The effect of these hunting regulations is to provide hunting opportunity, a form of outdoor recreation, to the public and to aid Federal and State governments in the management of migratory game birds.

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

ADDRESS: Send comments to: Director (FWS/MBMO), U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240.

FOR FURTHER INFORMATION CONTACT:
John P. Rogers, Chief, Office of Migratory Bird Management, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240, 202-343-8827.

SUPPLEMENTARY INFORMATION: The Fish and Wildlife Service proposes to establish hunting seasons, bag and possession limits, and shooting hours for migratory game birds under sections 20.101 through 20.107 of subpart K of 50 CFR 20.

"Migratory game birds" are those migratory birds so designated by conventions between the United States and several foreign nations for the protection of these birds. During the 1978-79 hunting season, regulations are proposed for certain designated members of the avian families Anatidae (wild ducks, geese, brant, and swans); Columbidae (wild doves and pigeons); Gruidae (cranes); Rallidae (rails, coots, and gallinules); and Scolopacidae (woodcock and snipe).

NOTICE OF INTENTION TO ESTABLISH OPEN SEASONS

This notice announces the intention of the Director, U.S. Fish and wildlife Service, to establish open hunting seasons, daily bag and possession limits, and shooting hours for all designated groups or species of migratory game birds for which hunting seasons are being considered for 1978-79 in the contiguous United States, Alaska, Hawaii, Puerto Rico, and the Virgin Islands.

FACTORS AFFECTING REGULATIONS PROCESS

This is the first notice in a series of proposed and final rulemaking documents for migratory bird hunting regulations, and sets forth proposed season frameworks and shooting hours for the various groups of migratory game birds, as well as proposed daily bag and possession limits for certain groups or species for which these regulations ordinarily do not vary significantly from year to year. The proposals set forth here for certain species, as well as the schedule by which more detailed proposals for these and other species will be developed, are dependent upon a number of factors. Among these are various annual population and habitat surveys, the times when these surveys are conducted and results are available for analysis, times of migration and other biological considerations, and times during which hunting may be allowed. The regulatory process for migratory game birds is strongly influenced by the times when the best and latest information is available for the development of regulations. For these reasons, the overall regulations process for hunting seasons and bag limits is divided into the following segments: (1) regulations for migratory game birds in the United States, Puerto Rico, and the Virgin Islands for which seasons prior to Sepotember 30 are proposed (early seasons); and (2) regulations for migratory game birds in the United States for which seasons opening on September 30 or later are proposed (late seasons). Regulations development for each of the two categories will follow similar but independent lines. Proposals relating to the harvest of migratory game birds that may be initiated after publication of this proposed rulemaking will be made available for public review in a supplemental proposed rulemaking to be published in the FEDERAL REGISTER. Also, additional supplemental proposals will be published for public comment in the FEDERAL REGISTER as population, habitat, and harvest information becomes available.

Because of the late dates when certain of these data become available, it is anticipated that comment periods on proposals dealing with specific hunting seasons, limits and certain other regulations pertaining to migratory shore and upland game birds and waterfowl will necessarily be abbreviated. Special circumstances which limit the amount of time which the Service can allow for public comment are involved in the establishment of these regulations. Specifically, two considerations compress the time in which the rulemaking process must operate: the need, on the one hand to establish final rules at a time early enough in the summer to allow affected State agencies to appropriately adjust their licensing and regulatory mechanisms, and, on the other hand, the lack before late July of specific, reliable data on this year's status of most waterfowl.

PUBLICATION OF REGULATORY DOCUMENTS

The process relating to the establishment of migratory bird hunting regulations in the united States involves a series of regulatory announcements published in the FEDERAL REGISTER in accordance with the Administrative Procedure Act. The publication of these documents is divided into three phases, as follows:

1. Proposed rulemakings—proposals to amend subpart K (and, when necessary, other subparts) of 50 CFR Part 20, including supplementary proposed migratory game bird hunting regulations, and/or regulations frameworks which prescribe season lengths, bag and possession limits, shooting hours, and outside dates within which States may make season selections.

2. Final rulemakings—frameworks. Final migratory game bird regulations frameworks which prescribe season lengths, bag and possession limits, shooting hours, and outside dates

II. Cab Dimensions Relat ' to Static H man Body Size

Insofar as possible all cab dimensions should be considered as ec-tions of their relevant human body dimension, i.e. should be determined on the basis of those anthropometric data necessary to insure proper accommodation for the largest number of drivers. Owing to their static nature, the human body measurements considered in this section ; rmit specific recommendations for the various dimensions of the Cab. Fig. 2 shows the relevant cab dimensions as di-cussed below.

1. Dimension: Distance from Seat to Roof

   a) Pertinent Body Dimension: Sitting height

   b) Purpose: Clearance for driver's head

   c) Discussion: Insufficient head clearance may forc the drive · to crouch over the wheel or may cause him to strike his head on the cab roof during sudden bumps or jolts. If 2 in. of clearance are allowed above the erect sitting height of the tallest group of drivers (95th percentile = 38.2 in.) such conditions may be largely avoided. The minimum vertical distance from the top of the seat cushion to the cab roof should thus be 40-1/4 in. Depression of the seat cushion by the driver's weight will give an added clearance which should more than cancel out any increased height owing to headgear or clothing thickness under the buttocks. (With vertical seat adjustability it should be remembered that taller drivers will have their seats in th lower positio s.)

   d) Recommendation: A minimum of 40-1/4 in. between the top of the seat cushion and the bottom of the cab roof (if seat is adjus ble vertically a minimum of 40-1/4 in. from the lowest p tion and a minimum of 36-1/4 in. from the highest position).

2. Dimension: Distance from Top of Foot Pedals to Lower Edge of Steeri Wheel

   a) Pertinent Body Dimension: Knee height

   b) Purpose: To give the driver sufficient leg room to apply the pedals without bumping or trapping the knee under the steering wheel

   c) Discussion: This is one of the most cr tical of the cab dimensions related to human body size. Frequently when larger drivers attempt to raise their leg and apply the brake, the knee either bumps the bottom of the wheel or cannot be raised high enough to place it on the pedal without first angling the leg out to the right of the wheel, and straightening the leg as the brake is depressed. In the latter case the loss of time during a critical operation is obvious. For this reason a bare minimum of 24 1/2 in. (95th percentile in knee height plus 1 in. shoe and clothing allowance) must be allowed between the top of the pedals and the bottom of the steering wheel. However, since this measurement is so critical it seems advisable to add at least an additional 1 1/2 in. to accommodate the majority of drivers in the upper 5%, making the minimum 26 in. in this dimension.

d) Recommendation: A minimum of 26 in. between the top surface of the foot pedals and the bottom of the steering wheel.

3. Dimension: Distance (Horizontal) from Lower Edge of Steering Wheel to Seat Back

a) Pertinent Body Dimension: Abdomen depth

b) Purpose: To avoid Contact of steering wheel with abdomen thus reducing possibility of serious abdominal injury in sudden stops or collision, and facilitating entrance and exit.

c) Discussion: This measurement is of importance for those heavier drivers who frequently find the steering wheel indenting their abdomens as a result of too small a space between the bottom of the wheel and the body. Since the 95th percentile of commercial drivers in abdomen depth is 12.1 in., plus an additional allowance for loose or bulky clothing and forward slump, there should be at least 15 in. of clearance (steering wheel to seat back) to avoid contact. It should be remembered that it is not only the tallest 95th percentile of drivers who will be of the 95th percentile in abdomen depth, but many shorter ones as well. For this reason this clearance should be taken not from the rearmost position of seat adjustability but rather from the midpoint.

d) Recommendation: A minimum of 15 in. in a horizontal line between the rearmost edge of the steering wheel and the seat back (at the midpoint of the range of fore and aft adjustability).

4. Dimension: Distance (Vertical) from Lower Edge of Steering Wheel to Floor.

a) Pertinent Body Dimensions: Knee height

b) Purpose: To help Insure lateral freedom of movement for lower leg.

c) Discussion: This dimension is of importance mainly to access to, and exit from, the cab and for freedom of lower leg movement when seated behind the wheel. A vertical clearance of 24 1/2 in. will permit lateral knee movement under the wheel for 95% of all drivers.

d) Recommendation: A minimum clearance of 24 1/2 in. between the bottom of the steering wheel and the floor.

. Dimension: Distance between Dashboard (or other items in this forward area) and Seat Back.

a) Pertinent Body Dimension: Buttock-knee length

b) Purpose: To establish sufficient clearance between the driver's knees and forward obstructions

c) Discussion: In some vehicles it was noted that the dashboard itself was uncomfortably close to the knee. This clearance dimension is directed primarily at eliminating unnecessary obstructions to the knee either during operation and changing of seat position, or while sliding in and out of the cab. Since the 95th percentile of buttock-knee length in commercial drivers is 25.8 in. (plus a 3 in. allowance for clothing and a possible shifting forward of the buttocks while seated), there should be at least 29 in. between the seat back and the point of rearmost projection of any controls, knobs, levers in the forward vertical level occupied by the knee. This is the minimum dimension from the point of rearmost adjustability for taller men with larger buttock-knee lengths. Since the men who adjust their seats farther forward will do so on the basis of shorter leg length the above provision will also be adequate for them.

d) Recommendation: A minimum clearance of 29 in. between any forward items in the knee area of the driver and the seat back in its rear-most adjustment.

6. Dimension: Distance from Steering Wheel Rim to Directional Signal

a) Pertinent Body Dimension: Hand length

b) Purpose: To enable the driver to operate directional or similar types of controls without removing the hands from the steering wheel.

c) Discussion: On the basis of the range of commercial drivers' hand length, it has been ascertained that if a control of this nature, requiring only an up or down movement, is located not more than 2 1/2 in. from the rim of the steering wheel it can be activated by all drivers without removing the hand from the wheel. While this is a convenience rather than a necessity, it should be pointed out that many such signals are just out of reach and could very easily be placed in this more comfortable position.

d) Recommendation: The directional (or similar type) signal to be located not more than 2 1/2 in. from the rim of the steering wheel.

7. Dimension: Breadth of Cab Seat

a) Pertinent Body Dimension: Seat breadth

b) Purpose: Minimum seat breadth for comfort

c) Discussion: In vehicles with a front seat extending across the width of the cab, this measurement will not be pertinent but where individual seats are supplied, the minimum seat width must be at least that of the 95th percentile of commercial drivers plus a suitable clothing allowance, or 16.3 in. plus 2.5 in. equals 18.8 in. This is especially important where the seat is equipped with sides as in the bucket type. Additional room should be given whenever possible to insure comfort through ability to change positions.

d) Recommendation: Minimum seat breadth, 19 in.

8. Dimension: Seat Depth

a) Pertinent Body Dimension: Buttock to back of calf distance

b) Purpose: To accommodate both long and short legged men with respect to seat depth

c) Discussion: If seat depth is too large, short legged drivers will find the front edge of the seat cutting into the back of the calf and will be unable to bend the leg at the knee satisfactorily unless they shift their buttocks forward on the seat. On the other hand, taller drivers will have no thigh support if the seat is too short. Buttock-back of calf distance was not taken for the commercial driver series, but comparison with a group of males measured by Hooton in A Survey of Seating[2] indicates that this dimension will closely approximate 17.5 in. for 5th percentile drivers. Although men rarely drive with the buttocks tightly in contact with the back of the seat but rather shift them forward varying amounts a 17 in. seat depth is the maximum that can assure comfort for 5th percentile drivers at all times. This seat depth will also give adequate thigh support for taller drivers.

d) Recommendation: A maximum seat depth of 17 in.

9. Dimension: Height of Seat Back

a) Pertinent Body Dimension (s): Trunk height and height of maximum concavity of back.

b) Purpose: To support part of body weight and to give a stable back support for applying pressure to foot controls.

c) Discussion: The minimum height of the seat back could be set at 12 in., which is sufficient to give support to the "small of the back" area, or region of maximum lumbar curvature. However, for purposes of comfort, additional height must be allowed. Maximum seat height, on the other hand, should not interfere with the driver's headgear and should not afford him a head rest, for the latter may interfere with alertness as well as freedom of movement. A maximum set at 22 in. will suffice for this purpose. In general the central range of 18 in. - 20 in. provided in most commercial vehicles seems quite satisfactory for this dimension.

d) Recommendations: 18 in. - 20 in. for Height of Seat Back.

10. Dimension: Br[illegible]h of Seat Back

a) Pertinent Body Dimension: Shoulder breadth

b) Purpose: To provide adequate lateral space for back and shoulder support

c) Discussion: A minimum breadth for this dimension will be necessary only where an individual seat is supplied for the driver. In such instances the seat back must be at least wide enough to support the maximum breadth across the shoulders of the 95th percentile of drivers. With a suitable clothing allowance this figure may be set at 21 in. A greater width will of course afford additional room for change of position.

c) Recommendation: A minimum breadth of 21 in. for the seat back.

11. Dimension: Height of Seat Front Above Floor

a) Pertinent Body Dimension: Lower leg length

b) Purpose: To avoid excessive height, resulting in pressure from the front edge of the seat on the under part of the leg and thigh.

c) Discussion: The problem of excessive s at height is of primary concern to shorter drivers who may find an uncomfortable pressure exerted on the under part of the thighs by the seat cushion if the feet cannot rest comfortably on the floor or pedals. The essential body measurement in such cases is the lower leg height from the floor to the under part of the thigh directly in back of the knee. Although this dimension was not taken on the commercial driver series, comparisons with other groups[1] indicate it to be about 16-3/4 in. including shoes. However, when the legs are extended forward knee height is reduced, thus requiring a lower seat level. In ge ral a maximum height of 15-1/2 in. should suffice for 5th percentile drivers. Taller drivers will, for the most part prefer lower adjustments (for reasons of visibility and head clearance).

d) Recommendations: A maximum height of 15-1/2 in. from the top of the front of the seat to the floor.

12. Dimension: Range of Vertical Seat Adjustability

a) Pertinent Body Dimension: Normal sitting eye height

b) Purpose: Optimum location of operator's eye level

c) Discussion: A primary requirement in the design of the cab area is that drivers of varying body size should be able to place themselves in a position of optimum visibility by means of vertical seat adjustment. If this is not possible, the shorter drivers may find themselves craning their necks or using seat pillows in order to see over the top of the hood. Taller drivers, on the other hand, may be forced to bend forward on occasion to see traffic signals or other objects under the top edge of the windshield or bend down to avoid striking their head on the roof. Since the range of normal sitting eye height in commercial drivers is 4 in., (5th percentile - 27.7 in., 95th = 31.6 in.), this amount of vertical seat adjustability in one inch increments or less will afford at least 90% of all drivers a satisfactory eye level for visibility. The location of the maximum and minimum points on this range must be determined experimentally (see section III-1-a).

d) Recommendation: A minimum range of vertical seat adjustability of 4 in. in increments of 1 in. or less.

13. Dimension: Range of Fore & Aft Seat Adjustability

a) Pertinent Body Dimension: Leg Length (buttock-knee length and knee height)

b) Purpose: Operation of foot controls

c) Discussion: As vertical seat adjustment is primarily dictated by requirements of an optimum eye level for visibility, fore and aft adjustment must be determined on the basis of the accessibility and comfort in the operation of foot controls. For this reason the range of adjustability should approximate that of the range in seated leg length, (buttock to heel) or slightly under 7 in.[1] Although variations in the angle of the knee will probably make it unnecessary to have this full amount of adjustability, it seems unlikely that anything less than 6 in. can provide optimum freedom and comfort of operation for both small and large drivers. In the course of the evaluation of twelve 1950-51 truck models it was found that two vehicles had no adjustability in this respect while the others ranged from a minimum of 2 in. to a maximum of 5 in.[8] The lower values of this range are clearly unsatisfactory, and there is some doubt that the maximum of 5 in. will be completely adequate for those drivers at the extremes of even the 90% of population considered here. The location of the maximum and minimum points on this range must be determined experimentally (see section III.)

d) Recommendation: A range of fore and aft adjustability of 6 in. in increments of 1 in. or less.

Attachment 3 (from McFarland, 1955)

Table 1

Body Dimensions of the 5th, 50th and 95th
Percentiles of Commercial Truck and Bus Drivers
(in inches)

Body Measurement	5th Percentile	50th Percentile	95th Percentile	Range 5th-95th Percentile
1. Height	64.6	68.4	72.5	7.9
2. Weight (lb)	129.0	[illegible]3.7	212.8	83.8
3. Abdominal Depth	7.9	9.5	12.1	4.3
4. Arm Reach, Anterior	32.9	35.7	38.4	5.5
5. Arm Span, Total	66.5	70.9	75.5	9.0
6. Buttock-Knee Length	22.1	23.8	25.8	3.7
7. Calf Circumference (average both)	12.6	14.1	16.1	3.5
8. Chest Breadth	10.2	11.8	13.5	3.3
9. Chest Circumference	34.1	38.3	44.2	10.1
10. Chest Depth	7.6	8.9	10.5	2.9
11. Elbow Breadth	14.9	17.5	20.7	5.8
12. Elbow Span	34.1	36.[illegible]	39.2	5.1
13. Elbow-Middle Finger Length	17.3	18.8	20.2	2.9
14. Foot Breadth	3.7	4.0	4.3	.6
15. Foot Length	9.6	10.4	11.3	1.7
16. Hand Breadth	3.2	3.5	3.[illegible]	.6
17. Hand Circumference	7.6	8.3	8.[illegible]	1.3
18. Hand Length	7.1	7.6	8.1	1.0
19. Head Circumference	21.4	22.3	23.4	2.0
20. Head Height	4.7	5.1	5.5	.8
21. Hip Breadth	10.7	11.7	13.1	2.4
22. Knee Breadth	7.3	8.1	9.2	1.9
23. Knee Height	20.1	2[illegible].7	23.5	3.4
24. Seat Breadth	13.2	14.5	16.3	3.1
25. Shoulder Breadth	16.9	18.3	19.9	3.0
26. Shoulder-Elbow Height	13.8	14.8	15.9	2.1
27. Sitting Eye Height, Normal	27.7	29.6	31.6	3.9
28. Sitting Height, Erect	34.3	36.3	38.2	3.9
29. Sitting Height, Normal	32.6	34.7	36.6	4.0
30. Trunk Height	22.0	23.7	25.2	3.2

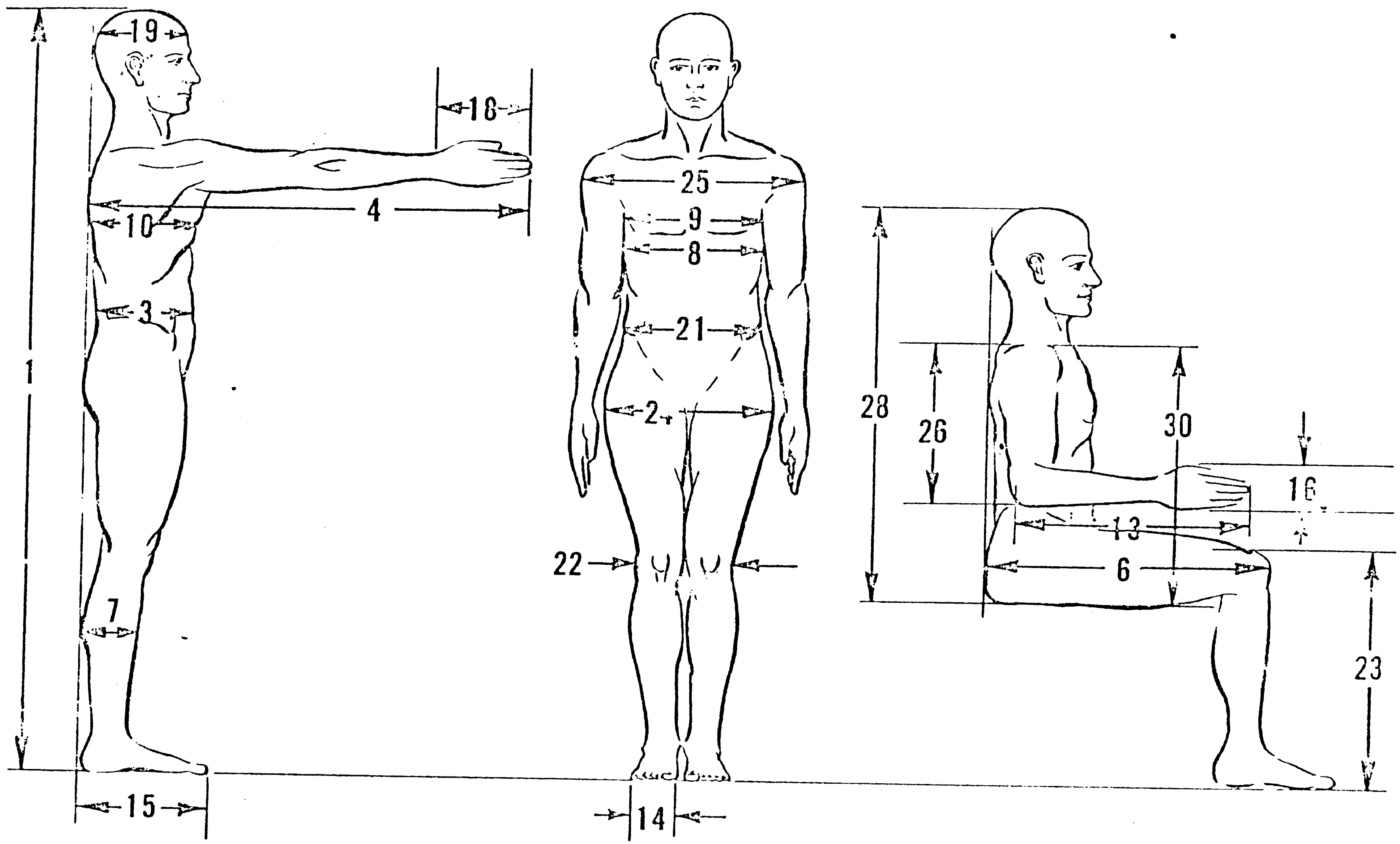


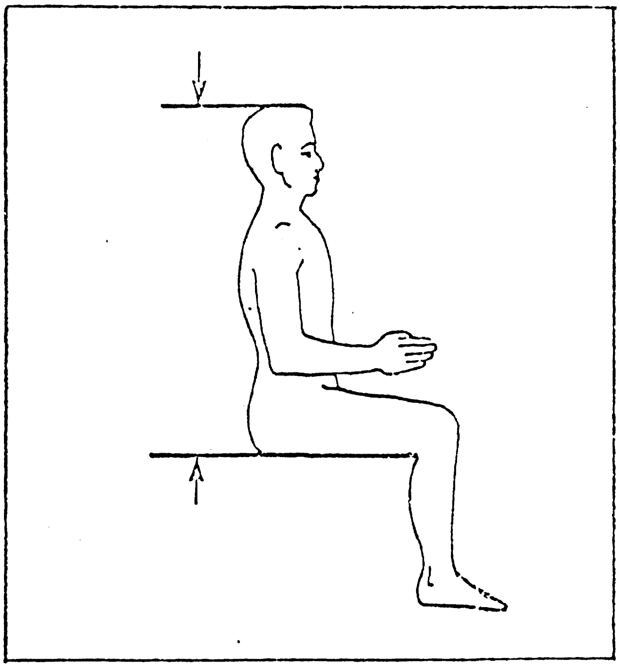
FIGURE 1

Human body measurements pertinent to vehicle design. See table 1 under the appropriate number for descriptions and percentile values.

TABLE 2-4. SITTING HEIGHT

Description:

Subject sat erect, looking straight ahead, knees together, back, buttock and head against seat back. Measure made vertically from top of seat surface to top of head. Measuring bar was brought down into firm contact with the top of the head in the midline

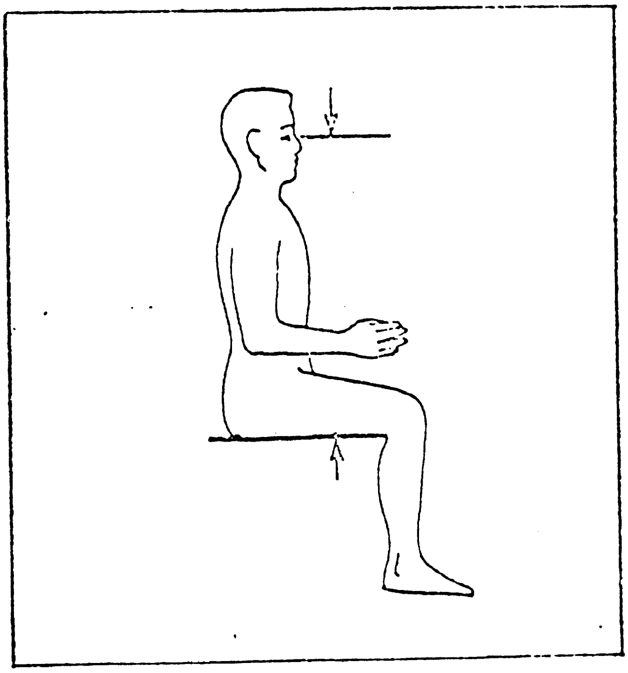


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	277	10	267		4061	
Mean	36.5	34.5	36.5		35.9	35.6
Standard Deviation	1.44	1.72	1.39		1.29	
Standard Error	.09	.54	.08		.02	
5th Percentile	33.8	32.1	34.0	33.9	33.8	33.2
50th Percentile	36.6	34.2	36.6	36.5	36.0	35.7
95th Percentile	38.6	37.0	38.6	39.2	38.0	38.0
Skewness	-.42	.50	-.36			
Kurtosis	.92	-.53	1.10			

TABLE 2-5. EYE HEIGHT, SITTING

Description:

Subject sat erect, head back against seat back, looking straight ahead, knees together, elbows at sides. Measure made vertically from top of seat surface to center of eye. (Photographic)

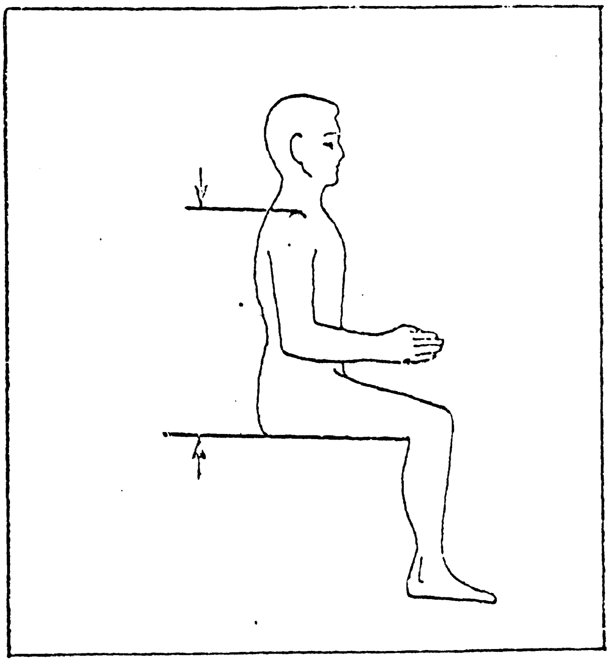


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	270	10	260		4061	
Mean	32.6	30.6	32.7		31.5	
Standard Deviation	1.46	1.67	1.40		1.27	
Standard Error	.09	.53	.09		.02	
5th Percentile	29.8	27.8	30.2		29.4	
50th Percentile	32.7	29.6	32.7		3.15	
95th Percentile	34.7	32.8	34.8		33.5	
Skewness	-.38	.11	-.29			
Kurtosis	.73	-1.16	.77			

Description:

TABLE 2-6. SHOULDER HEIGHT, SITTING

Subject sat erect with buttock, shoulders and head against seat back. Measurement was made vertically from the sitting surface to the uppermost point on the lateral edge of the shoulder.

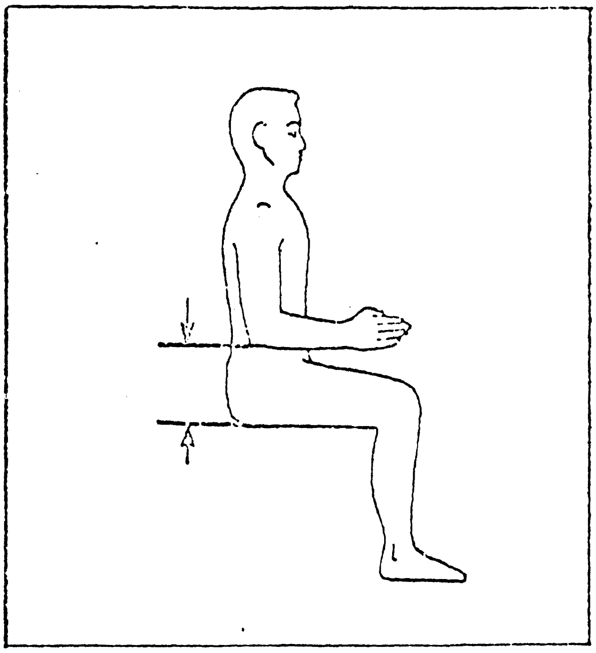


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	27.7	267	10		4057	
Mean	25.27	25.32	23.89		23.3	
Standard Deviation	1.40	1.38	1.34		1.14	
Standard Error	.08	.08	.42		.02	
5th Percentile	22.9	22.3	23.1		21.3	
50th Percentile	25.38	25.40	23.81		23.3	
95th Percentile	27.30	25.8	27.3		25.1	
Skewness	-.61	-.65	.50			
Kurtosis	1.14	1.43	-.94			

Description:

TABLE 2-7. ELBOW HEIGHT, SITTING

Subject sat erect, shoulders relaxed, both elbows at right angles, fingers straight. Measurement was made vertically from the sitting surface to the lowest bony portion of the elbow, using light contact only.

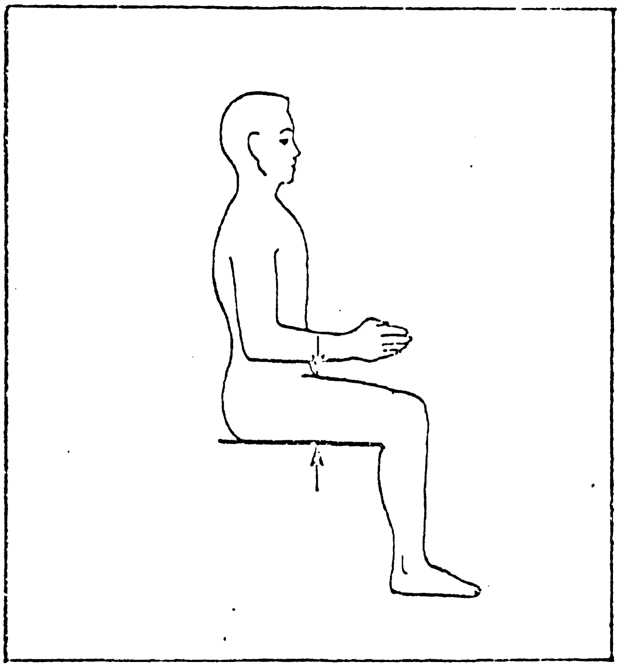


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	277	267	10		4063	
Mean	10.35	10.38	9.61		9.12	9.5
Standard Deviation	1.24	1.24	1.13		1.04	
Standard Error	.07	.08	.36		.02	
5th Percentile	8.3	8.3	8.4		7.4	7.4
50th Percentile	10.37	10.42	9.34		9.1	9.5
95th Percentile	12.1	11.4	12.1		10.8	11.6
Skewness	.37	.37	.50			
Kurtosis	2.19	2.31	-1.11			

Description:

TABLE 2-8. THIGH CLEARANCE HEIGHT, SITTING

Subject sat erect, knees and heels together, right arm extended forward. The measurement was made from the top of the sitting surface to the junction of the abdomen and thigh. (Photographic measurement).

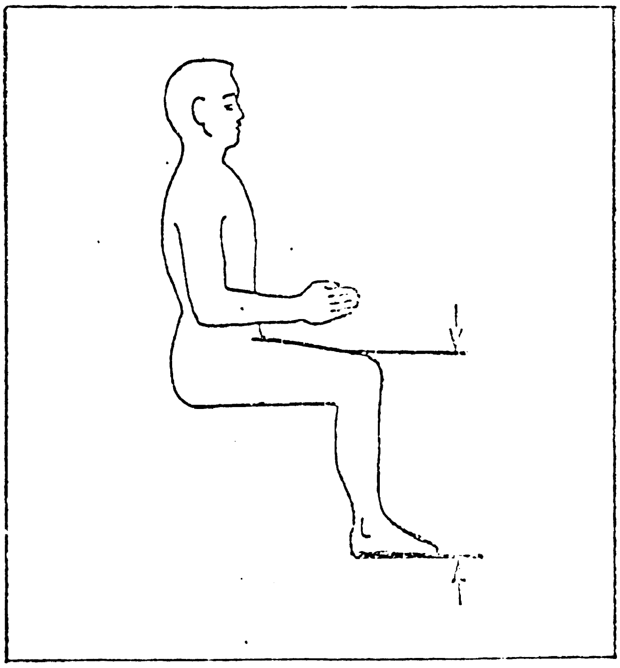


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	265	10	255		4061	
Mean	5.71	5.54	5.72		5.61	5.7
Standard Deviation	.70	.89	.69		.52	
Standard Error	.04	.28	.04		.01	
5th Percentile	4.8	4.8	4.8		4.8	4.3
50th Percentile	5.6	5.2	5.6		5.6	5.7
95th Percentile	6.7	6.9	6.7		6.5	6.9
Skewness	2.63	1.84	2.69			
Kurtosis	18.65	2.23	19.96			

Description:

TABLE 2-9. KNEE HEIGHT, SITTING

Subject sat erect, heels and knees together. The measurement was made from the top of the foot board to the top of the knee just in back of the patella (knee cap), with the horizontal bar in light contact with the leg. (Direct measurement).

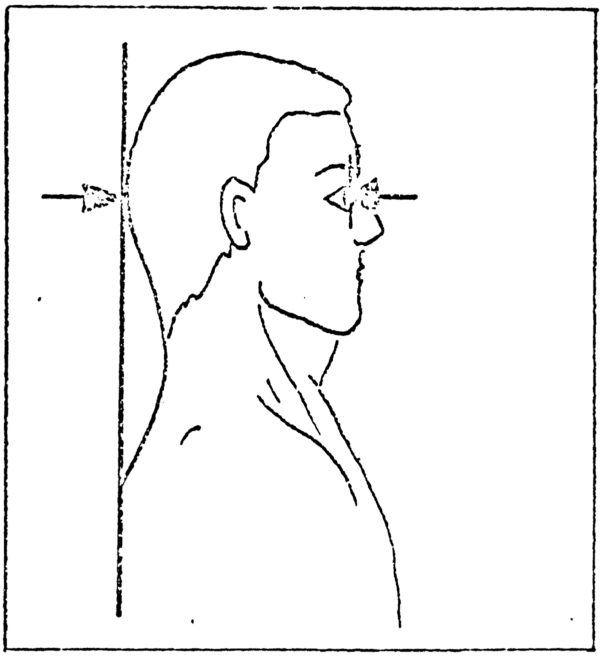


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	276	10	266	269	4060	6672
Mean	22.1	20.3	22.2		21.67	21.3
Standard Deviation	1.29	1.31	1.25		.99	
Standard Error	.08	.41	.08		.02	
5th Percentile	19.7	18.7	19.7	20.1	20.1	19.3
50th Percentile	21.8	19.7	21.8	21.7	21.7	21.4
95th Percentile	23.7	22.5	23.8	23.5	23.3	23.4
Skewness	-.27	.68	-.23			
Kurtosis	.17	-.87	.30			

Description:

TABLE 2-10. HEAD BACK TO EYE LENGTH

Subject sat erect with head in horizontal plane looking directly forward with head against seat back. Measurement made of the horizontal distance from the wall to the middle of the eyeball.



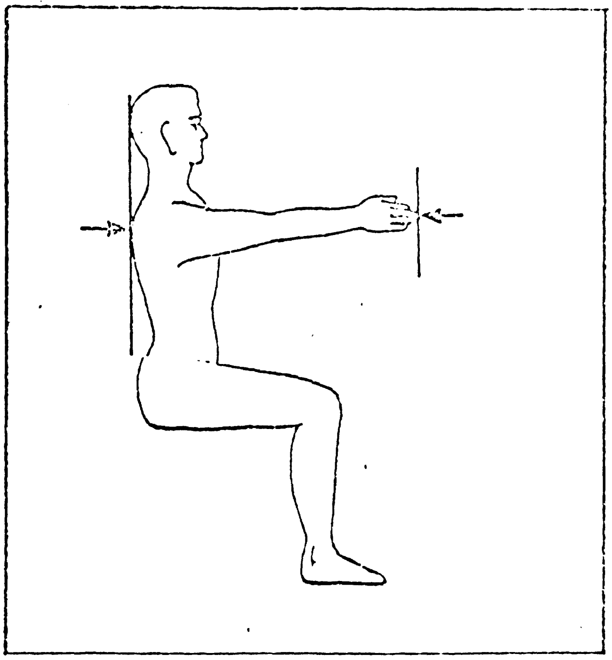
	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	268	10	258		4063	
Mean	7.41	7.14	7.42		7.75*	
Standard Deviation	.36	.45	.36		.34*	
Standard Error	.02	.14	.02		.01*	
5th Percentile	6.9	6.3	6.9		7.2*	
50th Percentile	7.3	7.1	7.3		7.8*	
95th Percentile	8.0	7.6	8.0		8.3*	
Skewness	.34	-.28	.45			
Kurtosis	1.70	-.66	1.74			

*Measures were made from back of head to nasal root (point of greatest indentation where the nose meets the forehead) rather than the middle of the eye.

Description:

TABLE 2-11. ARM REACH, SITTING

Subject sat erect, back, buttock, shoulder and head against seat back, arms extended parallel to floor, hands open. Measurement made from seat back to tip of middle finger. (Photographic measurement).

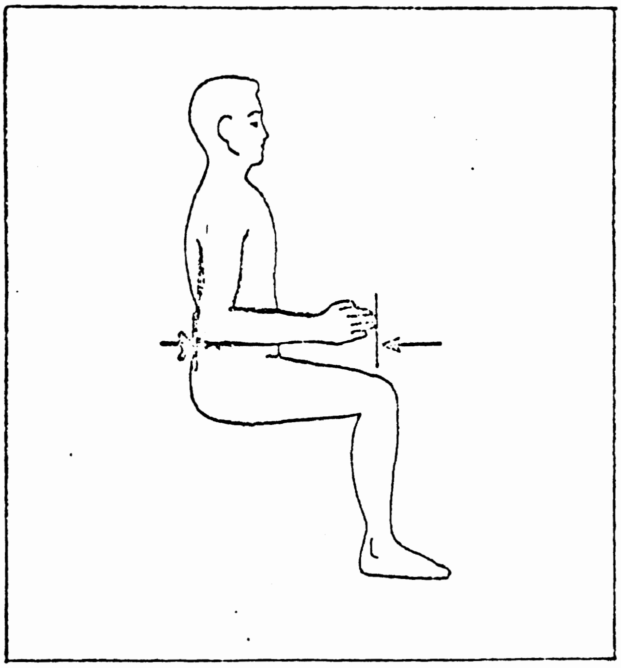


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	271	10	261		4062	
Mean	35.1	31.7	35.2		34.6	
Standard Deviation	2.02	2.04	1.90		1.65	
Standard Error	.12	.64	.12		.03	
5th Percentile	31.9	28.7	32.5	32.9	31.9	
50th Percentile	35.2	31.5	35.3	35.7	34.6	
95th Percentile	37.9	34.3	37.9	38.4	37.3	
Skewness	-1.69	.07	-1.87			
Kurtosis	10.80	-1.43	14.36			

TABLE 2-12. FOREARM - HAND LENGTH

Description:

Subject sat erect, knees together, elbow against seat back at right angle. Measurement was made from seat back to tip of middle finger. (Photographic measure).

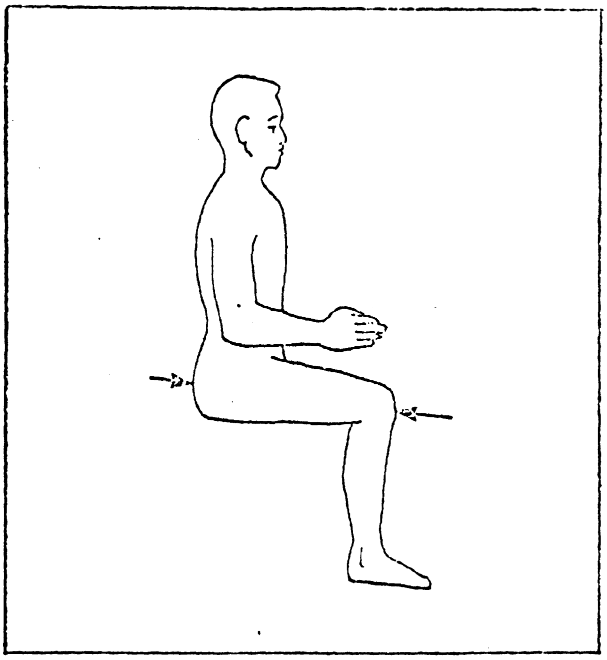


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	267	10	257		4059	
Mean	19.0	16.9	19.1		18.9	
Standard Deviation	1.06	.93	.98		.81	
Standard Error	.06	.29	.06		.01	
5th Percentile	17.2	15.7	17.6	17.3	17.6	
50th Percentile	19.1	16.7	19.2	18.8	18.9	
95th Percentile	20.7	18.4	20.7	20.2	20.2	
Skewness	-.24	.30	.00			
Kurtosis	.25	-1.28	-.01			

Description:

TABLE 2-13. BUTTOCK - KNEE LENGTH

Subject sat erect, knees and heels together, buttock against seat back. The measurement was made from the most posterior protrusion of the sacral area to the foremost edge of the patella.

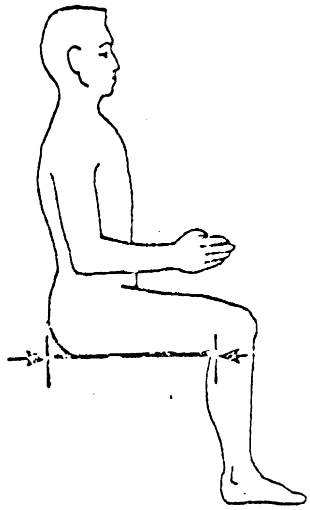


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	277	10	267		4060	
Mean	24.4	22.5	24.5		23.6	23.3
Standard Deviation	1.34	1.11	1.29		1.06	
Standard Error	.08	.35	.08		.02	
5th Percentile	22.1	21.3	22.3	22.1	21.9	21.3
50th Percentile	24.4	21.9	24.5	23.8	23.6	23.3
95th Percentile	26.6	24.5	26.7	25.8	25.4	25.2
Skewness	-.17	.89	-.14			
Kurtosis	.17	-.75	.34			

Description:

TABLE 2-14. BUTTOCK-POPLITEAL LENGTH

Subject sat erect, buttock against seat back, knees and heels together, knees at 90 degree angle, and pants bound to leg. Measurement made from seat back to popliteal fossae. (Photographic measurement).

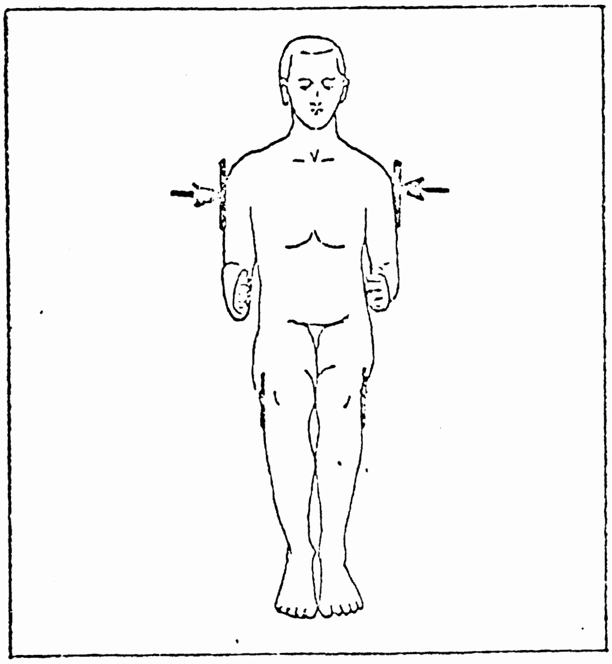


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	267	10	257			
Mean	19.9	18.7	19.9			19.4
Standard Deviation	1.08	1.01	1.06			
Standard Error	.07	.32	.07			
5th Percentile	18.0	17.2	18.2			17.3
50th Percentile	19.9	18.3	19.9			19.5
95th Percentile	21.4	20.1	21.4			21.6
Skewness	-.38	.31	-.40			
Kurtosis	.34	-1.18	.51			

Description:

TABLE 2-15. SHOULDER BREADTH

Subject sat erect, knees together, buttock and head against seat back, arms at side, elbows at right angles. Measure was made across the greatest lateral protrusions on each side of the shoulders, using light pressure to compress the clothing, but not the body.

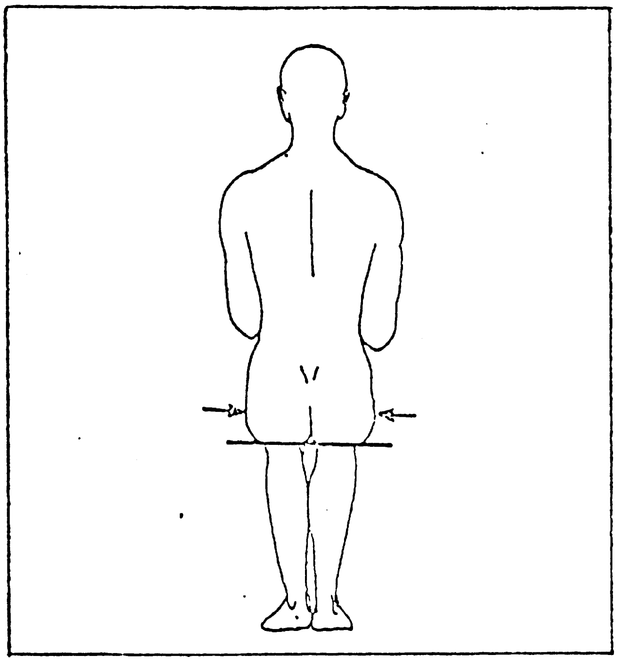


	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	277	10	267		4057	
Mean	18.22	15.74	18.31		17.88	
Standard Deviation	1.18	1.02	1.09		.91	
Standard Error	.07	.32	.07		.02	
5th Percentile	16.3	14.2	16.5		16.5	
50th Percentile	18.1	15.4	18.2		17.9	
95th Percentile	20.0	17.2	20.0		19.4	
Skewness	-.16	.22	.17			
Kurtosis	.22	-1.34	-.32			

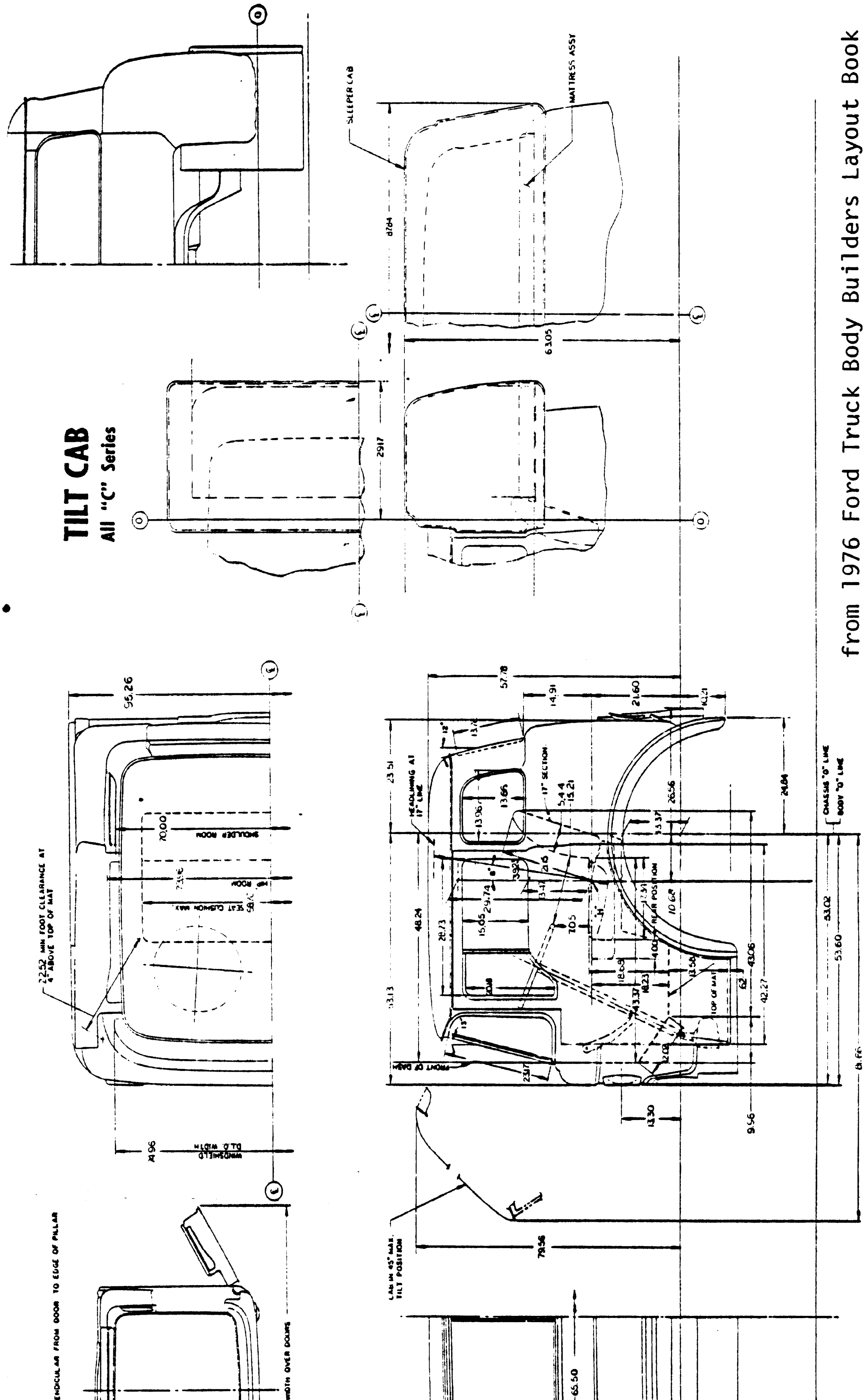
Description:

TABLE 2-16. SEAT BREADTH, SITTING

Subject sat erect, knees and heels together. Measurement was made with an anthropometer across the greatest lateral protrusion on each side of the buttocks, using light pressure to compress the clothing, but not the body.



	Present Study - inches			Comparison Samples - inches		
	Total Sample	Females Only	Males Only	Truck-Bus Drivers[1]	Air Force Personnel[2]	Civilian Men[3]
Sample Size	277	10	267		4058	
Mean	13.78	12.19	13.85		13.97	14.0
Standard Deviation	1.47	2.45	1.39		.87	
Standard Error	.09	.77	.08		.01	
5th Percentile	11.4	9.3	11.7	13.2	12.7	12.2
50th Percentile	13.6	11.2	13.6	14.5	13.9	14.0
95th Percentile	16.3	14.0	16.1	16.3	15.4	15.9
Skewness	.49	1.57	.60			
Kurtosis	1.17	1.76	1.16			

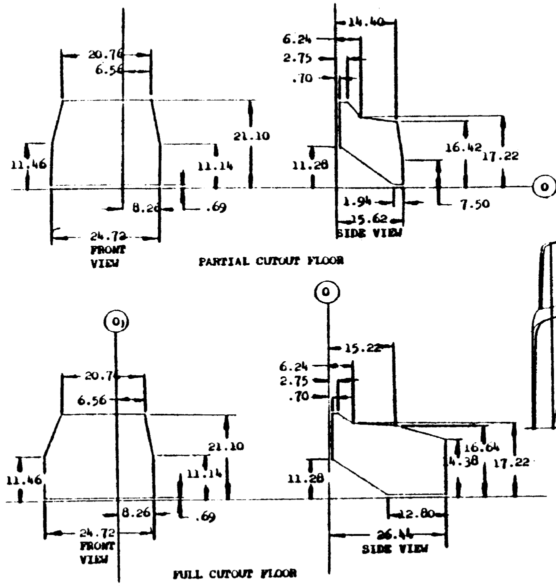


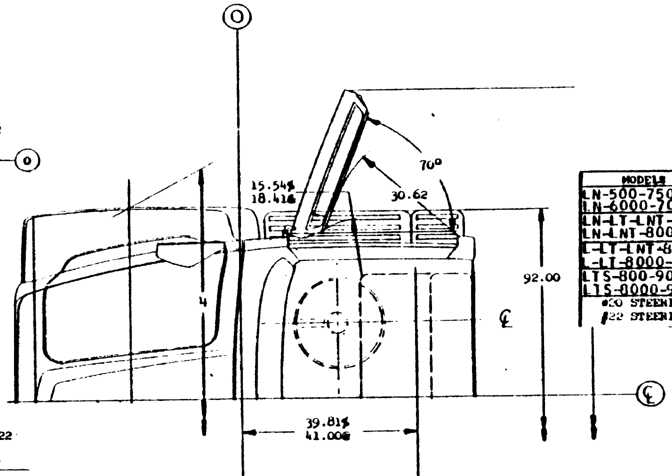
from 1976 Ford Truck Body Builders Layout Book
same dimensions in 1973 and 1978

BB903

CONVENTIONAL AND SHORT CONVENTIONAL CAB

All "L" Series

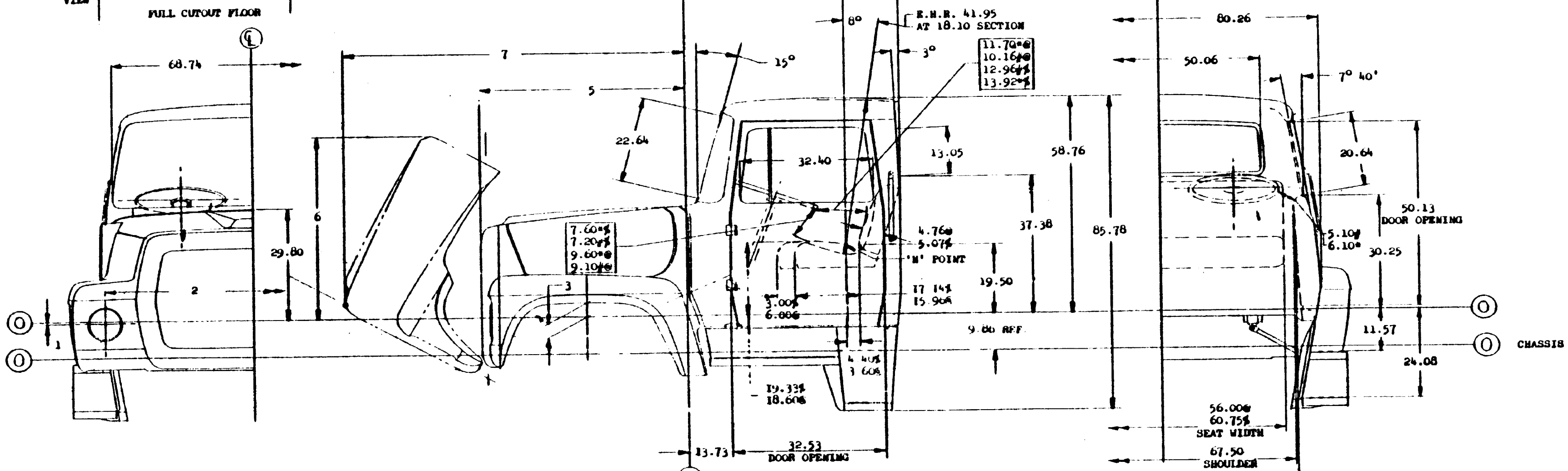




MODELS	1	2	3	4	5	6	7
LN-500-750 LN-6000-7000	-.88	72.60	3.33	90.52	39.70	37.43	73.20
LN-LT-LNT-800-880-900 LN-LNT-8000-9000	-.70	75.00	3.82	94.96		37.43$ 41.31¢	73.20$ 68.25¢
L-LT-LNT-800-880-900 L-LT-8000-9000	-.70	75.00	3.82	94.70	51.70	47.80$ 50.20¢	85.19$ 80.27¢
LTS-800-900 LTS-8000-9000	-2.04	81.44	2.30	94.66		49.39x	75.50x

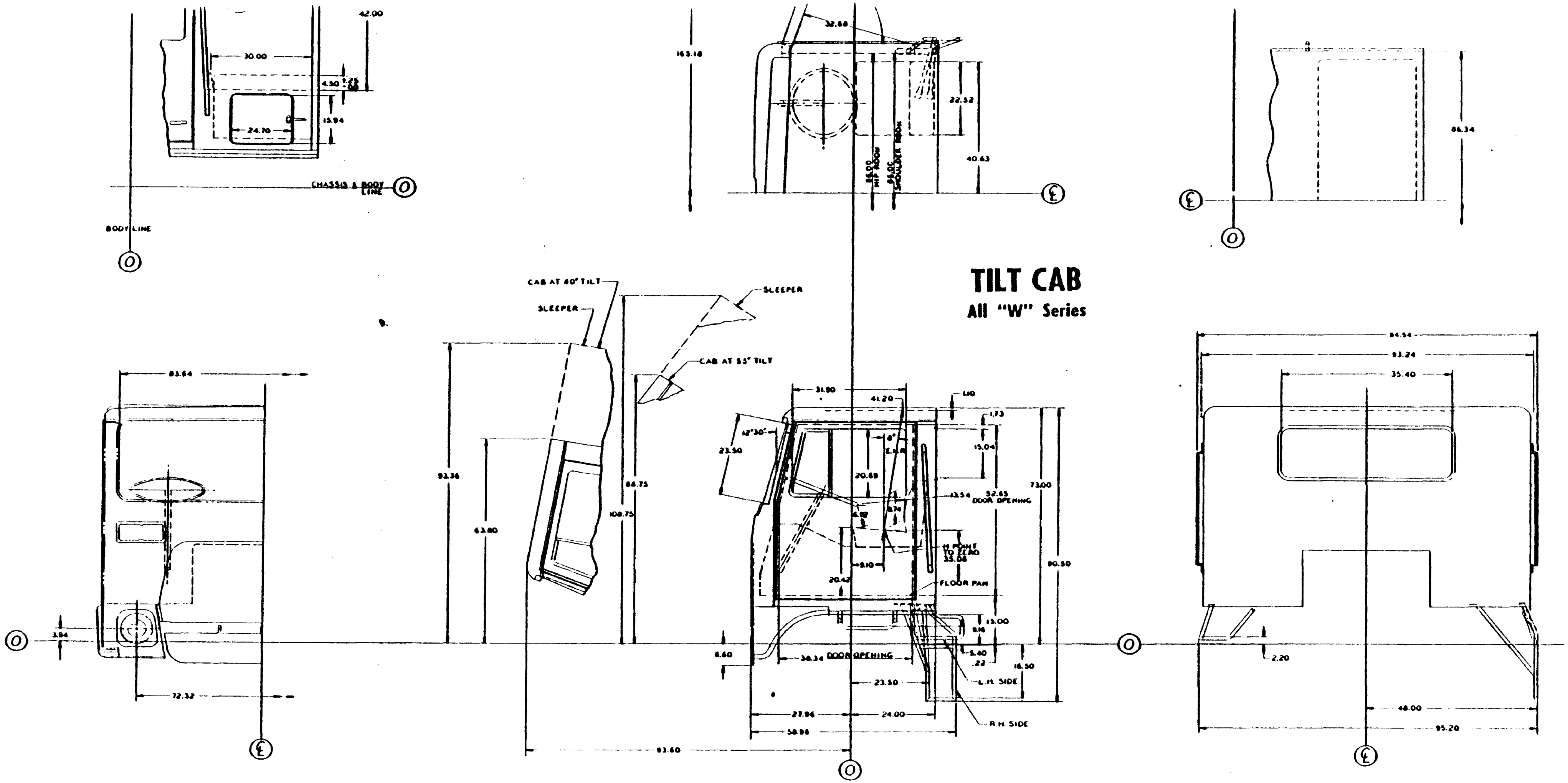
•20 STEERING WHEEL
¢22 STEERING WHEEL

$BENCH SEAT
@BUCKET SEAT



from 1976 Ford Truck Body Builders Layout Book
same dimensions in 1973 and 1978

76BB902-L



TILT CAB

All "W" Series

EXPOSED GLASS AREA SQ INCHES & GLASS TYPE			
WINDSHIELD	DOOR	BACK WINDOW	TOTAL EXPOSED
FLAT	FLAT	FLAT	FLAT
2008.93	1153.74	327.47	3490.14

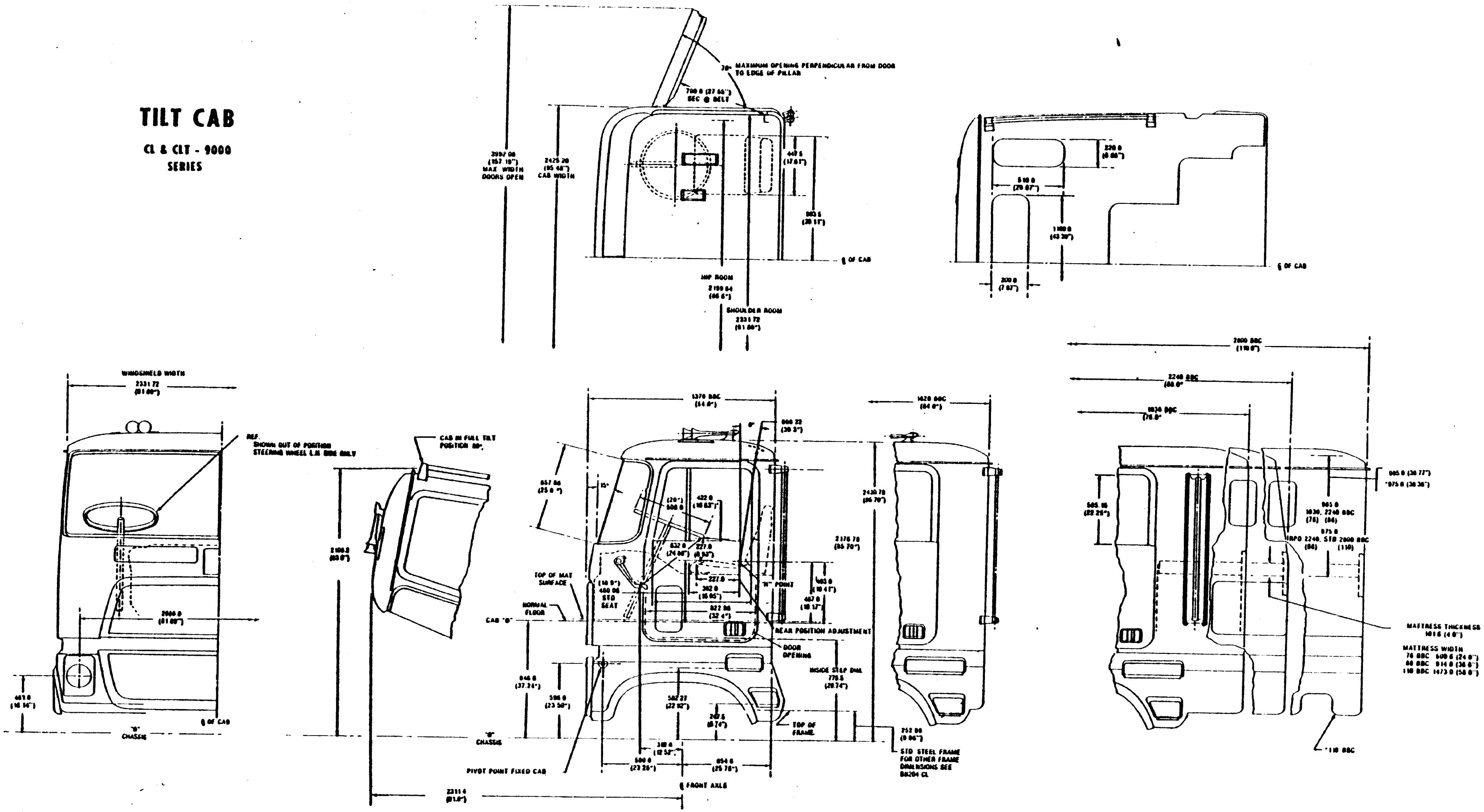
TO DETERMINE DISTANCE FROM TOP OF FRAME TO GROUND SEE BB208

FOR TIRE DATA SEE BB041 OR BB041-L

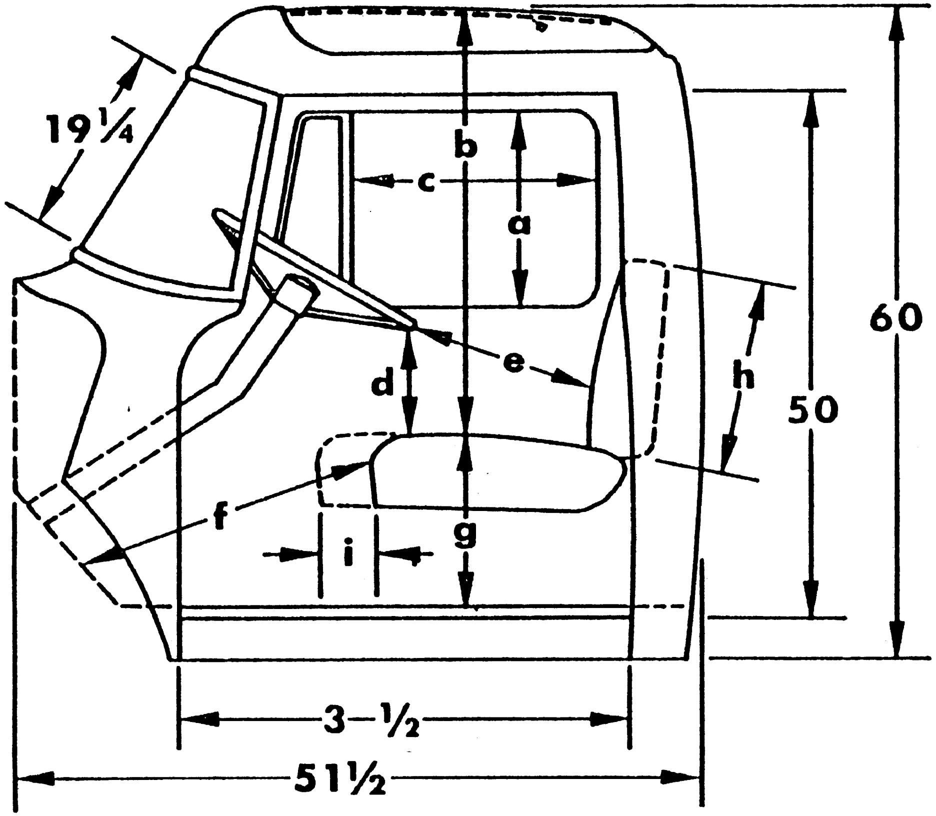
from 1976 Ford Truck Builders Layout Book
same dimensions in 1973

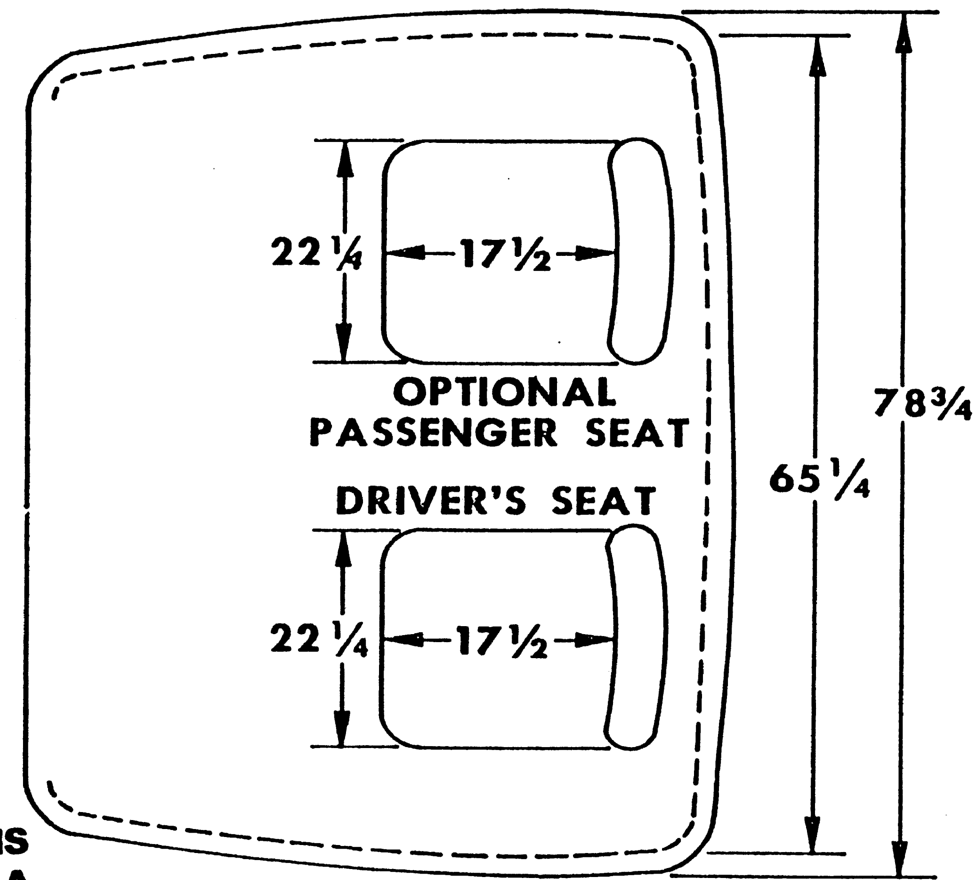
TILT CAB

CL & CLT - 9000
SERIES



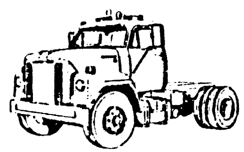
from 1978 Ford Truck Body Builders Layout Book
BB935-CL





a.....16¾	c.....17½	e.....14¼	g.....16	i.....4
b.....34	d.....8	f.....44½	h.....18	

CAB DIMENSIONS
FLEETSTAR A



from 1977 International Trucks Body Builders Diagrams

Attachment 6 (from 1978 SAE Transactions)

♦MOTOR VEHICLE DRIVER'S EYE RANGE—SAE J941e

SAE Recommended Practice

Report of Body Engineering Committee approved November 1965 and revised by Human Factors Engineering and Automotive Safety Committees February 1975. Editorial change March 1977.

1. Scope—This SAE Recommended Practice establishes two-dimensional Eyellipses representative of 90th, 95th, and 99th percentile increments of driver eye locations for use in passenger cars, trucks, buses, and multipurpose passenger vehicles. A uniform method for describing and measuring the driver's direct and indirect fields of view using the Eyellipse is established in the recommended practice, Describing and Measuring the Driver's Field of View—SAE J1050a.

2. Background—The Eyellipse contours were developed by the statistical analysis of photogrammetric data of driver eye locations[1] and represent a population mix, primarily of United States licensed drivers, with a male-to-female ratio of one-to-one. The Eyellipse templates are the perimeters of envelopes formed by an infinite number of planes dividing the eye positions so that (P) % of the eyes are on one side of the plane and (100 − P) % are on the other. It should be noted that the 95th Eyellipse does not include 95% of the driver eye locations. For example, if a plane seen as a straight line in the side view is drawn tangent to the upper edge of the 95th percentile Eyellipse, then 95% of the driver eye locations, both inside and outside of the ellipse, will be below the line and 5% of the driver eye locations will be above the line (Fig. 1). Conversely, if a plane seen as a straight line in the side view is drawn tangent to the lower edge of the 95th percentile Eyellipse, then 95% of the ♦driver eye locations, both inside and outside of the ellipse, will be above the line and 5% of the driver eye locations will be below the line. These planes or sight planes are drawn from the object in the driver's field of view tangent to the Eyellipse contour.

This recommended practice is based on an original study, involving drivers with a straight-ahead viewing task without head turning. A subsequent study[2] has provided a method of accounting for driver viewing targets that are located at extreme lateral angles from the forward line of sight which accommodates head movement up to 60 deg after an eye movement of up to 30 deg. An Eyellipse locator line has been developed in a third study,[3] to position the Eyellipse in the driver work space for back angles ranging 5–40 deg in 1 deg increments.

[1]J. F. Meldrum, "Automobile Driver Eye Position." SAE Transactions, Vol. 74 (1966), Paper 650464.

[2]W. A. Devlin and R. W. Roe, "The Eyellipse and Consideration in the Driver's Forward Field of View." Paper 680105 presented at SAE Automotive Engineering Congress, Detroit, 1968.

[3]R. W. Roe and D. C. Hammond, "Driver Head and Eye Position." Paper 720200 presented at SAE Automotive Engineering Congress, Detroit, January 1972.

There are six plan and side view Eyellipse templates included in this ♦ recommended practice, representing six specific normal driving and riding seat track travel lengths (L23) ranging from a minimum of 4.0 in (101 mm) to a maximum of 6.5 in (165 mm), in 0.5 (13 mm) increments.

The Eyellipse template contours and Eyellipse and head contour locator line adjustable seat template shape can be constructed from data in the Appendix. The Eyellipse contour drawing illustrated in Fig. 2, the Eyellipse template illustrated in Fig. 3, the Eyellipse and head contour locator line drawing illustrated in Fig. 4, and the Eyellipse and head contour locator line template illustrated in Fig. 5 can be obtained from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

3. Definitions

3.1 **Driver's Eye Range**—A statistical representation of the driver's eye location in a passenger car, multipurpose passenger vehicle, truck, or bus

3.2 **Eyellipse (Fig. 2)**—The contraction of the words "eye" and "ellipse' and is so named because of the elliptical shape of the driver's eye range. The term "eyellipse" should only be applied to the driver's eye range described in this recommended practice. Eyellipse is synonymous with driver's eye range The Eyellipse template is a two-dimensional drafting tool consisting of a plan view and side view of the driver's left and right eye ranges.

3.3 **H-Point**—The H-point is the pivot center of the torso and thigh on ♦ the two- or three-dimensional devices used in defining and measuring vehicl seating accommodation. (See SAE J1100a.)

3.4 **Design H-Point**—The design H-point is located on a drawing by th H-point on the two-dimensional drafting template placed in any designate seating position. If the designated seating position can be adjusted, the path of the design H-point through the full seat adjustment establishes the desig ♦ H-point travel line and can be dimensionally described by coordinates relativ to the three-dimensional reference system. (See SAE J1100a.)

3.5 **Seating Reference Point (SgRP)**—The manufacturer's design refe ence point is a unique design H-point which:

(a) Establishes the rearmost normal design driving or riding position[4] each designated seating position which includes consideration of all modes adjustment, horizontal, vertical and tilt, in a vehicle;

(b) Has X, Y, Z coordinates established relative to the designed vehic structure;

[4]The "normal design driving or riding position" includes considerations of all modes adjustment, horizontal, vertical and tilt.

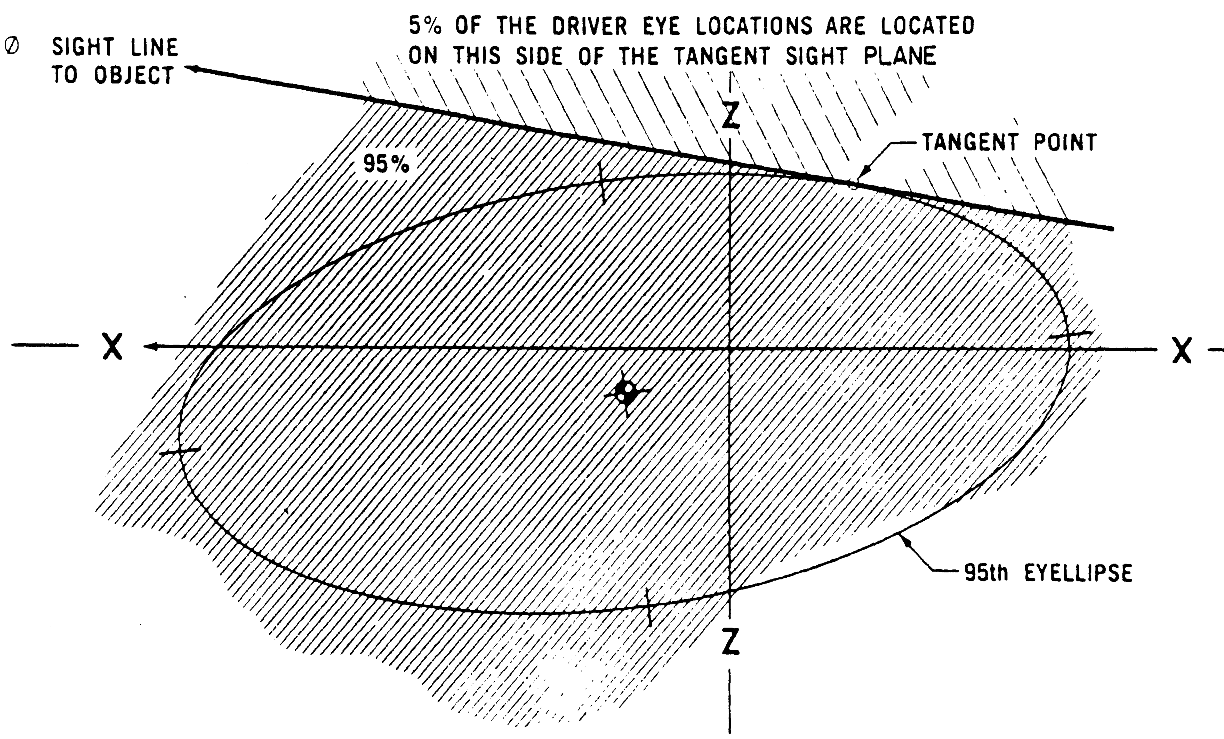


FIG. 1

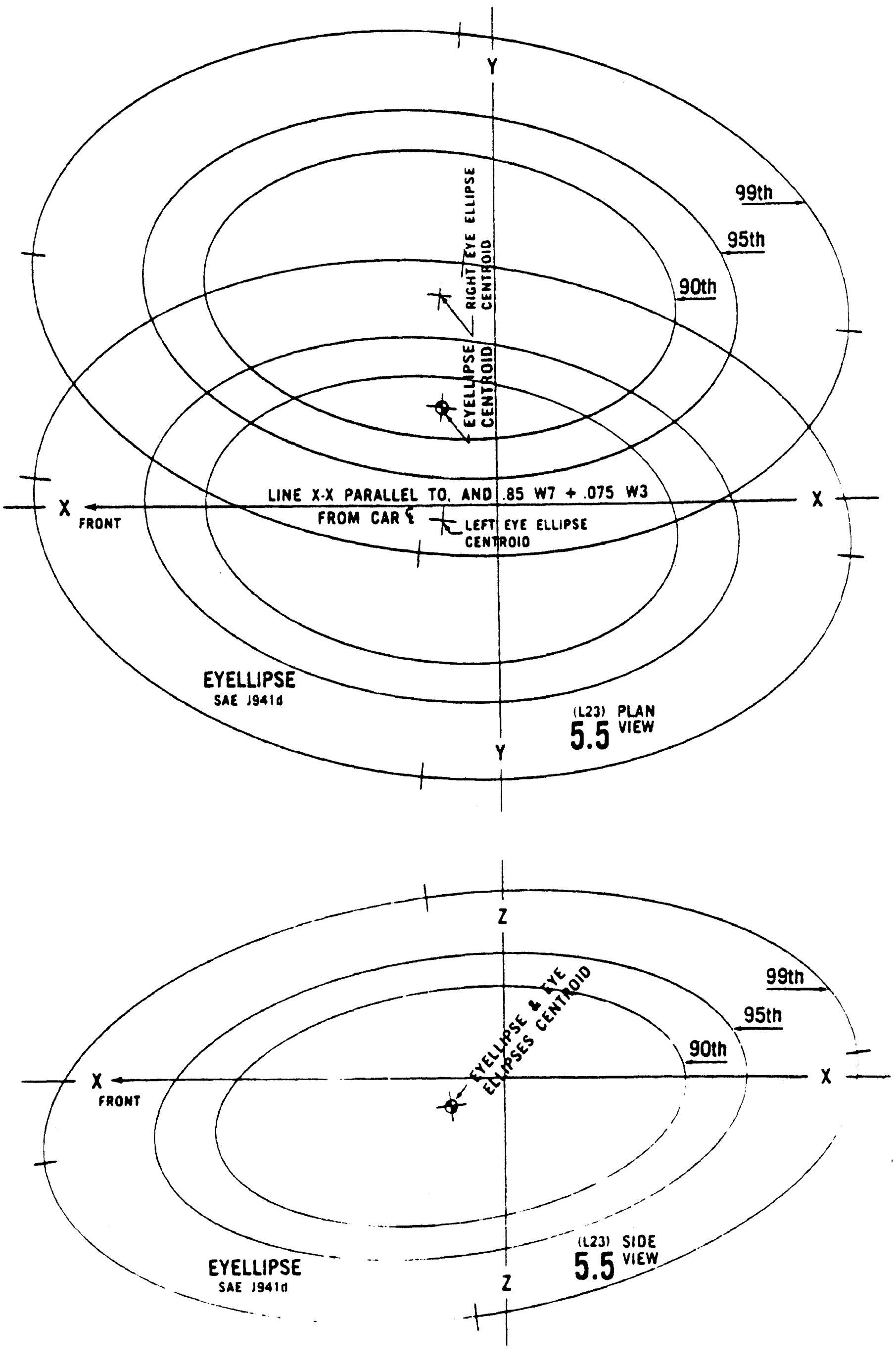


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FIG. 2—EYELLIPSE CONTOURS

(c) Simulates the position of the pivot center of the human torso and thigh, and

(d) Is the reference point employed to position the two-dimensional drafting template with the 95th percentile leg described in SAE Recommended Practice, Devices for Use in Defining and Measuring Vehicle Seating Accomodations—(See SAE J1100a.)

3.6 Sight Line—A line which is constructed by the designer to extend from the Eyellipse centroid, the left or right eye ellipse centroid, or a tangent point on the Eyellipse contour either to a target point or at a given angle from a line drawn parallel to the Z or Y plane and ground. (See SAE J1050a.)

3.7 Eyellipse and Head Position Locater Line Template[3] (Fig. 4 and Appendix)—A drafting tool that describes the position of the Eyellipse and the occupant head contour for horizontally adjustable seats with back angles between 5 and 40 deg.

ϕ 3.8 The vehicle interior dimensions containing prefixes used with this recommended practice are defined in SAE J1100a, Motor Vehicle Dimensions. The dimensions are:

ϕ 3.8.1 W20—SgRP-Front, "Y" Coordinate.

ϕ 3.8.2 L23—Normal Driving and Riding Seat Track Travel. The dimension measured horizontally between a point on the design H-point travel line from the SgRP to the displaced point on the design H-point travel line with the seat moved to the foremost seat position, but not to include seat track travel used for purposes other than normal driving and riding positions.

ϕ 3.8.3 L40—Back Angle—Front. The angle measured between a vertical line through the SgRP-front and the torso line. If the seatback is adjustable, use the normal driving and riding position specified by the manufacturer.

ϕ 3.8.4 L53—SgRP-Front to Heel. The dimension measured horizontally from the SgRP-front to the accelerator heel point.

3.8.5 H30—SgRP-Front to Heel. The dimension measured vertically from the SgRP-front to the accelerator heel point.

ϕ 3.8.6 H59—Normal driving and riding design H-point rise. The dimension measured vertically between the SgRP and the foremost design H-point in the normal driving and riding seat track travel (L23) position.

3.8.7 W3—Shoulder Room—Front. The minimum dimension measured laterally between the trimmed surfaces on the "X" plane through the SgRP-front within the belt line and 10.0 in (254 mm) above the SgRP-front.

3.8.8 W7—Steering Wheel Center "Y" Coordinate. The steering column center is the point located by the intersection of the steering column axis with the plane tangent to the upper surface of the steering wheel rim.

4. Application

4.1 The Eyellipse template is a design tool from which sight lines and planes can be constructed. These sight lines or planes are used to describe the

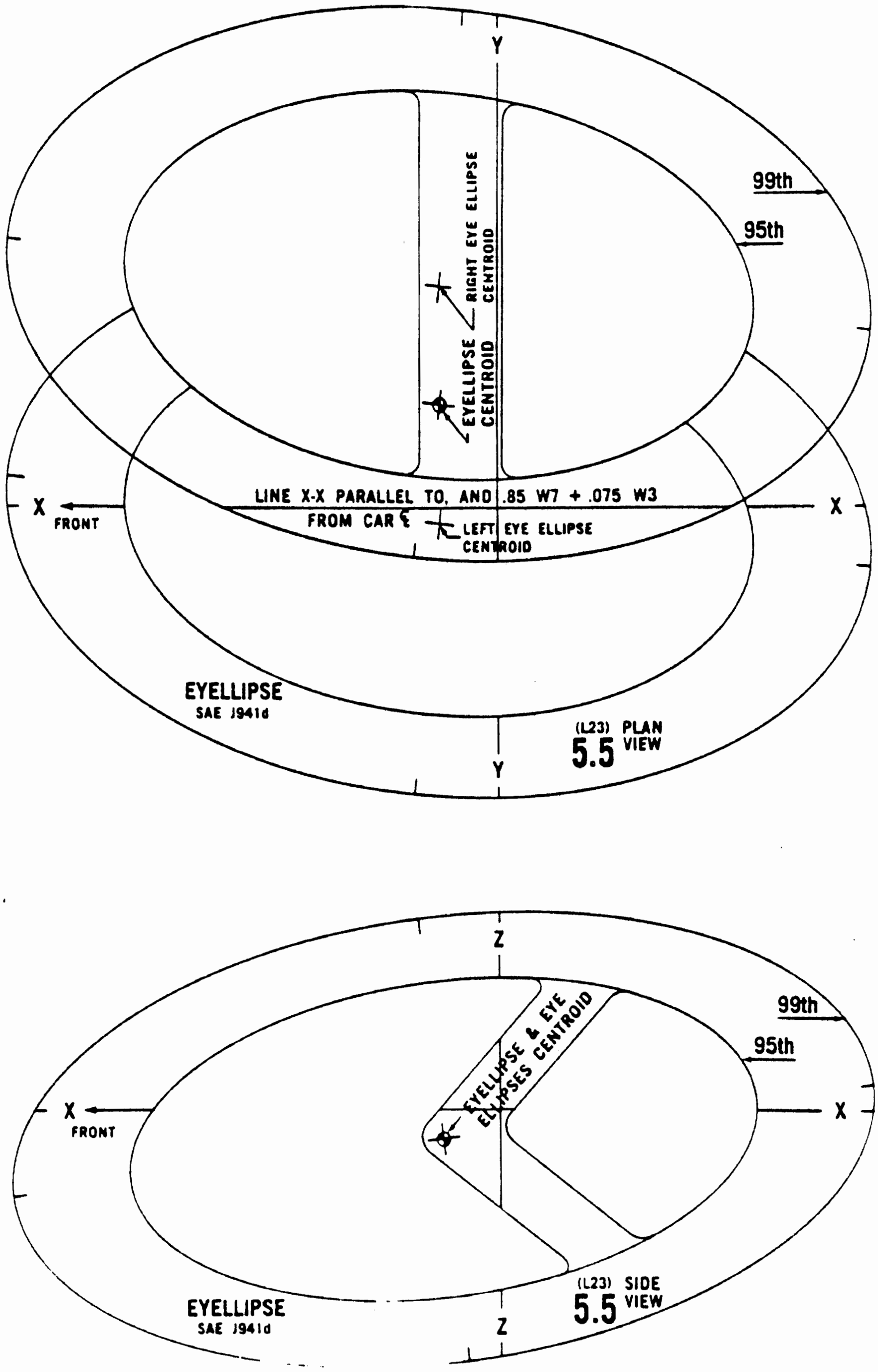


FIG. 3—EYELLIPSE TEMPLATES

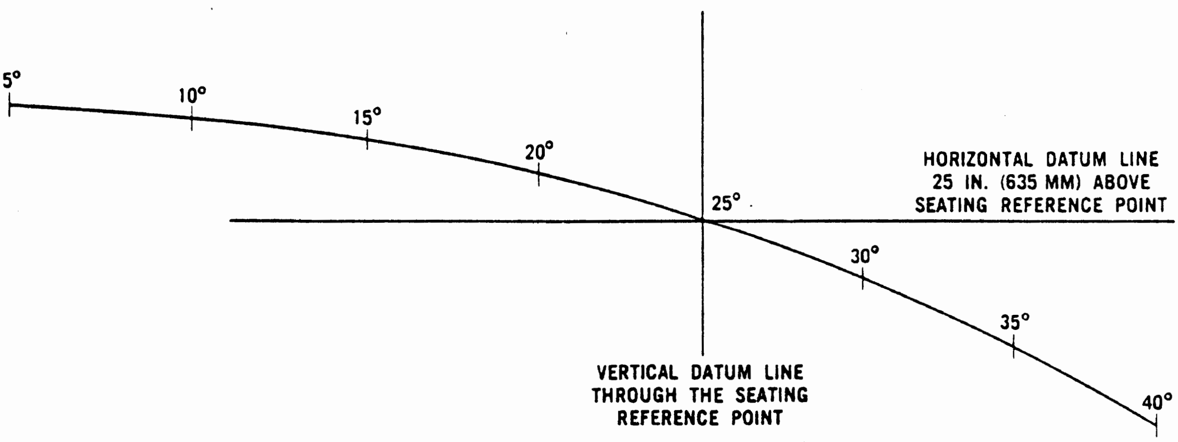


FIG. 4—EYELLIPSE AND HEAD CONTOUR LOCATOR LINE ADJUSTABLE SEAT

ϕ location of objects in the field of view of a seated driver. The Method for Describing and Measuring the Driver's Field of View—SAE J1050a, establishes a uniform method of describing the driver's field of view, a method for measuring vehicle window openings for comparison purposes and a procedure for establishing vision origin points (V points and E points).

4.2 The Eyellipse templates are applicable to motor vehicles designed as passenger cars, multipurpose passenger vehicles, trucks and buses with bench or bucket-type seats and within the following range of driver workspace dimensions:

(L40) Back Angle—Front	5–40 deg	(5–40 deg)
(H30) Vertical SgRP to Heel Point	5.0–18.0 in.	(127–457 mm)
(H59) Vertical Design H-Point Rise	0.0–1.5 in.	(0.0–38 mm)
(L23) Normal Driving and Riding Seat Track Travel	4.0–6.5 in.	(101–165 mm)
(L53 minus L23) Foremost Design H-Point to Heel Point	20.0 in. min	(508 mm min)

5. Eyellipse Location Procedure

5.1 The Eyellipse is located in the vehicle interior by longitudinal (X-X), ϕ lateral (Y-Y), and vertical (Z-Z) datum lines which are shown on the Eyellipse (See Figs. 2 and 3.) The datum lines relative to the Eyellipse centroid vary between the different seat track travel templates. These datum lines are not the tool's geometric axes; they are worklines to establish the tool's position in the vehicle with respect to seated drivers.

5.2 Eyellipse Template—Side View (Fig. 6)

5.2.1 Determine the length of the normal driving and riding seat track travel (L23).

5.2.2 Select the side view Eyellipse template (Fig. 2) which comes closest to matching the normal driving and riding seat track travel (L23).

5.2.3 Construct a vertical workline through seating reference point.

5.2.4 Construct a horizontal workline 25 in (635 mm) above the seating reference point.

5.2.5 Position the Locator Line Template (Fig. 5) at the intersection of the lines constructed in 5.2.3 and 5.2.4.

5.2.6 Position the side view Eyellipse template on the Locator Line Template at the intersection of the Eyellipse datum lines X-X and Z-Z at the designed back angle—front (L40) such that the Eyellipse datum lines and the worklines in 5.2.3 and 5.2.4 are parallel, and trace the Eyellipse outline on the layout.

5.3 Eyellipse Template—Plan View (Fig. 6)

5.3.1 Construct a lateral datum line (Y-Y) perpendicular to the vehicle centerline through the line Z-Z projected from the side view.

5.3.2 Construction of a longitudinal datum line (X-X).

5.3.2.1 *Passenger Cars With Bench or Individual Driver's Seat*—Construct a longitudinal datum line (X-X) parallel to the vehicle centerline and a distance ϕ from the vehicle centerline equal to 0.85 (W7) + 0.075 (W3). The dimensions W7 and W3 are defined in 3.8.8 and 3.8.7. The Eyellipse datum line X-X shall be located no further inboard than a dimension equal to W20 + 1.1 in. The dimension W20 is defined in 3.8.1.

5.3.2.2 *Multipurpose Passenger Vehicles, Trucks and Buses With Individual Driver's Seat*—Construct a longitudinal datum line (X-X) parallel to the vehicle centerline and a distance from the vehicle centerline equal to W20 + 1.1 in.

5.3.2.3 *Multipurpose Passenger Vehicles, Trucks and Buses With Bench Seats*—Construct a longitudinal datum line (X-X) similar to 5.3.2.1.

5.3.3 Position the plan view Eyellipse template datum lines (X-X) and (Y-Y) on the constructed worklines (X-X) and (Y-Y) and trace the outline on the layout.

APPENDIX

A1. Mathematical Description of the Eyellipses and the Eyellipse and Head Contour Locator Line—Adjustable Seat

A1.1 The Eyellipse contours may be constructed from the following data (See Fig. A-1):

A1.1.1 Centroid Location—Centroid offsets are measured from the X-X, Y-Y, and Z-Z datum lines and are given in Table A-1.

A1.1.2 Ellipse Axis Strength

A1.1.2.1 *Major Axis*—Since the ellipse major axis is tilted approximately the same amount in both side and plan views, the length of the major axis in

TABLE A-1—LEFT AND RIGHT EYELLIPSE CENTROIDS

L23		X Means[a]		Z Means[a]		Y Mean (left eye)		Y Mean (right eye)	
ϕ in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
4.0	102	+0.07	+ 1.8	−0.22	−5.6	−0.25	−6.4	+2.28	+58.0
4.5	114	−0.18	− 4.6	−0.25	−6.4	−0.22	−5.6	+2.32	+58.9
5.0	127	−0.42	−10.7	−0.28	−7.1	−0.20	−5.1	+2.33	+59.0
5.5	140	−0.67	−17.0	−0.30	−7.6	−0.17	−4.3	+2.35	+59.7
6.0	152	−0.80	−20.3	−0.33	−8.4	−0.16	−4.1	+2.37	+60.2
6.5	165	−0.90	−22.9	−0.33	−8.4	−0.16	−4.1	+2.38	+60.5

[a]Includes both left and right eyes.

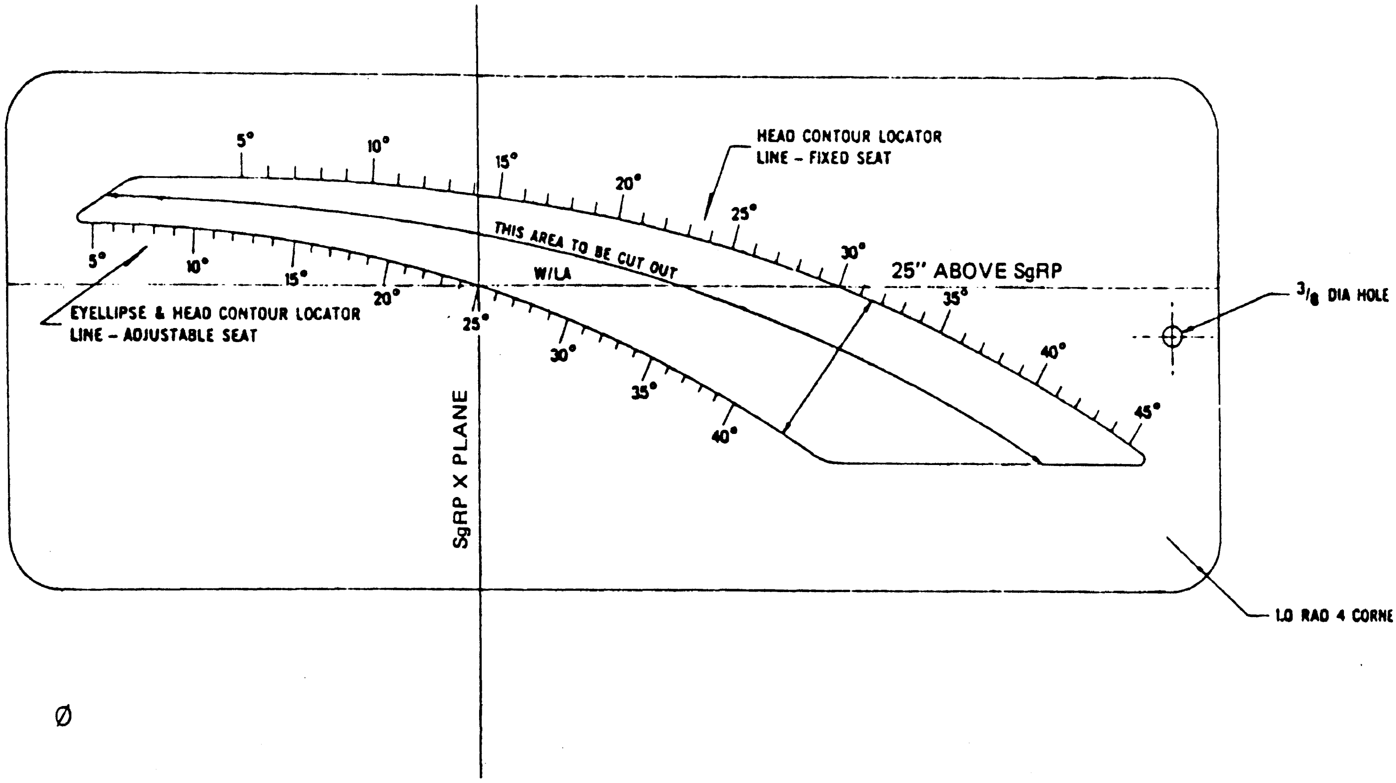


FIG. 5—EYELLIPSE AND HEAD POSITION LOCATOR LINE TEMPLATE

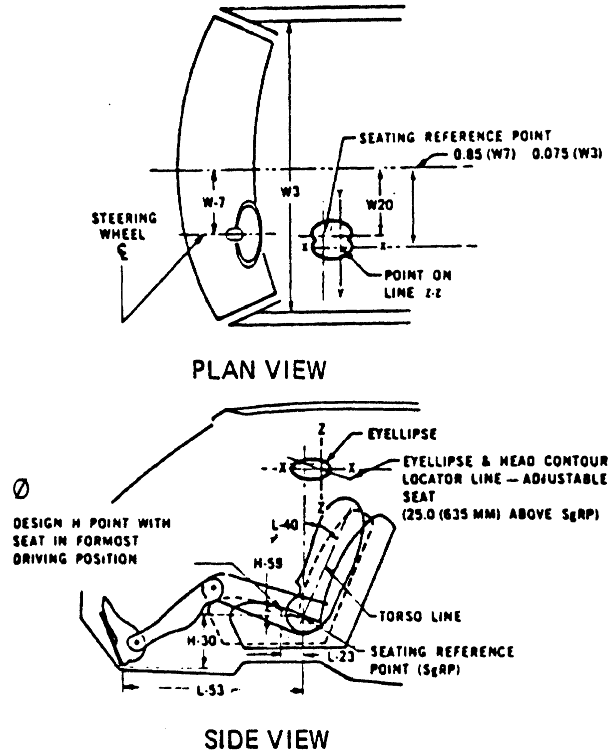


FIG. 6—EYELLIPSE TEMPLATE LOCATION

TABLE A-2—EYELLIPSE MAJOR AXIS LENGTHS—PLAN AND SIDE VIEW

L23		Percent Tangent Cutoff					
		90		95		99	
in.	mm	in.	mm	in.	mm	in.	mm
4.0	102	4.3	109	5.8	147	8.5	216
4.5	114	4.8	122	6.3	160	9.0	229
5.0	127	5.3	135	6.8	173	9.5	241
5.5	140	5.8	147	7.3	185	10.0	254
6.0	152	6.1	155	7.6	193	10.3	262
6.5	165	6.3	160	7.8	198	10.5	267

TABLE A-3—EYELLIPSE MINOR AXIS LENGTHS

	Percent Tangent Cutoff					
	90		95		99	
	in	(mm)	in	(mm)	in	(mm)
Side view	2.65	77	3.40	86	4.80	122
Plan view	3.24	82	4.12	105	5.86	149

both side and plan view is essentially the same for a given seat travel. Tl values are given in Table A-2.

A1.1.2.2 *Minor Axis*—The minor axes for the side and plan view are giv in Table A-3.

A1.1.3 Orientation—The ellipses are tilted in both side and plan view The side view angle is −6.4 deg (tilted downward looking forward). The pl view angle is 5.4 deg (tilted inward looking forward).

A1.2 The Eyellipse and head contour locator line may be construct from the following data. Table A-4 describes the horizontal and vertic displacement of the side view XX-ZZ datum lines of the Eyellipse relative the XX-ZZ intersection of the horizontal and vertical datum lines for ba angles—front (L40) ranging from 5 to 40 deg (See paragraphs 5.2.3 and 5.2 and Fig. 3).

A1.3 The locator line, dimensionally described in Table A-4, may computed from the following formulas:

$$X = -9.331288 + 0.404789\,(L40) - 0.0012611\,(L40)^2$$
$$Z = 1.067621 + 0.0156987\,(L40) - 0.0023347\,(L40)^2$$

Note: Rounding the coefficients in these equations will adversely aff their usefulness.

TABLE A-4—EYELLIPSE AND HEAD CONTOUR LOCATOR LINE—ADJUSTABLE SEAT—HORIZONTAL (X) AND VERTICAL (Z) DISPLACEMENT OF THE X-X AND Z-Z DATUM LINES OF THE EYELLIPSE RELATED TO A POINT 25 IN. (635 MM) ABOVE THE SgRP FOR BACK ANGLES (L40) RANGING FROM 5 to 40 DEG

Back Angle-Front (L40), deg	Horizontal Displacement (X)		Vertical Displacement (Z)	
	in.	mm	in.	mm
5.0	−7.34	−186.4	1.09	27.6
6.0	−6.95	−176.5	1.08	27.3
7.0	−6.56	−166.6	1.06	27.0
8.0	−6.17	−156.8	1.04	26.5
9.0	−5.79	−147.1	1.02	25.9
10.0	−5.41	−137.4	0.99	25.1
11.0	−5.03	−127.8	0.96	24.3
12.0	−4.66	−118.3	0.92	23.3
13.0	−4.28	−108.8	0.88	22.2
14.0	−3.91	− 99.4	0.83	21.0
15.0	−3.54	− 90.0	0.78	19.7
16.0	−3.18	− 80.7	0.72	18.3
17.0	−2.81	− 71.5	0.66	16.7
18.0	−2.45	− 62.3	0.59	15.0
19.0	−2.10	− 53.2	0.52	13.2
20.0	−1.74	− 44.2	0.45	11.3
21.0	−1.39	− 35.2	0.37	9.3
22.0	−1.04	− 26.3	0.28	7.2
23.0	−0.69	− 17.5	0.19	4.9
24.0	−0.34	− 8.7	0.10	2.5
25.0	0.00	0.0	−0.00	− 0.0
26.0	0.34	8.6	−0.10	− 2.6
27.0	0.68	17.2	−0.21	− 5.4
28.0	1.01	25.8	−0.32	− 8.2
29.0	1.35	34.2	−0.44	−11.2
30.0	1.68	42.6	−0.56	−14.3
31.0	2.01	50.9	−0.69	−17.5
32.0	2.33	59.2	−0.82	−20.8
33.0	2.65	67.4	−0.96	−24.3
34.0	2.97	75.6	−1.10	−27.9
35.0	3.29	83.6	−1.24	−31.5
36.0	3.61	91.6	−1.39	−35.4
37.0	3.92	99.6	−1.55	−39.3
38.0	4.23	107.5	−1.71	−43.3
39.0	4.54	115.3	−1.87	−47.5
40.0	4.84	123.0	−2.04	−51.8

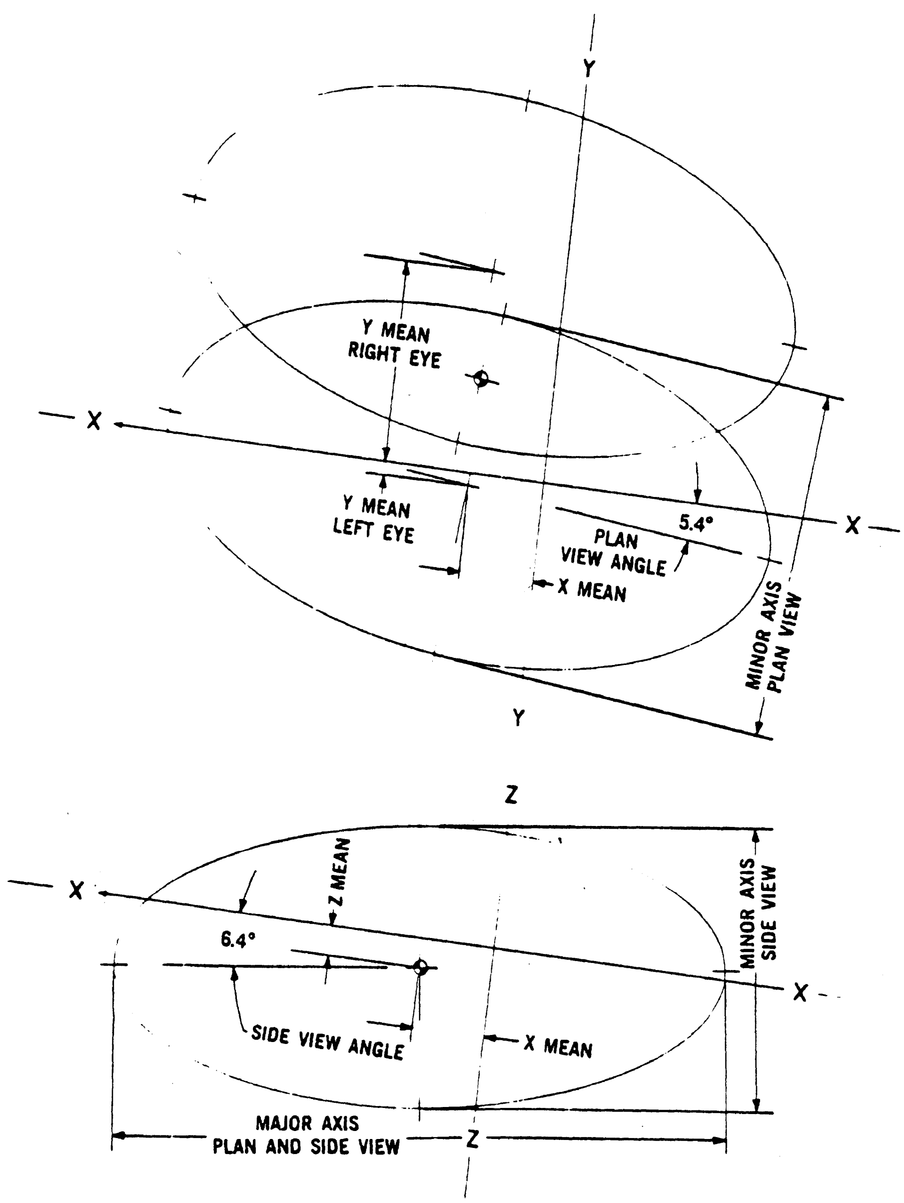


FIG. A-1—EYELLIPSE CENTER CONSTRUCTION—SIDE AND PLAN VIEW

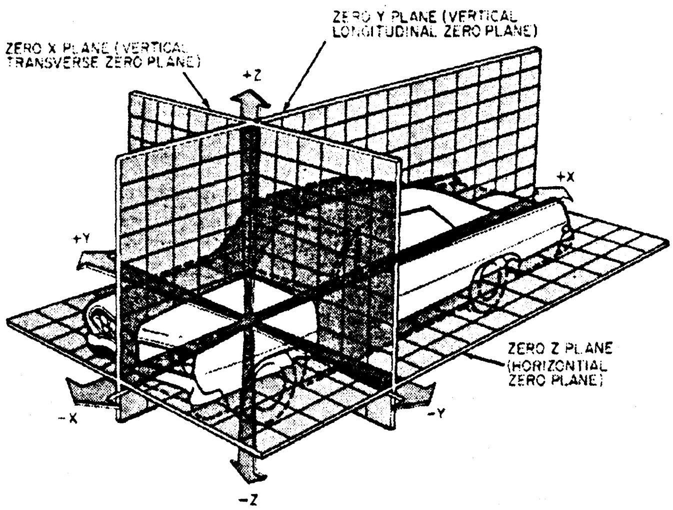


FIG. 1

MOTOR VEHICLE DRIVER AND PASSENGER HEAD POSITION—SAE J1052

SAE Recommended Practice

Report of Human Factors Engineering Committee approved August 1974.

1. Scope—This SAE Recommended Practice describes two-dimensional side and rear view 95th and 99th percentile driver and passenger seated head position contours for fixed and horizontally adjustable seats.

2. Background—The head position contours were developed using data gathered from eye position studies (Refs. 1-4) and anthropometric data of the head (Ref. 5). Mean top of head (including hair) and back of head (including hair) were determined relative to the eye from these studies (Refs. 2 and 3) and averaged. The mean front and side of head was determined relative to the eye from anthropometric data (Refs. 1, 5, and 8). This information was used to develop a mean head profile in side and rear view referenced to the eye.

Fixed-seat head position contours were developed by placing the mean head profile over the side- and rear-view eye ellipses developed in Ref. 7 and tracing the head contours as the eye is spotted around the eye ellipses. Only the upper half of the eye ellipses was used.

The same procedure was used with the side view 5.0 in. (127 mm) horizontal seat travel eyellipse (Ref. 6) to develop the adjustable seat head position contours. A rear-view head location contour for the adjustable seat was generated from a rear-view eye ellipse taken from the original driver's eye position study (Ref. 2). (This was a rear-view composite of the data from the Ford, Chevrolet, and Plymouth convertibles.)

The head contour templates are parameters of envelopes formed by an infinite number of planes dividing head positions so that (*P*) *percent* of the heads are on one side of the plane and (100 − *P*) percent are on the other. For example, if a plane seen as a straight line in the side view is drawn tangent to the upper edge of the 95th percentile head position contour, then 95% of the heads will be below the line and 5% will be above.

Head clearance is established as the distance between the tangent cutoff contour and any protrusion or surface. This distance is measured at the point of tangency normal (90 deg) to the tangent cutoff line. (See Fig. 1.)

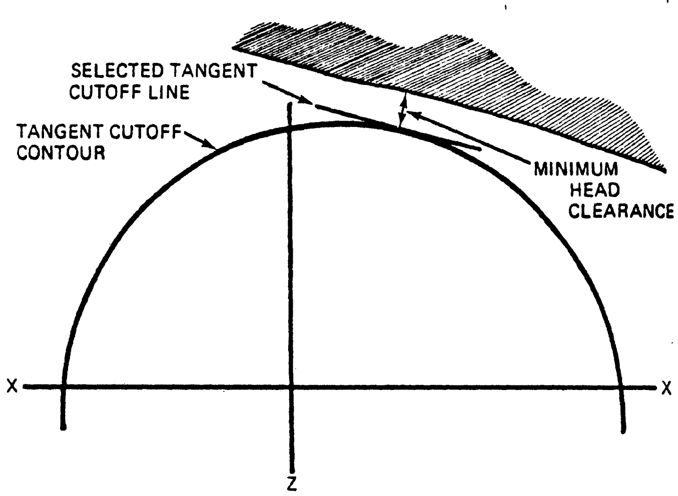


FIG. 1—MINIMUM HEAD CLEARANCE

These head locations are based on a 50-50 male/female population mix, with heads positioned for straight-ahead viewing without head turning.

Since head location will vary according to seatback angle, locater lines are used (Refs. 1, 4, and 6) to locate the head position contours relative to the seating reference point (SRP). See Tables 1 and 2.

There are two side-view and two rear-view head position contours included in this recommended practice. Reproduction of the templates may be obtained from SAE by ordering drawings supplementary to SAE J1052.

3. Definitions

3.1 **Head Position Range**—A statistical representation of the front, top, sides, and back of heads, when seated in a vehicle. Top and back of head includes hair.

3.2 **Head Position Contours**—Two-dimensional shapes that describe the seated vehicle occupant head positions in side and rear view. The driver head position contours with seat travel apply to drivers in horizontally adjustable seats. The head position contours without seat travel apply to both drivers and passengers in fixed seats.

3.3 **Head Location Clearance Line**—The edge view of a plane or boundary on either side of which a specific percentile level of driver head locations is known. A clearance line is drawn tangent to the head position contour in either side or rear view. The selection of the head location clearance lines relative to the head position contours are made by the user depending upon his design problem.

3.4 **Eyellipse and Head Locator Line—Adjustable Seats**—The side-view head position contour locater for horizontally adjustable seats with back angles between 5 and 40 deg (Table 1). Zero x-z coordinates are at the 25 deg back angle indice and are 25 in. (635 mm) above the H-point.

3.5 **Head Locater Line—Fixed Seats**—The side-view head position contour locator for seats with no adjustment (Table 2). The 25 deg back angle indice is 4.83 in. (122.7 mm) aft and 25.65 in. (651.5 mm) above the H-point.

3.6 The vehicle interior dimensions used with this recommended practice are defined in SAE J1100[1] and are listed below:

3.6.1 H-point.
3.6.2 Seating reference point.
3.6.3 L17—H-point travel.
3.6.4 L40—Back angle—front.
3.6.5 L53—H-point to accelerator heel point.
3.6.6 H30—H-point to heel point.
3.6.7 H58—H-point rise.
3.6.8 W3—Shoulder room.
3.6.9 W7—Steering wheel center to centerline of car.

[1]Available from SAE as HS J1100.

TABLE 1—HORIZONTAL (X) AND VERTICAL (Z) COORDINATES OF EYELLIPSE AND HEAD CONTOUR LOCATER LINE—ADJUSTABLE SEATS
(Relative to a horizontal line 25 in (635 mm) above the seating reference point and a vertical line extending upward from the seating reference point)

Back Angle, deg	Horizontal Displacement (X)		Vertical Displacement (Z)	
	mm	in	mm	in
5.0	−186.4	−7.34	27.6	1.09
6.0	−176.5	−6.95	27.3	1.08
7.0	−166.6	−6.56	27.0	1.06
8.0	−156.8	−6.17	26.5	1.04
9.0	−147.1	−5.79	25.9	1.02
10.0	−137.4	−5.41	25.1	0.99
11.0	−127.8	−5.03	24.3	0.96
12.0	−118.3	−4.66	23.3	0.92
13.0	−108.8	−4.28	22.2	0.88
14.0	−99.4	−3.91	21.0	0.83
15.0	−90.0	−3.54	19.7	0.78
16.0	−80.7	−3.18	18.3	0.72
17.0	−71.5	−2.81	16.7	0.66
18.0	−62.3	−2.45	15.0	0.59
19.0	−53.2	−2.10	13.2	0.52
20.0	−44.2	−1.74	11.3	0.45
21.0	−35.2	−1.39	9.3	0.37
22.0	−26.3	−1.04	7.2	0.28
23.0	−17.5	−0.69	4.9	0.19
24.0	−8.7	−0.34	2.5	0.10
25.0	0.0	0.00	−0.0	−0.00
26.0	8.6	0.34	−2.6	−0.10
27.0	17.2	0.68	−5.4	−0.21
28.0	25.8	1.01	−8.2	−0.32
29 0	34.2	1.35	−11.2	−0.44
30.0	42.6	1.68	−14.3	−0.56
31.0	50.9	2.01	−17.5	−0.69
32.0	59.2	2.33	−20.8	−0.82
33.0	67.4	2.65	−24.3	−0.96
34.0	75.6	2.97	−27.9	−1.10
35.0	83.6	3.29	−31.5	−1.24
36.0	91.6	3.61	−35.4	−1.39
37.0	99.6	3.92	−39.3	−1.55
38.0	107.5	4.23	−43.3	−1.71
39.0	115.3	4.54	−47.5	−1.87
40.0	123.0	4.84	−51.8	−2.04

4. *Application*

4.1 The head position contours provide a drafting tool from which driver and passenger head locations can be described in vehicles with horizontally adjustable or fixed seats.

4.2 The head position contours are applicable to motor vehicles designed as passenger cars, multipurpose passenger vehicles, trucks, and buses with bench or bucket type seats and within the following range of driver workspace dimensions:

(L40) Back angle	5–40 deg	
(H30) Vertical H-point to heel point	5.0–18.0 in	(127–457 mm)
(H58) Vertical H-point rise	0.0–1.5 in	(0.0–38 mm)
(L17) Horizontal H-point travel	0 or 4.0–6.0 in	(101–165 mm)
(L53 Minus L17) Horizontal H-point to heel point (minimum)	20.0 in	(508 mm)

5. *Head Position Contour Location*

5.1 The head position contours are located in the vehicle interior by longitudinal (X-X), lateral (Y-Y), and vertical (Z-Z) datum lines which are shown on the contours. These datum lines are not the contour's geometric axes, but are work lines to establish the contour's position in the vehicle with respect to seated drivers.

5.2 Driver Head Position Contour—Side View—Adjusted Seat—Relative to the vehicle[2]:

5.2.1 Select the side-view head position contour appropriate for adjustable seats.

5.2.2 Construct a vertical workline through the seating reference point.

5.2.3 Construct a horizontal workline 25.0 in. (635 mm) above the seating reference point.

5.2.4 Position the 25 deg mark of the eyellipse and head contour locater line (Table 1) at the intersection of the lines constructed in paragraphs 5.2.2 and 5.2.3.

5.2.5 Position the side-view driver head position contour on the eyellipse and head contour locater line at the intersection of the contour datum lines X-X and Z-Z at the packaged back angle—front (L40) such that the contour datum lines and the worklines of paragraphs 5.2.2 and 5.2.3 are parallel, and trace the outline on the layout.

5.3 Driver Head Position Contour—Rear View—Adjustable Seat—Relative to the vehicle:

5.3.1 Construct a lateral workline (Y-Y) perpendicular to the vehicle centerline through the line (X-X) projected from the rear view.

5.3.2 Construction of a vertical workline (Z-Z).

5.3.2.1 *Passenger Cars*—Construct a vertical workline (Z-Z) parallel to the vehicle centerline and a distance from the vehicle centerline equal to 0.85 (W7) + 0.075 (W3). The dimensions W7 and W3 are defined in paragraphs 3.6.8 and 3.6.9. (This formula positions the Z-Z workline at a point 15% of the distance from the steering wheel centerline to the inner surface of the driver's door as described in Ref. 6.) This formula is applicable to both passenger car bench and bucket-type seats; however, in the case of bucket-type seats, the contour centerline shall be located no further inboard than the longitudinal centerline of the seat.

5.3.2.2 *Multipurpose Passenger Vehicles, Trucks, and Buses with Individual Driver Seats*—Construct a vertical workline (Z-Z) parallel to the vehicle centerline and position it a distance from the vehicle centerline such that it will locate the contour centerline at the Y coordinate of the H-point.

5.3.2.3 *Multipurpose Passenger Vehicles, Trucks, and Buses with Bench Seats*—Use paragraph 5.3.2.1 as described above.

5.3.3 Position the rear view contour on the constructed worklines (Z-Z) and (Y-Y) and trace the outline on the layout.

5.4 Passenger Head Position Contour—Side View—Fixed Seat

5.4.1 Select the fixed seat head position contours and construct a vertical workline 4.83 in. (122.7 mm) aft of the H-point.

TABLE 2—HORIZONTAL (X) AND VERTICAL (Z) COORDINATES OF EYELLIPSE AND HEAD CONTOUR LOCATER LINE FOR FIXED SEATS
(Relative to a horizontal line 25 in (635 mm) above the seating reference point and a vertical line extending upward from the seating reference point)

Back Angle, deg	Horizontal Displacement (X)		Vertical Displacement (Z)	
	mm	in	mm	in
5	−114.6	−4.51	47.8	1.88
6	−101.7	−4.00	47.6	1.87
7	−88.9	−3.50	47.2	1.86
8	−76.2	−3.00	46.6	1.84
9	−63.6	−2.50	46.0	1.81
10	−51.1	−2.01	45.2	1.78
11	−38.7	−1.52	44.2	1.74
12	−26.5	−1.04	43.1	1.70
13	−14.3	− .56	41.9	1.65
14	−02.3	− .09	40.5	1.60
15	09.6	.38	39.0	1.54
16	21.5	.85	37.4	1.47
17	33.2	1.3	35.6	1.40
18	44.7	1.76	33.7	1.33
19	56.2	2.21	31.7	1.25
20	67.6	2.66	29.5	1.16
21	78.8	3.10	27.2	1.07
22	90.0	3.54	24.7	0.97
23	101.0	3.98	22.1	0.87
24	111.9	4.40	19.4	0.76
25	122.7	4.83	16.5	0.65
26	133.4	5.25	13.5	0.53
27	144.0	5.67	10.3	0.41
28	154.5	6.08	07.0	0.28
29	164.8	6.49	03.6	0.14
30	175.1	6.89	00.0	0.00
31	185.2	7.29	−03.7	−0.14
32	195.2	7.69	−07.5	−0.29
33	205.1	8.08	−11.5	−0.45
34	214.9	8.46	−15.6	−0.61
35	224.6	8.84	−19.8	−0.78
36	234.2	9.22	−24.2	−0.95
37	243.7	9.59	−28.7	−1.13
38	253.0	9.96	−33.4	−1.31
39	262.2	10.33	−38.2	−1.50
40	271.4	10.68	−43.1	−1.70
41	280.4	11.04	−48.2	−1.90
42	289.3	11.39	−53.4	−2.10
43	298.1	11.74	−58.8	−2.31
44	306.8	12.08	−64.3	−2.53
45	315.4	12.42	−69.9	−2.75

[2]If it is desired to obtain side-view driver's head position relative to the seat, follow procedures described in paragraphs 5.4.1 through 5.4.4 using the side-view fixed seat head position contour.

5.4.2 Construct a horizontal workline 25.6 in. (650 mm) above the H-point.

5.4.3 Position the 25 deg indice of the head contour locater line (Table 2) at the intersection of the lines constructed in paragraphs 5.4.1 and 5.4.2.

5.4.4 Position the side-view fixed seat head position contour on the head contour locater line (Table 2) with the intersection of the contour datum lines X-X and Z-Z at the packaged back angle-front (L40) such that the contour datum lines and the worklines of paragraph 5.4.1 and 5.4.2 are parallel, and trace the outline on the layout.

5.5 Passenger's Head Position Contour—Rear View—Fixed Seat

5.5.1 Construct a lateral workline (Y-Y) perpendicular to the vehicle centerline through the line (X-X) projected from the rear view.

5.5.2 Construct the vertical workline (Z-Z) as follows.

5.5.3 The rear view Z-Z line is positioned such that the contour centerline is at the Y coordinate of the H-point as specified by the manufacturer.

5.5.4 Position the rear-view fixed seat head position contour on the constructed worklines and trace the outline on the layout.

6. Head Location Clearance Line Construction—Minimum head clearances are measured from points on the selected contour that are closest to any protrusion or surface. (See Fig. 1.) The distance is measured normal to a line drawn tangent to the contour. The selection of 95th or 99th percentile tangent cutoffs and comfortable clearance distances must be made by the user.

7. References

1. D. C. Hammond and R. W. Roe, "Driver Head and Eye Position." SAE Transactions, Vol. 81 (1972), paper 720200.

2. J. F. Meldrum, "Automobile Driver Eye Position." SAE Transactions, Vol. 74 (1966), paper 650464.

3. Letter to SAE Driver Vision Subcommittee, Driver Eye Location Data from SAE Controls Reach Study, Ronald W. Roe, February 12, 1973.

4. Letter to SAE Vision Subcommittee, Definition of a Fixed Seat Eye Ellipse, Ronald W. Roe, May 30, 1973.

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

6. Society of Automotive Engineers Recommended Practice, "Motor Vehicle Drivers' Eye Range." SAE J941c, June 1972.

7. Letter to SAE Design Devices Subcommittee, Driver and Passenger Head Location, Ronald W. Roe, June 12, 1973.

8. Letter to SAE Design Devices Subcommittee, Driver Head Position Contours, Lewis J. Tomiko, February 3, 1972.

SYNTHETIC SKINS FOR AUTOMOTIVE TESTING—SAE J202

SAE Information Report

Report of Human Factors Engineering Committee approved February 1972.

This information report describes synthetic materials that are currently employed in automotive testing laboratories to simulate human skin.

Human skin is the external boundary layer of the body and serves as its protective container. It varies in thickness, elasticity, and blood supply according to body location; for example, compare the eyelids with the lower legs or the buttocks. The mechanical properties of skin change with age from the highly hydrous skin of infancy to the relatively anhydrous skin of maturity; its characteristics also vary from person to person, depending upon nutrition and genetic factors. Moreover, there is a variability in tensile strength associated with tissue direction, called the "lines of Langer," or cleavage lines of the skin (which change according to body location). Amid this tremendous variability it is necessary to select and standardize on some readily available materials which will simulate the skin reasonably closely for test purposes. A synthetic skin which is matched to the skin of the head and face is the most immediate need for automotive testers, as this area is the most frequently injured as well as the most cosmetically important skin of the body.

To date, the synthetic materials tested have been selected largely on a judgmental basis. Some research on damage testing of human skin has been reported recently (1,2,3), so it is likely that closer quantitative comparisons will eventually be achieved and reported.

The following materials are widely used as synthetic skins in automotive testing laboratories. No one material can be recommended as best, since current practice is based on qualitative judgment. These materials have been selected solely on their ability to simulate mechanical damage; no consideration has been given to the stiffness or "cushioning" properties of these synthetics relative to human skin. This latter area is only now beginning to be investigated.[1]

The first two materials described below have been employed on the SAE J984 headform as well as the head of the SAE J963 anthropometric test dummy; the third material has been fashioned only for the SAE J984 headform.

1. Chamois—Chamois is a natural material made from the skin of chamois, sheep, or goats. It is probably the most widely used human skin simulant at the present time. It has been employed either wet or dry and in both single and double layers. Lacerative rating scales for use with a double layer of chamois overlying a SAE J984 headform or SAE J963 test dummy face covering have been proposed by Blizard and Howitt[4] and Rieser and Chabal.[5]

The primary objection to the use of chamois is the lack of quality control inherent in a naturally produced material. It leaves much to be desired in terms of reproducibility of test results. Considerable care is necessary to select only the most uniform specimens from the lots obtained. Samples, as received, are found to vary from $\frac{1}{32}$ to $\frac{3}{32}$ in. (0.8–2.4 mm) in thickness within the same skin; therefore, a consistent arrangement should be adopted for chamois positioning on the test form. A further shortcoming of chamois is its anisotropic character which is undesirable in a test material.

Puncture resistance of chamois as measured by spade or razor tipped penetrometers[3] is somewhat lower both statically and dynamically than that of average human skin. Tensile and tear strengths are also lower. Chamois therefore usually yields greater laceration indication than would human skin.

2. PPG Formulation—Rieser and Chabal have reported on a composite synthetic skin which they have developed.[2] This consists of a sponge rubber base covered with an RTV silicone rubber, impregnated with human hair. Rieser and Chabal developed their synthetic until it gave the same quantitative performance as human skin when tested on special cutting machines which they built. This side-by-side quantitative testing is one of the very few comparisons available in the literature between human skin and a synthetic. A later paper by these same authors describes the performance of their skin simulant in tests of automotive windshields.[5] They report encouraging results in headform and dummy experiments when comparing the performance of their simulant against human skin in windshield testing.

3. Inland Skin and Flesh—Holcombe and Foster have described a composite headform covering which was developed for automotive hardware testing.[6] The outer layer (skin simulator) is a Neoprene based rubber 0.030 in. (0.8 mm) thick, reinforced with chopped fiberglass. It is loosely bonded to a $\frac{1}{4}$ in. (6.4 mm) thick layer of a natural rubber compound which simulates the subcutaneous zone of human skin. The authors felt this simulant, as developed, provides "the capability of making comparisons between various component designs to rank their injury potential qualitatively and to demonstrate improvements."

[1] C. W. Gadd, A. M. Nahum, D. C. Schneider, and R. G. Madeira, "Tolerance and Properties of Superficial Soft Tissues in Situ." Proceedings of Fourteenth Stapp Car Crash Conference (P-33), paper 700910. New York: Society of Automotive Engineers, Inc., 1970.

[2] R. G. Rieser and J. Chabal, "Safety Performance of Laminated Glass Configurations." SAE Transactions, Vol. 67, paper 670912. Also Proceedings of Eleventh Stapp Car Crash Conference (P-20), New York: Society of Automotive Engineers, Inc., 1967.

[3] C. W. Gadd, W. A. Lange, and F. J. Peterson, "Strength of Skin and Its Measurement." Biomechanics Monograph, ASME, New York, 1967.

[4] J. R. Blizard and J. S. Howitt, "Development of a Safer Nonlacerating Automobile Windshield." Paper 690484 presented at SAE Mid-Year Meeting, Chicago, May 1969.

[5] R. G. Rieser and J. Chabal, "Laboratory Studies on Laminated Safety Glass and Installations on Performance." SAE Transactions, Vol. 78 (1969), paper 690799. Also Proceedings of Thirteenth Stapp Car Crash Conference (P-28), New York: Society of Automotive Engineers, Inc., 1969.

[6] H. G. Holcombe and J. K. Foster, "Application and Development of the Tramasal Headform." Paper 690476 presented at SAE Mid-Year Meeting, Chicago, May 1969.

TABLE 4—MODIFIED MAXIMUM CVN TEST TEMPERATURES

Reference: ASTM A333—Indicates −29°C (−20°F)
Specimen Width (mm)

mm	in	9	8	7.5	7	6.67	6	5	4	3.33	3	2.5
10	0.394	—	—	−32°C −25°F	−33°C −28°F	−34°C −30°F	−37°C −35°F	−40°C −40°F	−46°C −50°F	−48°C −55°F	−51°C −60°F	−57°C −70°F
9	0.354	—	—	−32°C −25°F	−33°C −28°F	−34°C −30°F	−37°C −35°F	−40°C −40°F	−46°C −50°F	−48°C −55°F	−51°C −60°F	−57°C −70°F
8	0.315	—	—	−32°C −25°F	−33°C −28°F	−34°C −30°F	−37°C −35°F	−40°C −40°F	−46°C −50°F	−48°C −55°F	−51°C −60°F	−57°C −70°F
7.5	0.295	—	—	—	−31°C −23°F	−32°C −25°F	−34°C −30°F	−37°C −35°F	−43°C −45°F	−46°C −50°F	−48°C −55°F	−54°C −65°F
7	0.276	—	—	—	—	−30°C −22°F	−33°C −27°F	−36°C −32°F	−41°C −42°F	−44°C −47°F	−47°C −52°F	−52°C −62°F
6.7	0.262	—	—	—	—	—	−32°C −25°F	−34°C −30°F	−40°C −40°F	−43°C −45°F	−46°C −50°F	−51°C −60°F
6	0.236	—	—	—	—	—	—	−32°C −25°F	−37°C −35°F	−40°C −40°F	−43°C −45°F	−48°C −55°F
5	0.197	—	—	—	—	—	—	—	−34°C −30°F	−37°C −35°F	−40°C −40°F	−46°C −50°F
4	0.158	—	—	—	—	—	—	—	—	−32°C −25°F	−34°C −30°F	−40°C −40°F
3.3	0.131	—	—	—	—	—	—	—	—	—	−32°C −25°F	−37°C −35°F
3	0.118	—	—	—	—	—	—	—	—	—	—	−34°C −30°F
2.5	0.098	—	—	—	—	—	—	—	—	—	—	—

Use of Table: In the left vertical column, go to the value that is closest to, but not less than, 80% of the section involved. Then horizontally to find the test temperature under the actual width of the finish machined specimen.

EXAMPLE: Nominal thicknesses 9.5 mm (3/8 in). Want to run a 6 mm specimen which is only 63% of the thickness. 80% of 9.5 mm is 7.6 mm. Go down the left column to 8 mm, go to the right. Under 6 mm read −37°C (−35°F). From Table 3 the minimum energy is 8 Joules (6.0 ft-lbf); from Table 4 maximum test temperature is −37°C (−35°F). Thus, 10 mm x 6 mm specimen, minimum energy of 8 Joules at, or below, −37°C.

6.4 Longitudinal Tensile Properties—Table 2 gives properties of grades that are expected to be most commonly used but use of grades not in Table 2 is in no way prohibited.

6.5 Refer to paragraphs 3 and 4 for any topic not specifically covered in this paragraph.

TABLE 5—MECHANICAL PROPERTIES OF CASTINGS

Grade	Yield Strength Minimum	Tensile Strength Minimum	% Elongation-Min in 50 mm or 2 in	% RA Min	Hardness BHN	CVN, 10 mm x 10 mm Minimum[a]	
						Joules	ft-lbf
205	205 MPa (29.7 ksi)	410 MPa (59.5 ksi)	13	18	120–187	11	8
240	240 MPa (34.8 ksi)	450 MPa (65.3 ksi)	13	18	131–187	11	8
275	275 MPa (39.9 ksi)	480 MPa (69.6 ksi)	12	15	143–197	11	8

[a] The maximum permissible test temperature is −29°C (−20°F), lower temperatures may be used if convenient.

TABLE 6—KEEL BLOCK PROPERTIES (Information Only)

Grade	Yield Strength Minimum	Tensile Strength Minimum	% Elongation-Min in 50 mm or 2 in	% RA Min	Hardness BHN	CVN, 10 mm x 10 mm Minimum[a]	
						Joules	ft-lbf
205	205 MPa (29.7 ksi)	410 MPa (29.7 ksi)	24	35	—	15	11
240	240 MPa (34.8 ksi)	450 MPa (65.3 ksi)	24 24	35 35	— —	15	11
275	275 MPa (39.9 ksi)	480 MPa (69.6 ksi)	22	30	—	15	11

[a] The maximum permissible test temperature is −29°C (−20°F), lower temperatures may be used if convenient.

USA MALE AND FEMALE PHYSICAL DIMENSIONS FOR CONSTRUCTION AND INDUSTRIAL EQUIPMENT DESIGN—SAE J833a SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved June 1974.

Scope—To provide dimensions for the 5th, 50th, and 95th percentiles of United States male[1] and female operators of construction and industrial equipment.

Small Man—The small man represents the 5th percentile (only 5% of the population is smaller than the dimensions given).

Medium Man—The medium man represents the 50th percentile (50% of the population is larger than and 50% is smaller than the dimensions given).

Large Man—The large man represents the 95th percentile (only 5% of the population is larger than the dimensions given).

[1] For dimensions of Asian Males, see SAE Handbook Supplement J317.

Dimensions—Whenever available, the dimensions from civilian populations were used. Keep in mind that civilian populations are older, heavier, and shorter than military populations.

Include an allowance for height of shoes or boots, size of safety hat or helmet and thickness of work clothing when using the dimensions for calculation of clothed individuals. Safety hats or helmets will add 2 in. (50 mm) in height. Safety hats are approximately 12.0 in. (305 mm) long and 10.5 in. (345 mm) wide. Safety helmets are approximately 11.0 in. (280 mm) long and 9.0 in. (230 mm) wide.

In converting measurements, 1 in. = 2.5400 cm and 1 lb = 0.454 kg.

In Fig. 1, with the subject standing erect:

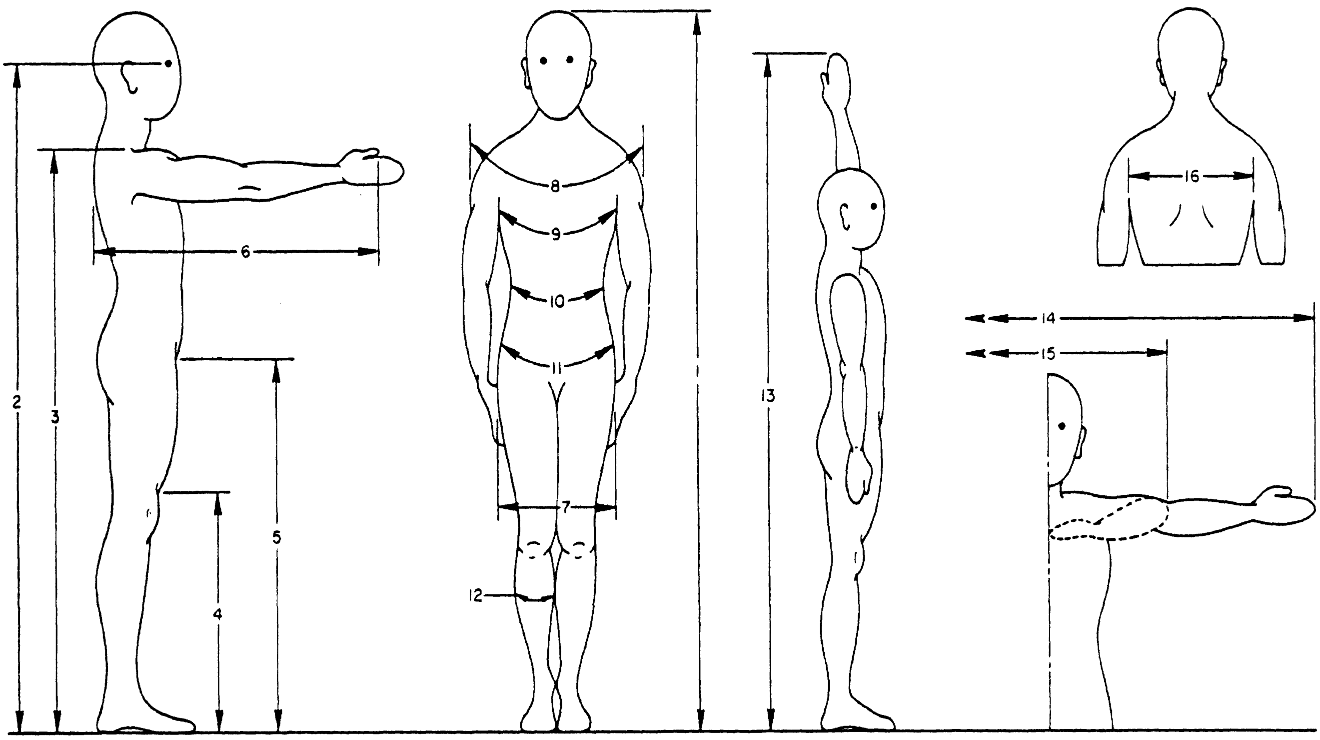


FIG. 1—STANDING MEASUREMENTS

1. **Stature**—Measured as distance from floor to top of head (vertex).

2. **Eye Height, Standing**—Measured as distance from floor to the level of the inner core of the right eye.

3. **Shoulder Height**—Measured as distance from floor to outer point of right shoulder (acromiale).

4. **Kneecap Height**—Measured as distance from floor to top of right kneecap.

5. **Crotch Height**—Measured as distance from floor to crotch.

6. **Functional Reach**—With subject's back against a wall and right arm extended forward parallel to the floor, the tip of his index finger touching the tip of extended thumb, distance from wall to tip of thumb is measured.

7. **Hip Breadth, Standing**—Measured as maximum breadth across the hips.

8. **Shoulder Circumference**—Measured as maximum circumference of shoulder with tape passing over bulge of both upper arm (deltoid) muscles.

9. **Chest Circumference**—Measured as average circumference of chest during normal breathing, with tape at level of nipples.

10. **Waist Circumference**—Measured as circumference at level of umbilicus with abdomen relaxed.

11. **Hip Circumference**—Measured as maximum circumference of hips at level of greatest buttock protrusion.

12. **Calf Circumference**—Measured as maximum circumference of right calf.

13. **Overhead Reach (Fingertip)**—Subject's arm extended straight above his shoulder, measurement made from floor to the tip of the middle finger (dactylion).

14. **Arm Span**—Arms extended straight out from shoulder, palms forward, measurement is made of the horizontal distance from the tip of the left middle finger (dactylion) to the tip of the right middle finger.

15. **Arm Akimbo Span**—Subject stands, arms horizontal, elbow flexed about 60 deg, and fists clenched and touching. A tape with its zero point on the midline of the spine is passed horizontally around the right shoulder and over the tip of the elbow to the wrist landmark. Measure the surface distance from the spine to the wrist landmark.

16. **Interscye Breadth**—Measured as distance along surface of back between armpit creases.

In Fig. 2, with the subject sitting erect on a table:

17. **Sitting Height**—Measured as distance from table surface to top of head (vertex).

18. **Eye Height, Sitting**—Measured as distance from table surface to level of inner core of right eye.

19. **Shoulder Height, Sitting**—Measured as distance from table surface to outer point of right shoulder (acromiale).

20. **Shoulder-Elbow Length**—With right arm held to form a right angle at elbow, measured as distance from outer point of shoulder (acromiale) to elbow (olecranon).

21. **Forearm-Hand Length**—With right arm held to form a right angle at elbow and with hand extended, measured as distance from elbow to tip of middle finger.

22. **Anterior Arm Reach, Sitting**—Subject's right arm extended horizontally in front of him, measurement is made of the horizontal distance from the back of the shoulder (greatest bulge of trapezius) to the tip of the middle finger of his extended hand.

23. **Buttock-Knee Length**—With legs bent to form right angle at knee, measured as distance from rearmost projection of buttock to front of right kneecap.

24. **Thigh Clearance Height**—Knees together, heels together. Measured from top of the sitting surface to the junction of the abdomen and thigh.

25. **Buttock-Popliteal Length**—With legs bent to form right angle at knee, measured as distance from rearmost projection of buttocks to back of right knee (medial head of gastrocnemius).

26. **Popliteal Height**—With legs bent to form right angle at knee, measured as distance from surface of footrest to underside of right knee (tendon of biceps femoris).

27. **Shoulder Breadth**—Measured as maximum breadth across the shoulders, including upper arm muscles (between outermost projections of deltoids).

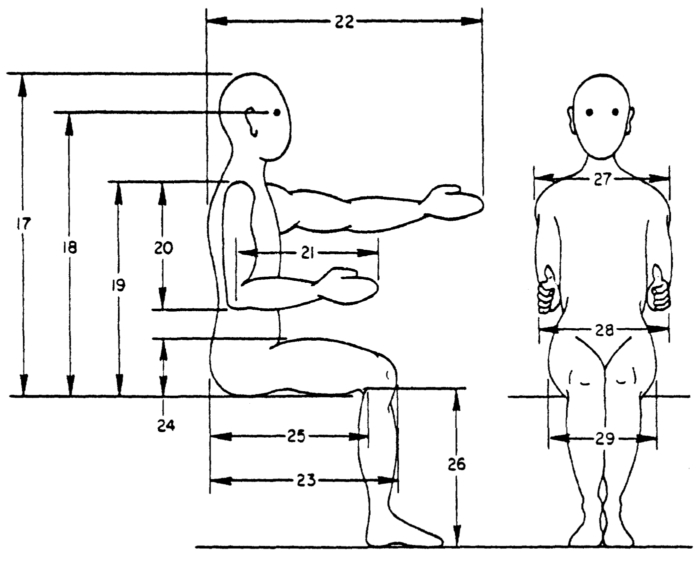


FIG. 2—SITTING MEASUREMENTS

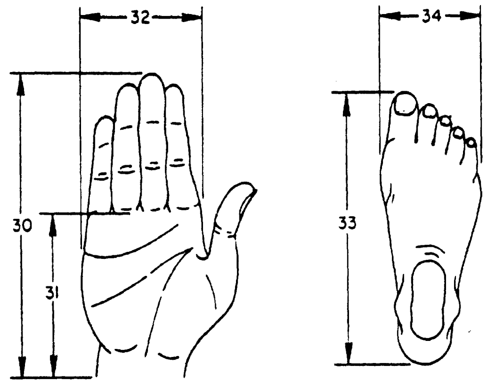


FIG. 3—HAND AND FOOT MEASUREMENTS

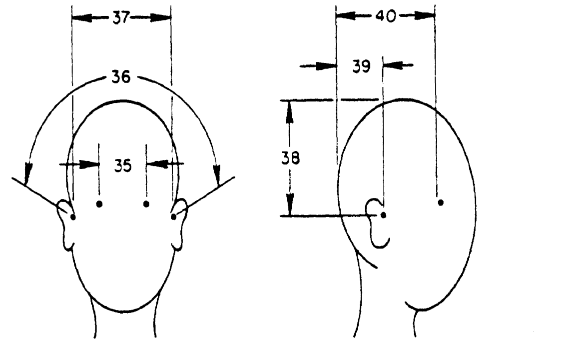


FIG. 4—HEAD AND FACE MEASUREMENTS

28. **Elbow-to-Elbow Breadth**—Knees together, forearms at right angles, hands open, palms facing each other, and elbows held as tightly as possible to the sides. Measured across the lateral projection of the elbows.

29. **Hip Breadth, Sitting**—Measured as maximum breadth across the hips.

In Fig. 3, the hand measurements and foot measurements with the weight equally distributed on both feet:

30. **Hand Length**—With right hand extended, palm up and fingers straight, measured as distance from wrist (navicula) to tip of middle finger (dactylion).

31. **Palm Length**—With right hand extended, palm up, measure distance from wrist (navicula) to tip of middle finger.

32. **Hand Breadth**—With right hand extended, palm up, measure maximum breadth across base of fingers (metacarpal-phalangeal joints).

33. **Foot Length**—Measured as distance from back of right heel to ti longest toe.

34. **Foot Breadth**—Measured as maximum breadth of right foot.

In Fig. 4, with the subject sitting or standing erect:

35. **Interpupilary Breadth**—Subject sits erect with head level. The tance between the centers of the pupils of the eyes is measured. Slic calipers are used.

36. **Bitragion-Coronal Arc**—Subject sits. With a tape held as close to

TABLE 1—PERCENTILES OF ANTHROPOMETRIC MEASURES, MALES—UNITED STATES

Dimension	5th		50th		95th	
	in	cm	in	cm	in	cm
STANDING						
1. Stature[a]	63.6	161.6	68.3	173.5	72.8	184.9
2. Eye height[b]	59.8	151.9	64.1	162.8	68.3	173.5
3. Shoulder height[b]	52.8	134.1	56.6	143.8	60.2	152.9
4. Kneecap height[a]	19.3	49.0	21.4	54.4	23.4	59.4
5. Crotch height[b]	30.4	77.2	32.8	83.3	35.7	90.7
6. Functional reach[b]	29.7	75.4	32.3	82.0	35.0	88.9
7. Hip breadth[b]	12.7	32.3	13.9	35.3	15.4	39.1
8. Shoulder circumference[b]	41.6	105.7	45.1	114.6	49.4	125.5
9. Chest circumference[b]	35.1	89.2	38.7	98.3	43.2	109.7
10. Waist circumference[b]	27.7	70.4	31.7	80.5	37.5	95.3
11. Hip circumference[b]	34.3	87.1	37.7	95.8	41.8	106.2
12. Calf circumference[b]	12.9	32.8	14.4	36.6	16.0	40.6
13. Overhead reach[c]	77.8	197.6	(Not available)		89.5	227.3
14. Arm span[c]	65.9	167.4	(Not available)		75.6	192.0
15. Arm akimbo span[d]	31.3	79.4	33.8	85.7	36.4	92.4
16. Interscye breadth[b]	10.8	27.4	12.0	30.5	13.4	34.0
SITTING						
17. Sitting height[a]	33.2	84.3	35.7	90.7	38.0	96.5
18. Eye height[b]	29.4	74.7	31.5	80.0	33.5	85.1
19. Shoulder height[b]	21.3	54.1	23.3	59.2	25.1	63.8
20. Shoulder-elbow[b]	13.2	33.4	14.3	36.3	15.4	39.1
21. Forearm-hand[b]	17.6	44.7	18.9	48.0	20.2	51.3
22. Anterior arm reach[c]	31.0	78.7	(Not available)		37.0	94.0
23. Buttock-knee[a]	21.3	54.1	23.3	59.2	25.2	64.0
24. Thigh clearance[a]	4.3	10.9	5.7	14.5	6.9	17.5
25. Buttock-popliteal[a]	17.3	43.9	19.5	49.5	21.6	54.9
26. Popliteal height[a]	15.5	39.4	17.3	43.9	19.3	49.0
27. Shoulder breadth[b]	16.5	41.9	17.9	45.5	19.4	49.3
28. Elbow-to-elbow[a]	13.7	34.8	16.5	41.9	19.9	50.5
29. Hip breadth[a]	12.2	31.0	14.0	35.6	15.9	40.4
30. Hand length[b]	6.9	17.5	7.5	19.1	8.0	20.3
31. Palm length[b]	3.9	9.9	4.2	10.7	4.6	11.7
32. Hand breadth[b]	3.2	8.1	3.5	8.9	3.7	9.4
33. Foot length[b]	9.8	24.9	10.5	26.7	11.2	28.2
34. Foot breadth[b]	3.5	8.9	3.8	9.7	4.1	10.4
35. Interpupilary[d]	2.2	5.5	2.4	6.1	2.7	6.8
36. Coronal arc[d]	13.2	33.5	14.0	35.5	14.8	37.5
37. Bitragion breadth[d]	5.0	12.6	5.3	13.5	5.7	14.5
38. Tragion-top of head[d]	4.7	11.9	5.2	13.2	5.7	14.5
39. Tragion to wall[d]	3.3	8.5	4.0	10.2	4.9	12.4
40. Eye to wall[d]	6.2	15.7	6.8	17.2	7.4	18.9
41. Weight[a]	126 lb	57.2 kg	166 lb	75.4 kg	217 lb	98.5 kg

[a]Ref. 5, subjects partially clothed, no shoes, civilians.
[b]Ref. 3, subjects nude, military population.
[c]Ref. 4, subjects clothed, military population.
[d]Ref. 6, subjects nude, military population.

TABLE 2—PERCENTILES OF ANTHROPOMETRIC MEASURES, FEMALES—UNITED STA

Dimension	5th		50th		95th	
	in	cm	in	cm	in	cm
STANDING						
1. Stature[a]	59.0	150.0	62.9	160.0	67.1	170.[illegible]
2. Eye height[b]	55.9	142.2	59.2	150.4	62.5	158.[illegible]
3. Shoulder height[b]	48.4	123.0	52.3	132.9	56.4	143.[illegible]
4. Kneecap height[a]	17.9	45.4	19.6	50.0	21.5	54.[illegible]
5. Crotch height[b]	26.1	66.2	29.0	73.6	32.0	81.[illegible]
6. Functional reach[b]	26.6	67.7	29.2	74.2	31.7	80.[illegible]
7. Hip breadth[b]	12.4	31.6	13.7	34.8	15.3	38.[illegible]
8. Shoulder circumference[c]	36.5	92.6	39.4	100.0	43.1	109.[illegible]
9. Chest (bust) circumference[b]	30.8	78.2	34.8	88.5	40.6	103.3
10. Waist circumference[b]	23.1	58.8	26.1	66.3	31.1	79.[illegible]
11. Hip circumference[b]	33.6	85.4	37.2	94.4	42.2	107.3
12. Calf circumference[b]	12.0	30.6	13.4	34.1	14.9	37.9
13. Overhead reach[c]	72.9	185.1	78.4	199.2	83.9	213.3
14. Arm span[d]	58.8	149.4	64.7	164.3	70.2	178.3
15. Arm akimbo span[c]	29.2	74.2	31.3	79.5	33.5	85.1
16. Interscye breadth[c]	12.3	31.2	13.8	35.0	15.4	39.2
SITTING						
17. Sitting height[a]	30.8	78.5	33.4	84.8	35.7	90.7
18. Eye height[b]	27.1	68.7	29.0	73.7	31.0	78.8
19. Shoulder height[b]	21.2	53.7	22.8	57.9	24.6	62.5
20. Shoulder-elbow[b]	11.9	30.2	13.1	33.2	14.3	36.2
21. Forearm-hand[b]	15.3	38.9	16.7	42.4	18.0	45.7
22. Anterior arm reach[d]	22.0	55.9	(Not available)		33.0	83.8
23. Buttock-knee[a]	20.4	51.9	22.4	56.9	24.6	62.5
24. Thigh clearance[a]	4.1	10.4	5.4	13.7	6.9	17.5
25. Buttock-popliteal[a]	17.0	43.2	18.9	48.0	21.0	53.3
26. Popliteal height[a]	14.0	35.6	15.7	39.9	17.5	44.5
27. Shoulder breadth[b]	14.1	35.8	16.0	40.6	18.0	45.8
28. Elbow-to-elbow[a]	12.3	31.2	15.1	38.4	19.3	49.0
29. Hip breadth[a]	12.3	31.3	14.3	36.3	17.1	43.4
30. Hand length[b]	6.4	16.1	7.1	17.9	7.9	20.0
31. Palm length[b]	3.5	8.8	3.9	9.9	4.3	10.8
32. Hand breadth[b]	2.7	6.9	3.0	7.6	3.4	8.6
33. Foot length[b]	8.7	22.2	9.4	24.0	10.2	26.0
34. Foot breadth[b]	3.2	8.0	3.52	8.9	3.9	10.0
35. Interpupilary[c]	1.9	4.9	2.4	6.1	2.9	7.4
36. Coronal arc[c]	12.5	31.7	13.3	33.9	14.3	36.3
37. Bitragion breadth[c]	4.8	12.1	5.1	12.9	5.4	13.7
38. Tragion-top of head[c]	4.6	11.6	5.0	12.7	5.5	14.1
39. Tragion to wall[c]	3.5	8.9	4.0	10.1	4.6	11.8
40. Eye to wall[c]	5.9	15.0	6.4	16.3	7.1	18.1
41. Weight[a]	104 lb	47.2 kg	137 lb	62.2 kg	199 lb	90.3 kg

[a]Ref. 5, subjects partially clothed, no shoes, civilians.
[b]Ref. 2, subjects nude, military population.
[c]Ref. 1, subjects nude, military population.
[d]Ref. 7, subjects nude, military population.

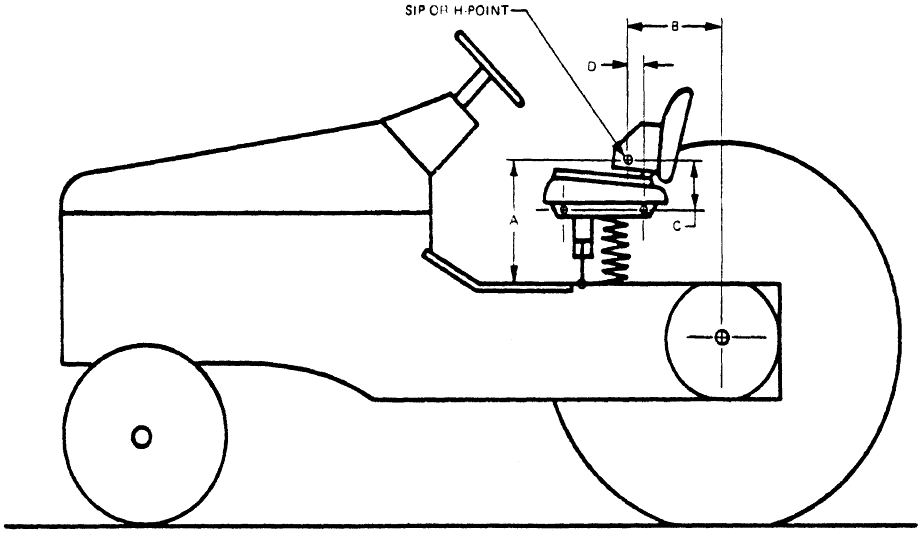


FIG. 2—SEAT DIMENSIONS

Device is used with seat adjustment positions other than the centered position specified in Section 4.2, the resulting dimensions shall not be defined as H-Point or SIP.

6.3 It shall be permissible for the seat manufacturer to designate the position of the H-Point or SIP relative to the cushion or frame of the suspended portion of the seat to aid in establishing seat location during the design phase of the machine (see dimensions C and D, Fig. 2).

7. *References*

7.1 SAE J826b—Devices for Use in Defining and Measuring Vehicle Seating Accommodation.

7.2 ISO/DP 5353—Determination of Seat Index Point for Work Vehicles.

7.3 ISO 3462 Agricultural Tractors and Machinery—Seat Reference Point.

7.4 SAE Information Report—Evaluation of Seat Index Point Checking Device for Tractor (D.C. Hammond) 15 April 1976.

7.5 ISO/TC 127/SC2 (Italy-22)—Correlation Between the Seat Index Point and the H-Point—October 1975.

7.6 BSI Document 75/13289—Seat Index Point—18 December 1975.

OPERATOR'S SEAT DIMENSIONS—CONSTRUCTION AND INDUSTRIAL EQUIPMENT DESIGN—SAE J899

SAE Recommended Practice

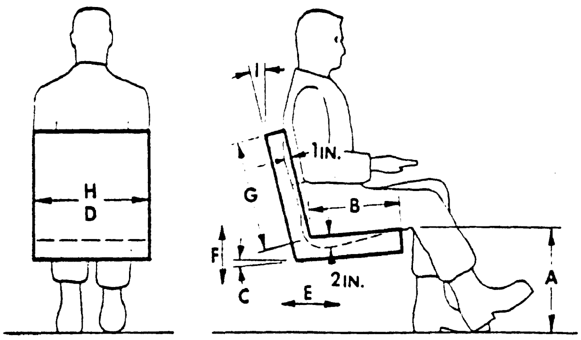
Report of Construction and Industrial Machinery Technical Committee approved August 1964.

The purpose of this report is to provide recommended dimensions and ranges of adjustment for the design of operator's seat for construction and industrial equipment.

The dimensions shown are consistent with the body dimensions shown in SAE J833.

NOTES:

1. When armrests do not interfere with necessary body movements they may be provided to increase operator comfort. Armrest height should be 7-9 in. above the seat cushion surface.
2. Dimensions shown will accommodate 90% of operators.
3. Dimensions cannot be completely specified without reference to specific controls and operator requirements.
4. On shovel-cranes and on rubber-tired machines, it is often desirable to have lesser seat back and cushion angles, and also to have seat height somewhat in excess of $16\frac{1}{2}$ in.
5. Bucket type seats are recommended on rubber-tired machines, such as scraper units, for operator side stability.



A — SEAT CUSHION HEIGHT: 16.5 in. at front edge of cushion nominal.
B — SEAT CUSHION LENGTH: 16 in. An adjustment to 18 in. is desirable.
C — SEAT CUSHION ANGLE: 5 deg at base. ' 5 deg adjustment is desirable. Angle of base may be less if compensated for by increased rake of seat cushion surface.
D — SEAT CUSHION WIDTH: 20 in. for normal support. Minimum 16.5 in.
E — HORIZONTAL ADJUSTMENT: 4 in. minimum. 6 in. desirable.
F — VERTICAL ADJUSTMENT: An adjustment of 3 in. is desirable.
G — SEAT BACK HEIGHT: 18 in. May be increased to 22 in. 15 in. max to permit free swing of shoulders and arms over top of back.
H — SEAT BACK WIDTH: 20 in. for normal support. 10 in max if elbows must swing rearward of back.
I — SEAT BACK ANGLE: 10 deg from vertical. ±5 deg adjustment is desirable.

FIG. 1—SEAT DIMENSIONS

CONTROL LOCATIONS FOR CONSTRUCTION AND INDUSTRIAL EQUIPMENT DESIGN—SAE J898a SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved June 1974.

1. Purpose—This report is to define the most desirable placement of hand- and foot-operated controls for construction and industrial equipment such that they are convenient for the 5th through the 95th percentile seated operator.

2. Discussion

2.1 The dimensions in Figs. 1-4 are consistent with the United States male body dimensions shown in SAE J833 and seat configuration shown in SAE J899. Both high and low H-point (SAE J826) locations are shown to cover requirements for the various types of vehicles involved.

2.2 Additional constraints peculiar to the particular vehicle (such as windshield size, posts, requirements for external viewing, etc.) must be considered in selecting the H-point location. (Note: The leg, in some maximum and optimum foot area positions, intrudes into the hand control areas.)

2.3 The seat reference point (SRP) used in SAE J898 (1964 revision) is no longer to be used. To provide an *approximate* means of correlation between the SRP and H-point, the SRP is located approximately 4.0 in. (102 mm) to the rear and 2.2 in. (56 mm) lower than the H-point.

3. Definitions

3.1 **H-Point**—The pivot centers of the torso and thigh.

3.2 **Optimum Hand and Foot Control Space**—The space where the controls can be reached most quickly and accurately, and with the greatest application of force. This space is considered the most desirable.

3.3 **Maximum Hand and Foot Control Space**—An acceptable space reserved for less frequently operated controls which are not needed quickly in emergency situations.

3.4 **SAE J898-1964 Seat Reference Point (SRP)**—The point where the middle lines of the seat and backrest intersect (undeflected cushion).

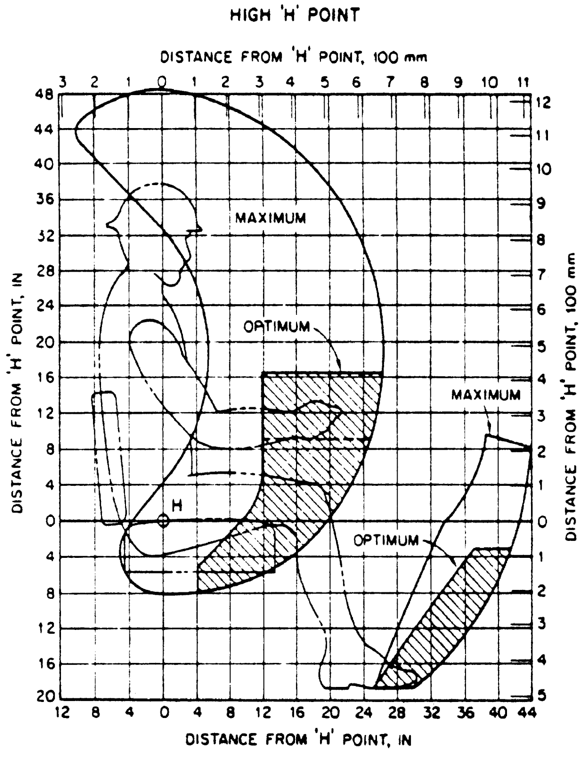
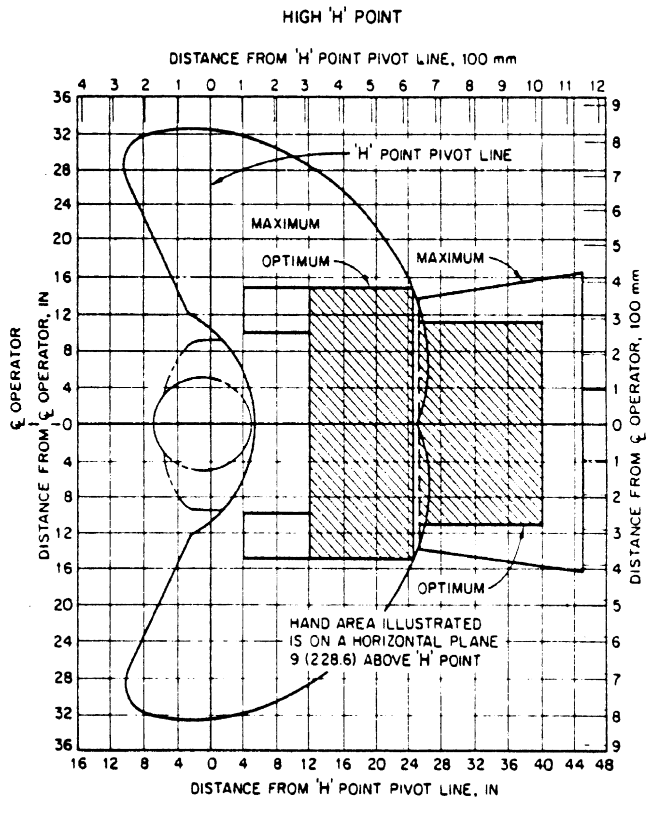


FIG. 1—OPTIMUM AND MAXIMUM HAND AND FOOT CONTROL SPACE WITH HIGH H-POINT LOCATION. SHOWN WITH LARGE 95th PERCENTILE U.S. MALE AND WITH SEAT AT REAR POSITION OF FORE-AND-AFT ADJUSTMENT. (PROVISION OF 4 IN (102 MM) HORIZONTAL SEAT ADJUSTMENT WILL PERMIT 90% OF OPERATOR POPULATION TO REACH CONTROLS IN OPTIMUM AREAS. NO ALLOWANCE FOR OPERATOR SLUMP.)



NOTE: DIMENSIONS ARE IN (mm)

FIG. 2—OPTIMUM AND MAXIMUM HAND AND FOOT CONTROL SPACE WITH HIGH H-POINT LOCATION. SHOWN WITH LARGE 95th PERCENTILE U.S. MALE AND WITH SEAT AT REAR POSITION OF FORE-AND-AFT ADJUSTMENT

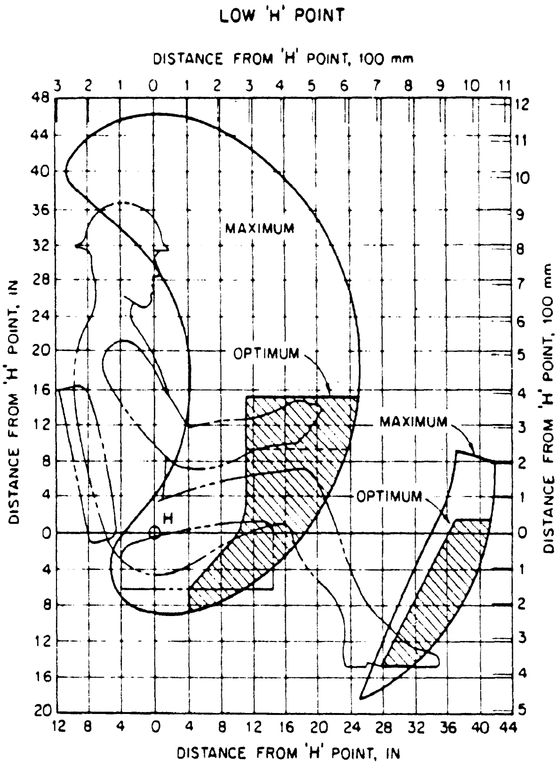


FIG. 3—OPTIMUM AND MAXIMUM HAND AND FOOT CONTROL SPACE WITH LOW H-POINT LOCATION. SHOWN WITH LARGE 95th PERCENTILE U.S. MALE AND WITH SEAT AT REAR POSITION OF FORE-AND-AFT ADJUSTMENT. (PROVISION OF 4 IN (102 MM) HORIZONTAL SEAT ADJUSTMENT WILL PERMIT 90% OF OPERATOR POPULATION TO REACH CONTROLS IN OPTIMUM AREAS. 1 IN (25 MM) OF OPERATOR SLUMP ALLOWED FOR)

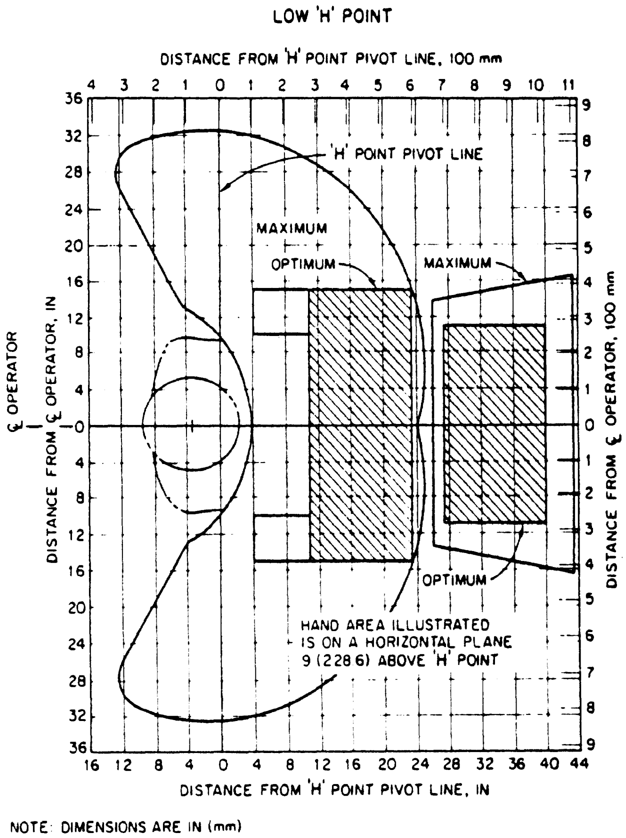


FIG. 4—OPTIMUM AND MAXIMUM HAND AND FOOT CONTROL SPACE WITH LOW H-POINT LOCATION. SHOWN WITH LARGE 95th PERCENTILE U.S. MALE AND WITH SEAT AT REAR POSITION OF FORE-AND-AFT ADJUSTMENT

OPERATOR ENCLOSURES (CABS)—HUMAN FACTOR DESIGN CONSIDERATIONS—SAE J154

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved February 1970. Editorial change June 1973.

Scope and Purpose—This SAE Recommended Practice is intended to be used as a guide for determining the *minimum* normal operating "space envelope" around the operator in operator enclosures (cabs) of the type generally applicable to mobile construction and industrial equipment.

It is recognized that particular types of equipment may necessitate use of a "space envelope" smaller than the minimum indicated by this recommended practice. When this is necessary, the designer should recognize, however, that a smaller "space envelope" may adversely affect performance.

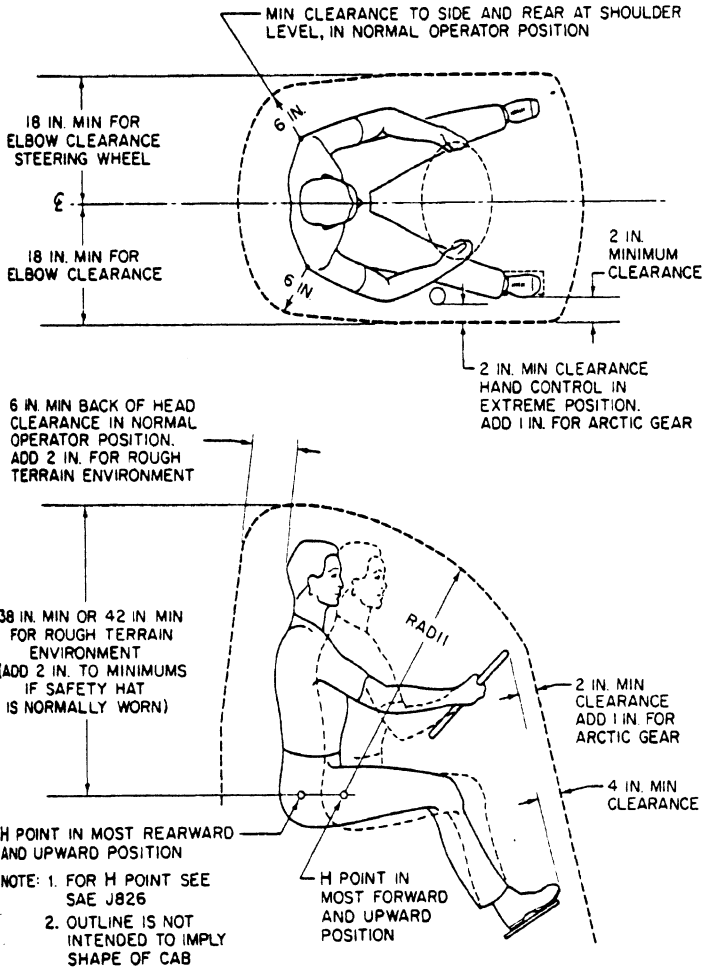


FIG. 1—SEATED OPERATOR (95TH PERCENTILE U.S. MALE, SEE SAE J833)

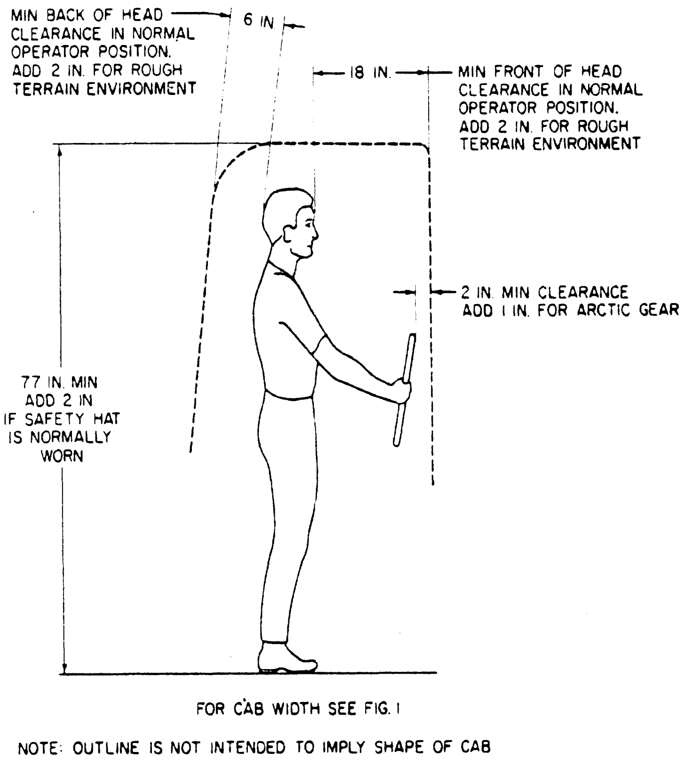


FIG. 2—STANDING OPERATOR (95TH PERCENTILE U.S. MALE, SEE SAE J833)

INSTRUMENT FACE DESIGN AND LOCATION FOR CONSTRUCTION AND INDUSTRIAL EQUIPMENT—SAE J209

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved March 1971.

1. Scope

1.1 The instrument design criteria and grouping described are recommended to manufacturers of construction and industrial equipment for all new designs.

1.2 Adherence to these recommendations will promote improved performance and ease of vehicle operation, protect vehicle and operator, and simplify instrument design and production.

2. Instrument Face Design—To promote ease of vehicle operation, gages must be quickly readable and understandable. To accomplish this, the following face design criteria should be adhered to:

2.1 Dial size should be large enough for the viewing distance. At the optimum 28 in. viewing distance, a $1^3/_4$ in. diameter dial such as shown in Fig. 1 is satisfactory; with this size dial, major scale graduations should be 0.030 in. wide and 0.22 in. long, intermediate graduations should be 0.025 in. wide and 0.16 in. long. For shorter or longer viewing distances, consult standard texts to determine gage size required.

2.2 Colored zone type dials are preferred, except where numerical information is required by the operator.

2.2.1 Color choice of background, labels, graduations, and pointer should promote reading ease provided by high contrast; for example, black on white or white on black.

2.2.2 It is preferred that operating zone colors be limited to green for the normal zone and red for the danger or stop zone.

2.2.3 Green zones may be labeled NORMAL and red zones may be labeled DANGER or STOP, preferably within the colored zone.

2.3 Where a numerical scale is needed, use the simplest scale that will give sufficient information.

2.3.1 Scale divisions should be limited in number to the accuracy desired and should not exceed the error of the instrument system.

2.3.2 Scale graduation intervals should be 1, 2, or 5, and decimal multiples thereof.

2.3.3 Numbers should be placed over the scale marks or colored zones. Numbers should be oriented to read in a horizontal or in an arcuate arrangement.

2.3.4 The dial scale should increase from low to high readings in a clockwise direction.

2.3.5 The arc or length of the scale should be approximately the same for all grouped instruments. The normal operating zone should be approximately in the same angular position, generally vertical, so that the pointers are all in a similar position to permit rapid checking.

2.4 All instruments should be labeled to identify their function.

2.4.1 Labeling is preferred on the face of the dial, so that it is not obscured by repainting the vehicle or panel damage.

2.4.2 The label should convey exactly what is being measured, such as BRAKE AIR PRESSURE, ENGINE WATER TEMPERATURE, etc., or equivalent international symbols.

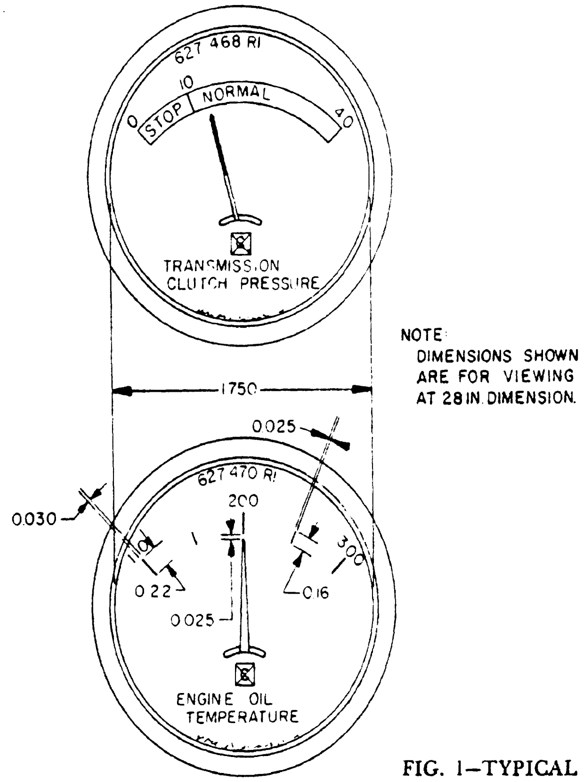


FIG. 1—TYPICAL GAGES

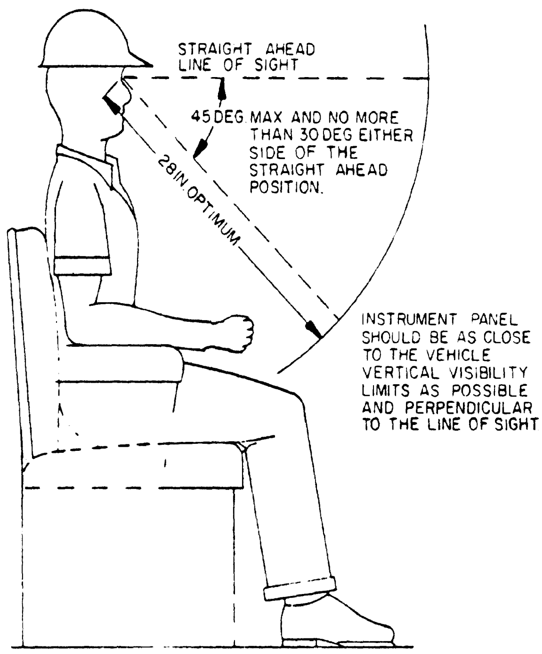


FIG. 3—PREFERRED INSTRUMENT PANEL LOCATION

2.4.3 The label should be located so as not to be obscured at any pointer position.

2.4.4 The manufacturer's monogram and part number should not be so placed or so large as to detract from the reading or appearance of the instrument.

2.4.5 A simple letter and number style should be used; the letters should be large enough for easy viewing without obscuring or detracting from other markings on the instrument face.

2.5 The pointer should be a simple symmetrical shape.

2.5.1 The pointer end should be approximately the width of the smallest graduation mark.

2.5.2 The pointer should terminate just short of the dial graduations.

2.5.3 The pointer should be mounted close to the reading surface to eliminate parallax at acute viewing angles.

2.6 Instruments should be properly illuminated for night time operation.

3. Instrument Grouping—Grouped gages should be consistent in size, color scheme, pointer design, and label style and size. Gages required and their location are to be determined by the manufacturer.

3.1 Instrument arrangement should consist of subgroups monitoring from left to right: engine, operational, and power train performance. See Fig. 2.

3.1.1 The engine subgroup should have ENGINE WATER TEMPERATURE and ENGINE OIL PRESSURE in that order.

3.1.2 The operational subgroup should have SPEEDOMETER and/or TACHOMETER, etc.

3.1.3 The power train gage cluster should have TRANSMISSION or CONVERTER OIL TEMPERATURE and TRANSMISSION or CONVERTER OIL PRESSURE in that order.

3.1.4 Additional instruments required should be located side by side, with the more important gage to the left, in successive rows if necessary, in the subgroup indicated. Instrument dials are more effective when separated more horizontally than vertically.

3.2 The location of secondary instruments and dash-mounted controls, such as fuel level gage, light switches, etc., is optional with the manufacturer but they should not be so placed as to disturb the primary indicator arrangement.

4. Instrument Panel Location

4.1 The distance from the operator's eye to the instruments usually mounted in an instrument panel should be consistent with quick readability without detracting from the operator's visibility or handling of the vehicle.

4.1.1 Optimum instrument panel location is 28 in. from the operator's eyes, as close to the line of sight as possible, and consistent with SAE reach recommendations. See Fig. 3.

4.1.2 Instruments should be placed so that they are least obstructed by controls such as the steering wheel, etc.

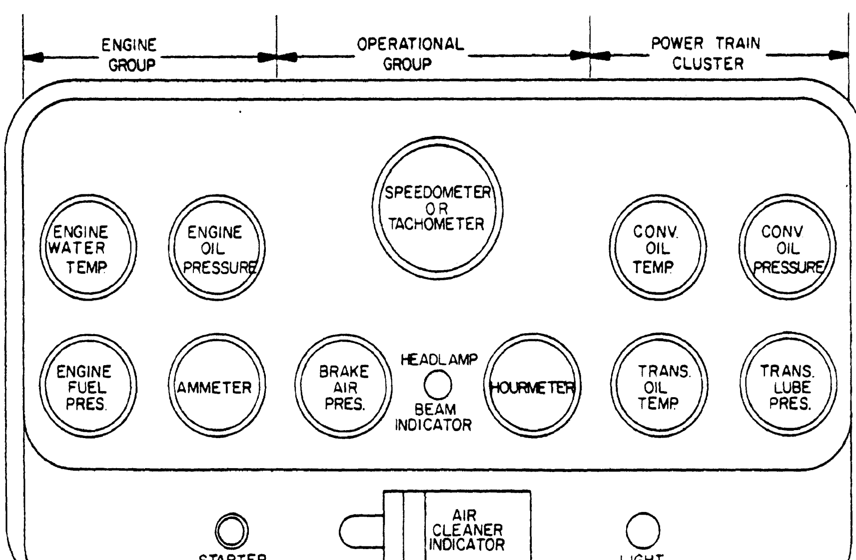


FIG. 2—INSTRUMENT PANEL GROUPING

4.2 Instruments should not be placed more than 45 deg below the horizontal line of sight.

4.3 Instruments should not be placed more than 30 deg either side of a straight-ahead position.

4.4 The instrument panel face, or isolated individual instruments, should be positioned so that they are perpendicular to the line of sight.

4.5 It may be necessary to compromise the above parameters for vehicles which are bi-directional or in which the operator has the option of sitting or standing while operating.

4.6 The instrument panel or other mounting surface should have a finish to minimize reflections.

5. *General Recommendations*—Visual or auditory warning devices, in addition to visual gages, are recommended for all conditions critical to equipment operation.

5.1 A means should be provided to verify that warning devices are functioning.

5.2 These warning lights or sounding devices should have their own source for actuation, rather than being dependent on another instrument.

5.3 Warning lights should be bright enough to stand out during all operating conditions and should preferably be located above and readily identified with the related gage.

5.4 Audible signals should be distinguishable from the operating noises of the vehicle.

UNIVERSAL SYMBOLS FOR OPERATOR CONTROLS ON INDUSTRIAL EQUIPMENT—SAE J298 SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved May 1973.

1. *Purpose and Scope*—These symbols provide a symbolic language for operator controls on industrial equipment.

2. *Definition*—Industrial equipment is defined as that class of tractors, either wheeled or track type, and associated equipment used in operations such as landscaping, construction services, loading, digging, grounds keeping, and highway maintenance.

3. *General*

3.1 Color combinations and sizes of all symbols should be adjusted to each particular application. It is desirable to use the universal language of color to indicate the urgency of action, such as red, amber, green.

3.2 Word captions and numbers as illustrated are for reference only and are not part of the recommendation. However, suitable descriptive words may be used to initially define the application of symbols. Twentieth Century Bold numerals should be used for clear readability.

3.3 For applications, where appropriate symbols are not shown, the principles illustrated herein should be used for guidance in developing symbols for the specific need.

4. *Universal Symbols for Operator Controls*—See Fig. 1.

5. *Use of Color with Universal Symbols*—Typical illustrations are shown in Fig. 2.

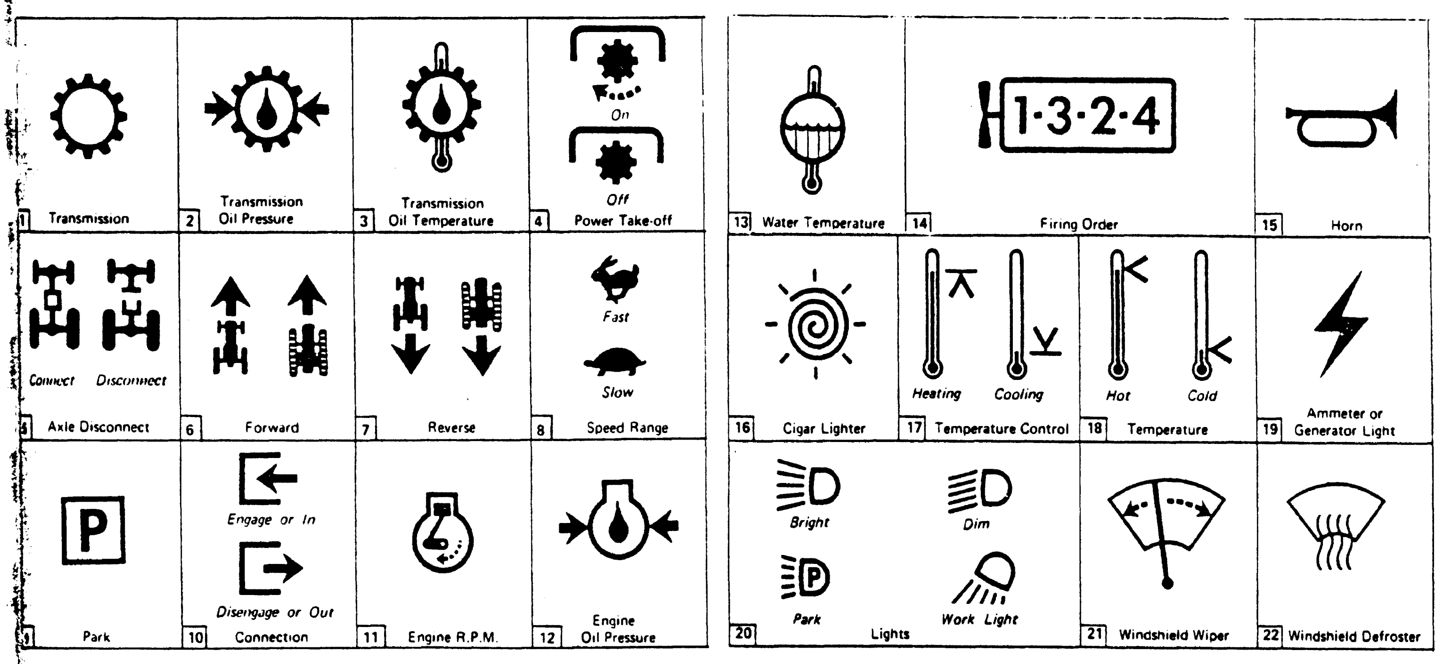


FIG. 1—UNIVERSAL SYMBOLS FOR OPERATOR CONTROLS

(continued on next page)

provided that external calibration is accomplished immediately before or after field use.

5.3 Vehicles used for tests must not be operated in a manner such that the break-in procedure specified by the manufacturer is violated.

6. *References*—Suggested reference material is as follows:

ANSI S1.1-1960, Acoustical Terminology

ANSI S1.2-1967, Physical Measurement of Sound

ANSI S1.4-1971, Specification for Sound Level Meters

Applications for copies of these documents should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.

APPENDIX

The SAE recommends that a maximum A-weighted sound level of 88 dB when measured in accordance with the test procedure described above be used as a reference in the design and development of heavy trucks and buses.

An additional 2 dB allowance over the sound level limit is recommended to provide for variations in test site, temperature gradients, test equipment, and inherent differences in nominally identical vehicles.

Attachment 7 (from 1978 SAE Transactions)

SOUND LEVEL FOR TRUCK CAB INTERIOR—SAE J336a

SAE Recommended Practice

Report of Vehicle Sound Level Committee approved June 1968 and last revised July 1973.

1. Introduction—This SAE Recommended Practice describes the equipment and procedure for determining the maximum truck cab interior sound level. This practice applies to motor trucks and truck-tractors and does not include construction and industrial machinery. The appendix contains SAE recommended design criteria for new vehicles.

2. Instrumentation—The following instrumentation shall be used, where applicable, for the measurement required:

2.1 A sound level meter which meets the Type 1 requirements of ANSI S1.4-1971, Specification for Sound Level Meters.

2.2 A set of octave bandpass filters which meet the Class II requirements of ANSI S1.11-1966, Specification for Octave, Half-Octave and Third-Octave Band Filter Sets.

2.2.1 As an alternative to making direct measurements with a sound level meter and octave band filter set, a microphone or sound level meter may be used with a magnetic tape recorder and/or a graphic level recorder or indicating meter, provided that the system used meets the requirements of SAE J184.

2.3 A sound level calibrator (see paragraph 4.2.3).

2.4 An engine-speed tachometer.

3. Test Procedure—The following procedure is to be used for the purpose of this SAE Recommended Practice.

3.1 Establish a seat reference point at the intersection of the tangent lines to the predominant surfaces of the undeflected cushion and backrest at the lateral center of the seat (or intended operator location). Adjust the seat to the midpoint of its horizontal and vertical travel. Locate the microphone, oriented vertically upward, at a point 29 in. (740 mm) vertically above the seat reference point and 10 in. (250 mm) laterally to the right (to the left for right-hand drive vehicles) of the seat reference point.

Position the driver so that his ear is reasonably aligned with, and approximately 6 in. (150 mm) laterally from, the microphone. Seat adjustment may be made to meet this provision.

3.2 Sound level tests may be conducted with or without a trailer or body on the vehicle.

3.3 On vehicles equipped with radiator shutters, the shutter position causing the maximum sound level should be determined and the tests conducted with the shutters in such position.

3.4 Vehicle windows and vents are to be in the fully closed position with all accessories "off."

3.5 The tests are to be conducted on smooth, dry concrete or asphalt road surfaces. No large sound reflecting surfaces should be within 50 ft (15 m) of the test vehicle. Wind speed should not exceed 15 mph (24 km/h).

3.6 Select a transmission and/or axle gear ratio so that approximately 50 mph (80 km/h) is obtained at rated engine speed.

3.7 Obtain the maximum band pressure level reading in each octave band during acceleration in the selected gear ratio of paragraph 3.6 at wide-open throttle from a beginning engine speed of one-half rated engine speed up to rated engine speed. The meter shall be set for "fast" response for these measurements and a minimum of four test runs shall be made.

3.7.1 If a magnetic tape recording system is used, make recordings during at least four test runs. Obtain a band pressure level measurement for each octave band for each test recording. Set the level indicating device for "fast" response or equivalent for these measurements.

3.8 The applicable reading for each band shall be the highest band pressure level observed. The band pressure levels reported shall be the average of the two highest readings within 2 dB of each other. The observer is cautioned to rerun the test if unrelated peaks should occur due to extraneous ambient noises.

4. General Comments

4.1 It is strongly recommended that technically qualified personnel select the equipment and that tests are conducted only by qualified persons trained in the current techniques of sound measurement.

4.2 Proper use of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer should be referred to for both recommended operation of the instrument and precautions to be observed. Specific items to be considered are:

4.2.1 The effects of ambient weather conditions on the performance of all instruments (that is, temperature, humidity, and barometric pressure).

4.2.2 Proper signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems.

4.2.3 Proper acoustical calibration procedure, to include the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Internal calibration means is acceptable for field use, provided that external calibration is accomplished immediately before or after field use.

If a magnetic tape recorder is used, record a calibration signal of known acoustic level immediately prior to, or following, each sequence of test recordings.

4.2.4 For analysis of the recordings, use the calibration signal to establish playback gain and thus calibrate the analysis system.

4.3 Vehicles used for tests must not be operated in a manner such that the break-in procedure specified by the manufacturer is violated.

5. References—Suggested reference material is as follows:

5.1 ANSI S1.1-1960, Acoustical Terminology

5.2 ANSI S1.2-1962, Physical Measurement of Sound

5.3 ANSI S1.11-1966, Octave, Half-Octave, and Third-Octave Band Filter Sets

5.4 ANSI S1.4-1971, Specification for Sound Level Meters

5.5 SAE J184, Qualifying a Sound Data Acquisition System

Applications for copies of these documents should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018; or, the Society of Automotive Engineers Inc., 400 Commonwealth Drive, Warrendale, Penna. 15096.

APPENDIX
DESIGN CRITERIA

The SAE recommends that the octave band pressure levels listed below considered during the development of new vehicles:

Octave Band Center Frequency, Hz	Band Pressure Level, dB	Octave Band Center Frequency, Hz	Band Pressure Level, dB
63	101.5	1000	79.5
125	96.0	2000	74.0
250	90.5	4000	70.0
500	85.0	8000	70.0

Trucks meet the design criteria if the sum of reported band pressure lev does not exceed the sum of the criteria band pressure levels, provided that reported band pressure level exceeds the corresponding criteria band level more than 3 dB. (See paragraph 3.8.)

MEASUREMENT OF EXTERIOR SOUND LEVELS FOR HEAVY TRUCKS UNDER STATIONARY CONDITIONS—SAE J1096

SAE Recommended Practice

Report of Vehicle Sound-Level Committee approved March 1976. Rationale statement available.

1. Introduction—This SAE Recommended Practice establishes the test procedure, environment, and instrumentation for determining the maximum exterior sound level of heavy trucks with governed engines under stationary vehicle conditions. The basic procedure involves a full throttle engine acceleration and a closed throttle deceleration with the engine inertia as the load.

2. Instrumentation—The following instrumentation shall be used, where applicable, for the measurement required.

2.1 A sound level meter which satisfies the Type 1 requirements of American National Standard Specification for Sound Level Meters, S1.4-1971.

2.2 As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape recorder and/or a graphic level recorder or other indicating instrument, providing the system meets the requirements of SAE Recommended Practice J184, Qualifying a Sound Data Acquisition System.

2.3 A sound level calibrator, accurate to ±0.5 decibel (dB) (see paragraph 5.3.3).

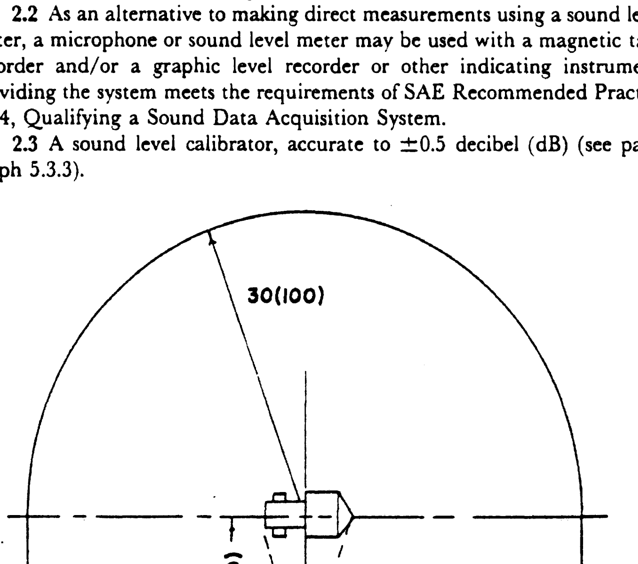


FIG. 1—TEST SITE CONFIGURATION

2.4 A windscreen may be used. The windscreen shall not affect microphone response more than ±1 dB for frequencies of 20–4000 Hz $\pm 1\frac{1}{2}$ dB for frequencies of 4000–10,000 Hz (see paragraph 5.1).

2.5 An engine—Speed tachometer.

3. Test Site—The following test site requirements shall be considered n essary to perform effective measurements for this stationary procedure.

3.1 A suitable test site shall consist of a flat open space free of la reflecting surfaces, such as parked vehicles, signboards, buildings, or hillsid located within 30 m (100 ft) of either the vehicle or the microphone. Fig. 1.

3.2 The measurement area (defined as shown in Fig. 1) shall be surfac with concrete, asphalt, or similar hard non-porous material, and shall be f of snow, grass, soil, ashes, or other sound-absorbing materials.

3.3 The microphone shall be located 15 m (50 ft) from the centerline the vehicle and 1.2 m (4 ft) above the ground plane as shown in Fig. 1. T microphone shall be located on a line perpendicular to the vehicle centerl and in line with the rear of the cab.

3.4 Because bystanders have an appreciable influence on meter respo when they are in the vicinity of the vehicle or microphone, not more than person, other than the observer reading the meter, shall be within 15 m (50 of the vehicle or instrument, and that person shall be directly behind observer reading the meter, on a line through the microphone and the server.

3.5 The ambient sound level (including wind effects) coming fr sources other than the vehicle being measured shall be at least 10 dB lo than the level of the tested vehicle.

4. Procedure

4.1 The vehicle shall be tested in a stationary position with maxim engine acceleration and deceleration with no external load applied.

4.1.1 The engine governor and throttle delay (if one is installed) shall be to the manufacturer's specifications.

4.1.2 The vehicle engine coolant temperature shall be raised to the norn operating range.

4.1.3 The vehicle shall be positioned at the test site as shown in Fig. 1, w the main transmission in neutral and the clutch engaged.

4.1.4 The engine shall be accelerated, by rapidly establishing full throt from a low idle condition to the maximum governed speed. After the eng speed has been stabilized (3–5 s), the engine shall be decelerated at clo throttle to low idle speed.

4.2 Measurements

4.2.1 The sound level meter shall be set for fast response and A-weight network. Equivalent settings shall be used with other instruments.

4.2.2 The meter shall be observed during the entire engine accelerati deceleration cycle. The applicable reading shall be the highest sound le obtained during this cycle. Unrelated peaks due to extraneous ambient no should be ignored.

4.2.3 The sound level for each side of the vehicle shall be the average of first two highest readings which are within 1 dB of each other. Report sound level for the side of the vehicle with the highest average value.

6.3.3 Maximum width of the beam shown in Fig. 3 shall be 16 in. (406 mm).

7. Performance Requirements

7.1 General Requirements

7.1.1 Performance requirements specified in paragraphs 6.1.1, 6.1.2, and 6.1.3 of SAE J168 shall apply.

7.1.2 Additional performance requirements as specified in paragraphs 7.2 and 7.3 of this standard shall apply when applicable.

7.2 Drop Test Performance Requirements

7.2.1 Instantaneous deflection due to impact of the sphere shall not enter the protected zone as illustrated in Figs. 2, 4, and 5.

7.2.2 Minimum allowable dimensions are listed in paragraph 6.1.1 of SAE J168.

7.3 Crush Test Performance Requirements—The protected zone as described in Figs. 4 and 5 shall not be encroached. (For dimensions, see paragraph 6.1.1 of SAE J168.

MEASUREMENT OF WHOLE BODY VIBRATION OF THE SEATED OPERATOR OF AGRICULTURAL EQUIPMENT—SAE J1013

SAE Recommended Practice

Report of Tractor Technical Committee and Construction and Industrial Machinery Technical Committee approved August 1973.

1. Scope—This recommendation defines a method for the measurement of the whole body vibration to which the seated operator of an agricultural tractor or other field machine is exposed while performing an actual or simulated agricultural operation. It applies to those cases in which the vibration is transmitted to the operator through the vehicle seat.

2. Field of Application—In the main body of this recommendation, conditions for measuring and recording whole body vibration of the seated operators of agricultural tractors and field machines are defined. The specification of instruments and frequency analysis or weighting and description of site and operating conditions allows the measurements to be made and reported with an acceptable precision. The procedure includes means of weighting the vibration level at different frequencies as specified in ISO/DIS 2631 (Ref. 1).

This procedure is a measuring method only and is not intended for the evaluation or selection of seating systems.

3. Definitions

3.1 Letter Symbols

a = instantaneous acceleration.

b_f = rms value of $\frac{1}{3}$ octave acceleration having center frequency f.

b_w = frequency weighted acceleration signal.

B_w = weighted rms acceleration calculated from $\frac{1}{3}$ octave components.

f = frequency.

I = mean square weighted acceleration multiplied by averaging period duration.

rms = root mean square.

T = test period duration.

m/s^2 = acceleration units, metres per second squared.

Hz = Hertz, standard notation for frequency, cycles per second.

W_f = frequency dependent, dimensionless weighting factor.

g = acceleration of gravity, by international agreement equal to 9.80665 m/s² at sea level.

3.2 **Whole Body Vibration**—As used in this recommendation, this term means vibrations transmitted to the body as a whole through the buttocks of a seated person.

3.3 **Vehicle Seat**—Specifically for the purposes of this document, that portion of the vehicle provided for the purpose of supporting the buttocks of the seated operator.

3.4 **Frequency Analysis**—Process of arriving at a quantitive description of the amplitude of a vibration as a function of frequency.

3.5 **"Ride Meter"**—A vibration analysis instrument of the general type described by Hilton (Ref. 2).

3.6 **Measuring Period**—The time duration in which vibration data for analysis is obtained.

3.7 **Average Ground Speed**—Ratio of the distance traveled during the test period to the time period.

3.8 Other terminology used in this recommendation is in accordance with ANSI S1.1 and ISO DR 2041 (Refs. 3, 4).

4. Vibration Measurement Axes—The vibration shall be measured along three mutually perpendicular axes, passing through a point on the interface between the operator and the vehicle seat. These axes are substantially vertical, longitudinal, and lateral (a_z, and a_x, a_y) with respect to the orientation of the seated operator and are defined in Fig. 1. The operator should sit in a typical upright position and should keep both hands in a normal position for operating the controls as suggested by Fig. 1. Armrests on seats so equipped should either be folded up or removed (where practical) to prevent the operator from leaning on them during the test. Such a posture would significantly influence the test results.

5. Instruments

5.1 **Vibration Pickups**—The vibration shall be sensed by acceleration transducers (accelerometers) attached near the center of a thin disc 200 ± 5 mm in diameter placed between the operator and the vehicle seat. The primary requirements for the disc are that it provide a suitable mounting for the accelerometers, not disturb operator comfort, and not significantly distort the buttock-cushion load distribution. Either a rigid or semirigid disc may be used; however, the semirigid type is recommended especially for rather soft or highly contoured cushions. Suggested disc designs are shown in Figs. 2 and 3. Either disc shall be placed on the seat so that the accelerometer assembly is midway between the ischial tuberosities. If a rather rough ride is expected, the disc should be taped or similarly attached to the cushion to maintain its location.

The transducers, together with their associated amplifiers, shall be sensitive to vibration levels of 0.5 m/s² and shall be capable of measuring vibrations of 5 m/s² rms with a crest factor as great as 3 without amplitude distortion of more than ±1% in the range 0.1–100 Hz. Acceleration sensitivity shall not vary in the range of 0–100 Hz by more than ±5%.

5.2 **Magnetic Tape Recorder**—The electrical signals generated by the transducers may be recorded for later analysis on magnetic tape. The magnetic tape recorder should have a replay accuracy of better than ±2% over the frequency range of 0–100 Hz, including any change in tape speed during replay for the purpose of analysis.

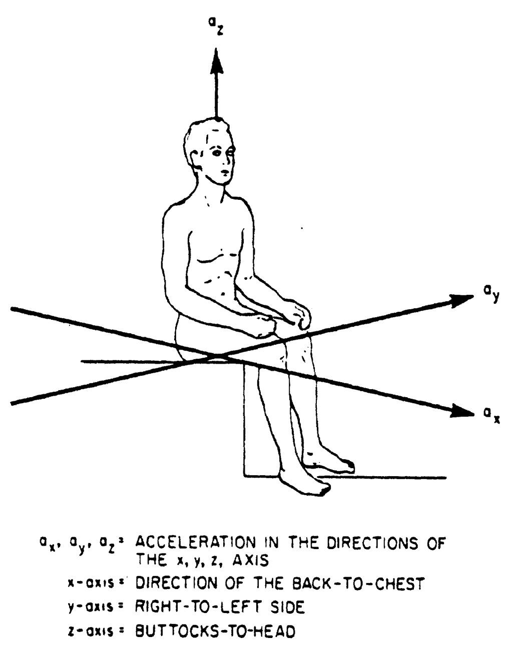


FIG. 1—MEASUREMENT AXES

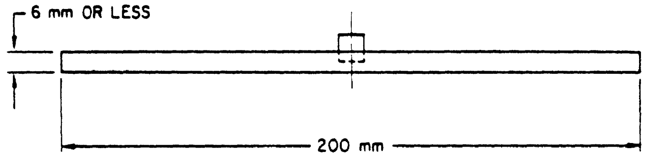


FIG. 2—SUGGESTED DESIGN FOR RIGID DISC WITH ACCELEROMETER ASSEMBLY BONDED AT CENTER

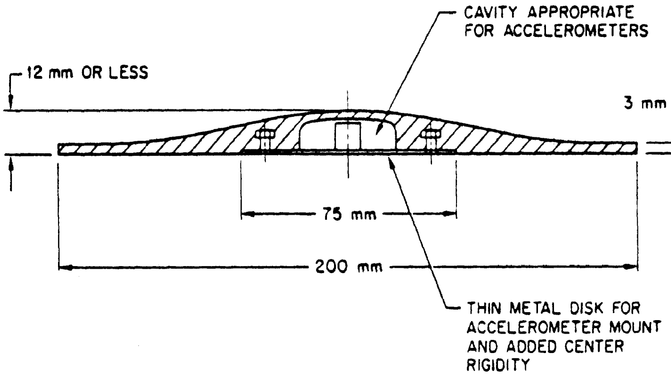


FIG. 3—SUGGESTED DESIGN FOR SEMI-RIGID DISC OF APPROXIMATELY 80-90 DUROMETER (A-SCALE) MOLDED RUBBER, PLASTIC, ETC.

5.3 **Frequency Weighting**—Frequency weighting may be achieved in either of two ways: by analysis of the acceleration into ⅓ octave band levels, weighting the levels in individual bands and recombination; or by direct use of electrical filters in a frequency weighting "ride meter."

5.3.1 FREQUENCY ANALYSIS METHOD—Each vibration tape recording shall be analyzed into ⅓ octave component accelerations over the frequency range 1.0–80 Hz. The ⅓ octave center frequencies shall be in compliance with IEC Publication 225 (Ref. 5) which must be extrapolated for the lower frequencies. The rms value of each component (b_f) shall be averaged over the duration specified for the measurement. The ⅓ octave values shall each be multiplied by the weighting factors (w_f) listed in Table 1, and a weighted acceleration (B_w) value calculated for each recording as the square root of the sum of the squares of the weighted ⅓ octave values.

$$B_w = \left[\sum_{f=1}^{80} W_f^2 b_f^2\right]^{1/2}$$

5.3.2 FREQUENCY WEIGHTING "RIDE METER"—The "ride meter," if employed for direct indication of the weighted vibration, shall consist of an electronic weighting network incorporated between the transducer and a time integration stage. The weighting network shall have an insertion loss according to the curve in Fig. 4 for vertical vibration, or Fig. 5 for horizontal vibration. The loss shall not deviate from the curve by more than ±1 dB at 6.3 and 31.5 Hz for vertical measurement or at 1.25 and 31.5 Hz for horizontal measurement, and ±2 dB at any other frequency. The integration stage shall be capable of indicating the integral of the square of weighted acceleration (b_w^2) for the time period of the test run (T). That is,

$$I = \int_{t=0}^{T} b_w^2 dt$$

5.3.3 CALIBRATION—The entire measurement and analysis system should be regularly calibrated by technically trained instrumentation personnel following manufacturer's recommendations for the adjustment and application of individual components.

Acceleration pickups should be calibrated in accordance with a suitable recognized calibration method such as outlined in ANSI S2.2-1959 (Ref. 6).

Where a tape recorder is employed as part of the data acquisition system, the tilting support method (ANSI S2.2-1959) for static calibration of acceleration pickups should be used to obtain overall system acceleration sensitivity for each of the three data channels. Tilting the sensitive axis of each pickup in the field of gravity provides a peak-to-peak change in output representing a $2g$ change in input acceleration. This signal should be recorded immediately before and after each run.

The output from each accelerometer amplifier should be nulled by proper

TABLE 1—VIBRATION WEIGHTING FACTORS

1/3 Octave Center Frequency, f	Weighting Factor, w^f		1/3 Octave Center Frequency, f	Weighting Factor, w^f	
	Vertical Vibration	Horizontal Vibration		Vertical Vibration	Horizontal Vibration
1.0	0.50	1.00	10.0	0.80	0.20
1.25	0.56	1.00	12.5	0.63	0.16
1.6	0.63	1.00	16.0	0.50	0.125
2.0	0.71	1.00	20.0	0.40	0.100
2.5	0.80	0.80	25.0	0.315	0.080
3.15	0.89	0.63	31.5	0.25	0.063
4.0	1.00	0.50	40.0	0.20	0.050
5.0	1.00	0.40	50.0	0.16	0.040
6.3	1.00	0.315	63.0	0.125	0.315
8.0	1.00	0.25	80.0	0.10	0.025

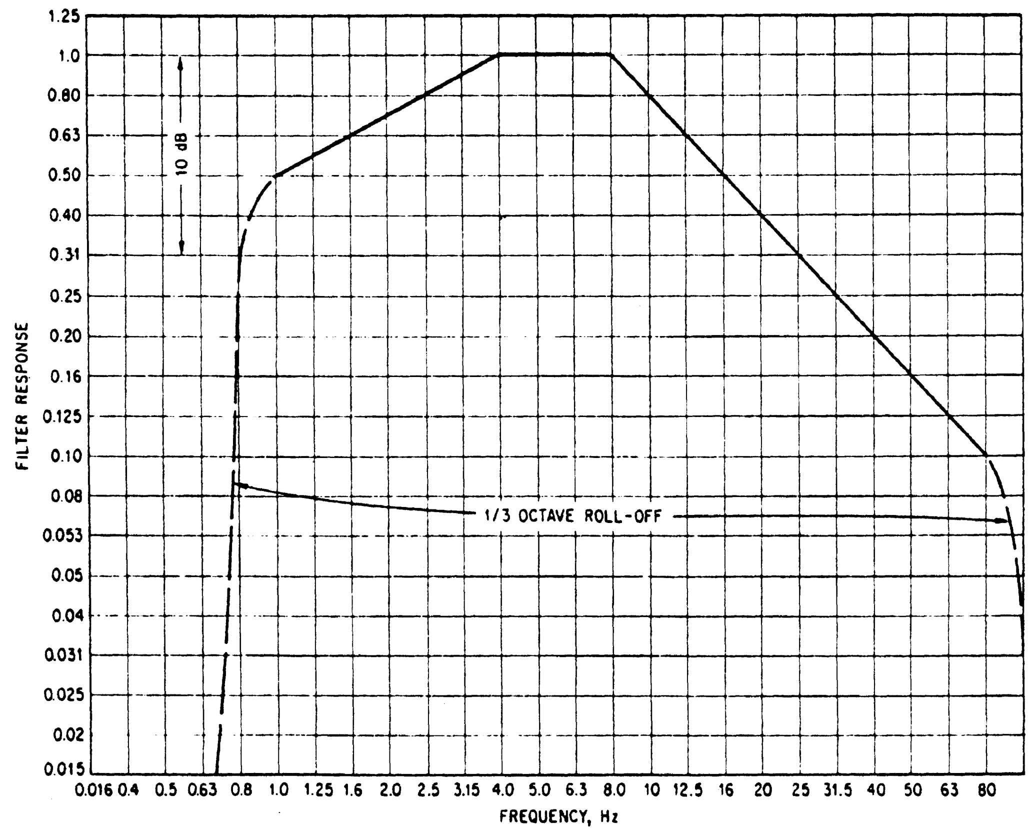


FIG. 4—FILTER RESPONSE IN VERTICAL MODE, a_z

balancing and zeroing techniques while the accelerometers are in test position between the seat and the operator.

6. Measurement Site and Operating Conditions—Measurements shall be made on actual or simulated work sites. Measurement sites and operating conditions shall be appropriate for the machine whose vibration characteristics are being measured.

Vehicle ground speed has significant influence on vibration intensity. Hence, due to the method of analysis recommended here, ground speed shall be kept relatively constant throughout each measuring period and average ground speed during the period shall be reported. If the vibration test is being conducted during a work cycle which involves several operating speeds, then a separate measuring period should be devoted to each such segment of the work cycle and the corresponding results shall be so reported along with a description of the work cycle involved.

In all cases, the measuring period shall be as long as is required to obtain vibration measurements representative of the machine and operating conditions.

The operating conditions shall be recorded in detail, including such things as general condition of the site (plowed, sodded, soil characteristics, etc.) and a complete description of attached and/or towed implements.

7. Machine Description—The following details shall be reported:

(a) Machinery manufacturer.
(b) Model designation.
(c) Serial number.
(d) Front and rear and total weights.
(e) Tire manufacturer, tire code designation per SAE J711, tire size, ply rating, inflation pressures, and approximate state of wear.
(f) Type and amount of ballasting.
(g) Tread and wheel base spacing.
(h) Description of seat and suspension, if any.

Also, any known deviations from the machinery manufacturer's specifications and recommendations should be reported. If the test is conducted during transport conditions, front and rear axle weights shall be reported with implements in the transport position.

8. Operator—Operator height and weight shall be reported. Seat shall be adjusted per manufacturer's instructions. For operator position requirements, refer to paragraph 4.

9. Reported Vibration Levels—The weighted vibration level in each of the three directions shall be reported separately, to the nearest 0.1 m/s².

If the ⅓ octave analysis method has been employed, the weighted and/or unweighted rms in each ⅓ octave band may be presented graphically.

10. General Comments

10.1 It is strongly recommended that technically trained personnel select the instrumentation and that the tests be conducted only by qualified persons trained in the current techniques of vibration measurement.

10.2 Proper usage of all test instrumentation is essential to obtain valid

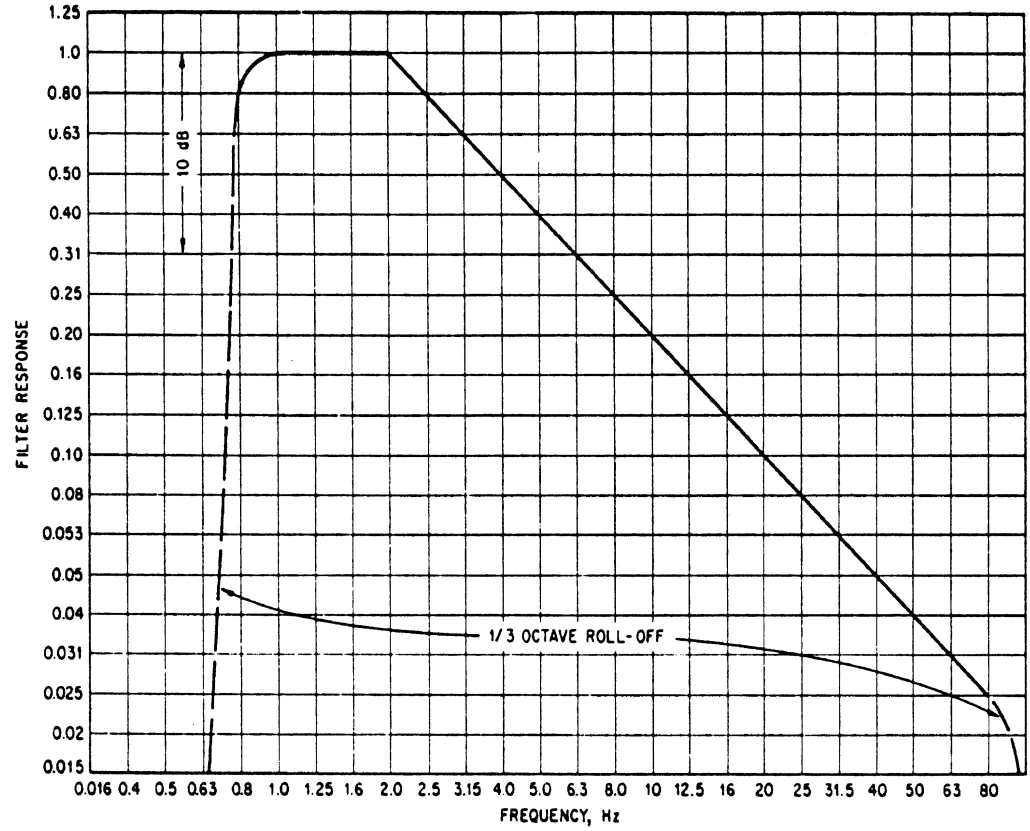


FIG. 5—FILTER RESPONSE FOR a_x and a_y

measurements. Operating manuals or other literature furnished by the instrument manufacturer should be reviewed for both recommended operation of the instrument and precautions to be observed. Specific terms to be considered are:

10.2.1 The type and specifications of accelerometer, its connecting cable, its directional response characteristics, and its orientation relative to the a_z, a_x, a_y axes as defined in Fig. 1.

10.2.2 The effects of ambient weather conditions on the performance of all instruments (for example, temperature and humidity). Instrumentation can be influenced by low temperature and great caution should be exercised.

10.2.3 Proper signal levels, terminating impedances, and cable length on multi-instrument measurement systems.

10.2.4 Proper acceleration calibration procedure, to include the influence of extension cables, etc. Field calibrations shall be made immediately before and after each test sequence.

10.3 It is recommended that field instrumentation be protected from adverse environmental effects such as dust, excessive shock and vibrations, etc.

11. References

1. ISO/DIS 2631, Guide for the Evaluation of Human Exposure to Whole Body Vibration.
2. D. J. Hilton, "A Frequency Weighted Ride Meter." *Jrl. Agricultural Engineering Research*, Vol. 15, (1970), No. 4, pp. 379-384.
3. ANSI S1.1-1960 (R-1971), Acoustical Terminology (Including Mechanical Shock and Vibration).
4. ISO DR 2041, Vibration and Shock-Terminology.
5. IEC. Publication 225, Octave, Half-Octave and Third Octave Band Filters Intended for the Analysis of Sounds and Vibrations, 1960.
6. ANSI S2.2-1959 (R-1971), Calibration of Shock and Vibration Pickups.
7. ANSI S1.11-1966 (R-1971), Octave, Half Octave, and Third Octave Band Filter Sets.
8. ANSI S2.4-1960 (R-1971), Specifying the Characteristics of Auxiliary Equipment for Shock and Vibration Measurement.
9. SAE HS J6a, Ride and Vibration Data Manual.

TECHNICAL PUBLICATIONS FOR AGRICULTURAL EQUIPMENT—SAE J1035

SAE Recommended Practice

Report of Tractor Technical Committee approved June 1973.

1. Purpose—The purpose of this recommendation is to establish guidelines for the preparation of publications dealing with predelivery setup, operation, lubrication, adjustment, maintenance, and repair of agricultural equipment.

2. Scope—These recommendations deal with the format for publications intended to be used by the persons responsible for the predelivery setup, operation, and servicing of agricultural equipment.

3. Definitions—The publications listed below can be published under one cover, separately, or any combination thereof. The grouping of publications may be dictated by the type of equipment involved.

3.1 **Predelivery Setup Publications**—Outlines, in detail, the procedures for properly preparing equipment for delivery to the customer.

3.2 **Operator's Manual**—Explains the procedures for the proper operation of the equipment.

3.3 **Lubrication Instructions**—Outlines all facets for lubrication of the equipment. (Recommend this be included in Operator's Manual.)

3.4 **Maintenance Instructions**—Explains the maintenance required and method of performing same on the equipment at the operator's level. (Recommend this be included in Operator's Manual.)

3.5 **Shop Manual**—Provides detailed procedures to repair or overhaul the equipment properly by a qualified individual.

3.6 **Parts Catalog**—Lists parts which are required to service product. (Recommend this be a separate publication.)

3.7 **Miscellaneous Instructions**—Publications required to supplement items 3.1 through 3.6.

4. Publication Specifications

4.1 **Size**—8½ in. wide x 11 in. high (215 x 280 mm) is the recommended size. Alternate sizes are acceptable if dictated by other considerations.

4.2 **Paper**—The paper shall have a reasonable durability when exposed to rain, dampness, or grease.

4.3 **Cover**—When required, the cover shall have a reasonable durability

DESIGN GUIDELINES FOR AIR CONDITIONING SYSTEMS FOR CONSTRUCTION AND INDUSTRIAL EQUIPMENT CABS—SAE J169

SAE Information Report

Report of Construction and Industrial Machinery Technical Committee approved July 1970. Editorial change January 1977.

*1. **Introduction***—Air conditioning construction equipment cabs is a relatively new art and much is yet to be learned. The experience gained from automotive air conditioning is very important, but it must be remembered that operating conditions for automobiles and construction equipment are vastly different. Most automobiles are similar in many areas, such as size of passenger space, engine and radiator location, glass area, and operating speeds. Furthermore, most automobiles are operating on similar roads and under similar ambient conditions. It is true that ambient temperatures may vary but one may now make a 4000 or 5000 mile trip to most any place in the United States and drive the entire distance on well paved, dust free roads. This is not true for construction equipment which must be designed to meet the most severe conditions of heat, dust, vibration, and general rough usage.

*2. **Scope***—The purpose of this document is to establish air conditioning design guidelines that will apply to most systems rather than the specific design of any particular system. Operating conditions and characteristics of the equipment will determine the design of any successful system, and since these characteristics and conditions vary greatly from one application to another, the designer must determine the goals he expects to reach under the conditions encountered. To determine the capacity of such items as blowers, condenser fans, condenser coils, evaporator coils, filters, compressors, etc., will require the adherence to several guide lines, some of which are outlined in the following paragraphs.

*3. **Size of Cab***—The size of the cab must be considered and the number of riders that may normally be in the cab.

*4. **Air Flow***—The position of the cooling vents and direction of air flow will affect the comfort of the operator and may be more important than the average temperature in the cab.

*5. **Glazing***—The amount and type of glazing in a cab becomes a very definite factor in the design of an air conditioning system. It is usually possible to insulate the cab walls, roof, floor, etc., but very little can be done in the glazing area unless thermopane glass is used and this is not too practical from the standpoint of cost. If plastic is used instead of glass, the relative heat transfer should be considered. Tinted glass may be used to advantage, if visibility is not affected.

*6. **Insulation***—The extent of insulation required is determined by the capacity of the air conditioning system and by the ambient conditions expected. Solar radiation is one area of use that may require considerable insulation in the roof area. Heat generated by the engine and by hydraulic equipment may require more insulation in fire walls and floor plates than would usually be expected.

*7. **Sealing of Openings***—If a cab is used in extremely hot ambients and unless the air conditioner is of very high capacity, it will be necessary to recirculate some of the cab air. When all or a major portion of the cab air is recirculated, it is necessary that the cab be well sealed. When it is not necessary to recirculate the cab air and all outside air is inducted through the air conditioning system, a ventilator should be provided in the cab. This ventilator should be located in a position relative to the cool air vents that will allow the cool air to circulate through the cab in a manner to achieve maximum cooling. In all cases, the vent should be a size that will permit a slight pressurization within the cab. This pressurization will prevent the entrance of dust and hot air through any cracks or small openings that are not sealed.

*8. **Ambient Conditions***—To be successful, an air conditioning system must have the ability to achieve a desirable temperature level when operating in any ambient expected to be encountered. High temperature and high humidity perhaps create the most difficult conditions, but the presence of dust also creates problems. Regardless of how often a filter is changed or cleaned in extreme dust conditions, there will be some clogging of the filter. The filter, therefore, must be large enough to allow sufficient air passage even though it is partially clogged with dust. The dust conditions also determine the size of the evaporator blowers and the condenser location. In some systems, it may be practical to locate the condenser coil in front of the vehicle's radiator and, if this can be done, it will give good results; but careful consideration must be given to the problem of dust and dirt clogging the coil and then cutting down the efficiency of the radiator. The alternative is to mount the condenser in some other location and cool it with a motor driven fan or fans. The advantage of cooling with motor driven fans is that the condenser can be mounted in the best possible location relative to the rest of the system and freedom from dirt and dust. The size of the condenser coils, location, and air flow must be such that the head pressure on the compressor is not over 300 psi continuous. The head pressure will be determined by the temperature of the refrigerant at the inlet of the expansion valve.

*9. **Accessibility of Serviceable Components***—To assure the proper servicing of the filter, it must be located so it can be removed and replaced with a minimum effort and without the need of special tools. Provisions must also be made to prevent the accumulation of dust and dirt on the filter from falling on the operator when the filter is removed. Even with the use of a filter, some dust will eventually accumulate on the evaporator coil and, therefore, the coil should be located so it can be cleaned when necessary. Controls, switches, hose, belts, etc., may require replacement and this should be possible without major disassembly.

10. Refrigerant Lines—Suction line from evaporator to compressor should be as short as possible and of sufficient size to keep pressure drop to a minimum. Fittings, such as self-sealing couplings, will create some pressure drop, and their design should be considered.

11. Noise—Fans or blowers can create objectionable noise and vibrations in a cab if not properly located and balanced.

12. Evaporator Condensate Control—In humid conditions, a considerable amount of condensate accumulates on the evaporator coil, and provisions must be made to prevent this from being carried into the cab by the air stream, or from leaking in if the evaporator is in the cab roof. If the evaporator is ahead of the blower, as much as 2 in. water gage negative pressure may result and this must be considered in design of drip pan and drains.

13. Power Requirement—Sufficient power must be available to operate fans, blower, and compressor clutch. The amount of power required is considerable and the output of the vehicle's electrical system may not be sufficient. It may be necessary to use a large capacity generator and heavy duty battery, if an electric motor is used to drive the condenser fan.

14. Safety—All components should be positioned in such a manner that they will not create a hazard to the operator when entering or leaving the cab, or while operating the equipment. It is very important to position air intakes so that exhaust gas will not be drawn into the cab.

15. Durability—Most designers of construction equipment and accessories for such equipment are well aware of the shock and vibration usually encountered, and therefore, should make provisions in an air conditioning system to withstand such conditions. This may require shock mounting of some components. Sheet metal parts may have to be fastened together with bolts and lock nuts rather than sheet metal screws. Systems designed for trucks and automobiles are not always sufficiently durable to withstand the shock and vibration of construction equipment, especially that which is track mounted, such as crawler tractors.

16. Convenience—All controls, switches, etc., should be positioned for the convenience of the operator. See SAE J680.

17. References

1. William H. Jackson, "The Physiological Aspects of Automotive Heating, Ventilating, and Air Conditioning." General Motors Engineering Journal.
2. Frank Eischen, "Producing a Quiet and Comfortable Cab." Paper 680587 presented at SAE Farm, Construction, and Industrial Machinery Meeting, Milwaukee, September 1968.
3. "Design and Modification of Industrial Vehicles for Operation at Low Temperatures." SAE SP-346, January 1969.
4. SAE J639.
5. J. T. Kreasky, "Controlling the Automotive Air Conditioner for Comfort." Paper 146C presented at SAE Automobile Week, Detroit, March 1960.
6. "Auto Air Conditioning Forum." SAE SP-185, May 1961.
7. B. F. Vogelaar, "Engineering and Operational Characteristics of Air Conditioned Cab." Paper 59-639 presented at ASAE meeting, December 1969.
8. ASHRAE Guide and Data Book. Vol. 1, Fundamentals and Equipment.
9. Richard C. Jordan and Gayle B. Preister, "Refrigeration and Air Conditioning." Englewood, N. J.: Prentice-Hall, Inc.

OPERATOR CAB ENVIRONMENT FOR HEATED, VENTILATED, AND AIR CONDITIONED CONSTRUCTION AND INDUSTRIAL EQUIPMENT—SAE J1129

SAE Information Report

Report of Construction Machinery Technical Committee approved April 1976. Rationale statement available.

1. Purpose—The purpose of this Information Report is to establish minimum performance levels in the operator's environment for heated, ventilated, and air-conditioned construction and industrial equipment cabs. Also established are heating and air-conditioning test procedures for determining operator environment temperature, humidity, and pressurization.

NOTE: The subject of noise is not treated in this Information Report.

2. Scope

2.1 This Information Report establishes the following minimum performance levels in the operator's environment:

2.1.1 Minimum cab pressurization and ventilation levels under all conditions of heating, air conditioning, and ventilation.

2.1.2 Maximum humidity and minimum temperature differential under air conditioning operation.

2.1.3 Minimum temperature differential under heater operation.

2.2 The report also establishes uniform test procedures for determining minimum performance levels, as defined under 2.1.1–2.1.3, under Heater and Air Conditioner Operation.

3. Definitions

3.1 **Operator Environment**—The space surrounding the operator as defined by the temperature measurement locations of test procedures 6.0 and 7.0.

3.2 **Air-Conditioning System**—Any system which lowers the effective temperature of the air within the operator's environment.

3.3 **Heating System**—Any system which raises the effective temperature of the air within the operator's environment.

3.4 **Filtered Fresh Air**—Outside air which is passed through a filter that is 99.5% efficient using A.C. coarse test dust, defined under Air Cleaner Test Code—SAE J726b.

4. Minimum Performance Levels Common for Heating Ventilating, and/or Air-Conditioning Systems

NOTE: All metric conversions of data in this report are approximate for ease of interpretation.

4.1 Under all conditions of heating, ventilating, and air conditioning, the cab should be pressurized at a minimum level of 0.05 in of water pressure (12.4 pascals).

4.2 Under all conditions of heating, ventilating, and air conditioning, a minimum of 25 CFM (11.8 dm^3/s) of filtered fresh air per cab occupant should be provided.

4.3 Under all conditions of heating, ventilating, and air conditioning, the temperatures measured in the operator's environment should be uniform within 9°F (5°C).

5. Minimum Air Conditioning Performance upon Stabilization under the Test Conditions as Outlined in 6.

NOTE: Sun Loading is not a test requirement.

5.1 The air-conditioning system should be capable of reducing the operator environment temperature a minimum of 20°F (11.1°C) below the ambient for ambient temperatures of 85°F (29.4°C) to the highest ambient temperature at which the machine is designed to operate.

5.2 The operator environment humidity should not exceed 70%.

6. Air Conditioning System Performance Test Procedure

6.1 Test Equipment and Instrumentation Recommendation

6.1.1 A room sufficiently large to contain the base machine with provisions to circulate conditioned air.

6.1.1.1 Field test conditions may be used.

6.1.2 Thermometers or other temperature measuring devices. Maximum error should not exceed ±1°F (±0.5°C).

6.1.3 Psychrometer to obtain wet bulb temperature reading in system. Maximum error should not exceed ±1°F (±0.5°C).

6.1.4 Manometer to measure enclosure pressurization. Maximum error should not exceed ±0.01 in water of water pressure (±2.5 pascals).

6.2 Test Conditions

6.2.1 The air conditioner system shall be completely powered by equipment on the test machine.

6.2.2 All machine accessories pertinent to the operation of the enclosure, enclosure components, filters, and blowers shall be standard production parts or equivalent, adjusted within the machine manufacturer's specification limits.

6.2.3 If a test room is used, the ambient conditions for moderate temperature, high humidity shall be:

Dry bulb temperature: 90 + 4, −0°F
(32 + 2, −0°C)

Wet bulb temperature: 78 + 2, −0°F
(25.5 + 1, −0°C)

NOTE: The velocity of air passing the machine shall not exceed 10 mph (4.5 m/s).

6.2.4 If a field test procedure is used, the test conditions shall be a minimum of 80°F (27°C) dry bulb and 69°F (20.5°C) wet bulb.

6.2.5 MACHINE LOAD AND SPEED—The machine shall be operated at rated engine speed under no load conditions when used in the test room or under field conditions.

6.3 Measurement Locations

6.3.1 The ambient air temperatures shall be measured at a location where the ambient air is not affected by the machine.

6.3.2 The operator enclosure pressurization with the air conditioner in operation shall be measured according to SAE J1012 and recorded.

6.3.3 Temperatures shall be measured at the following locations (see Fig. 1):

6.3.3.1 Record dry bulb temperatures as close as practical to the following locations:

6.3.3.1.1 Two locations 8 in (203 mm) above floor and within 8 in (203 mm) of the operator's legs.

6.3.3.1.2 Three locations at 90 deg intervals in a horizontal plane 30 in (760 mm) above the machine floor within 8 in (203 mm) of the operator.

6.3.3.1.3 One location 8 in (203 mm) in front of the operator at 48 in (1220 mm) above the enclosure floor.

6.3.3.2 Record wet bulb temperatures. Use the same height coordinate parameters as for the dry bulb, but with only one reading 8 in (203 mm) in front of operator at the 30 in (760 mm) elevation. A motor driven psychrometer is recommended for these readings.

6.4 Test Procedure

6.4.1 The test conditions described in paragraph 6.2 are to be maintained throughout the duration of the test.

6.4.2 Record the operator environment temperatures as described in paragraph 6.3 at approximately 5 min intervals.

6.4.3 The machine operator environment dry bulb temperatures shall be

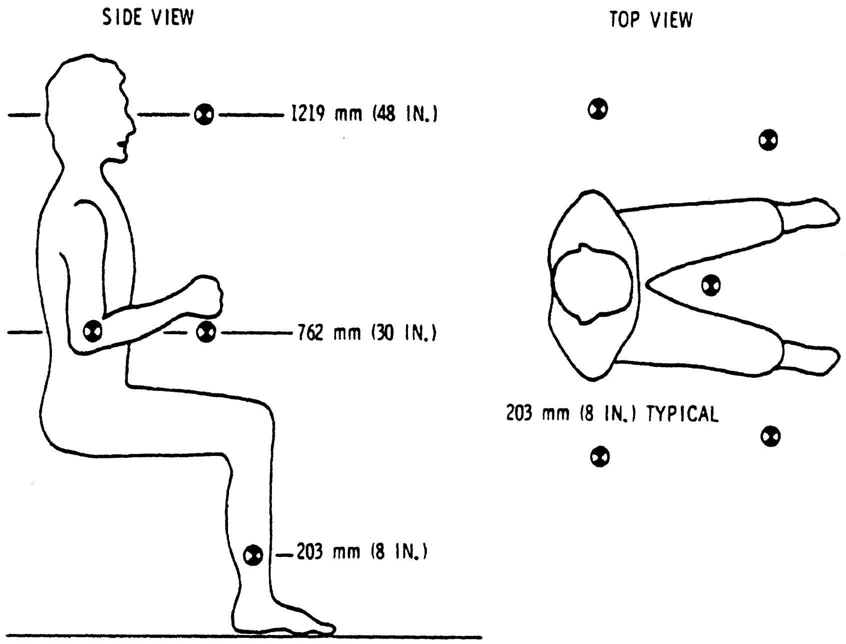


FIG. 1—TEMPERATURE MEASUREMENT LOCATIONS
(REF. SAE J1006)

averaged to obtain an overall enclosure dry bulb temperature at each reading interval.

6.4.4 The machine operator environment wet bulb temperatures shall be averaged to obtain an overall enclosure wet bulb temperature at each reading interval.

6.4.5 The test shall be considered terminated when either of the following conditions are fulfilled:

6.4.5.1 The minimum temperature recorded in paragraph 6.4.3 does not drop more than 1°F (0.5°C) in three consecutive 5 min intervals.

6.4.5.2 One hour of test operation.

6.4.6 The following data shall be recorded:

6.4.6.1 The averaged data specified in paragraphs 6.4.3 and 6.4.4.

6.4.6.2 The ambient conditions.

6.4.6.3 Test duration time to achieve final results.

6.4.6.4 Enclosure pressurization.

7. Minimum Heating Performance upon Stabilization under the Test Conditions as Outlined in 8.

7.1 The heating system should be capable of increasing the operator environment temperature a minimum of 50°F (28°C) above the ambient for ambient temperatures of 20°F (−6.7°C) to the lowest ambient temperature at which the machine is designed to operate.

NOTE: Under ambient conditions where Arctic type clothing is worn the maximum operator environment temperature should not exceed 25°F (−4°C).

8. Heater System Performance Test Procedure

8.1 Test Equipment and Instrumentation Recommendation

8.1.1 A room sufficiently large to contain the base machine with provisions to circulate conditioned air.

8.1.1.1 Field test conditions may be used.

8.1.2 Thermometers or other temperature measuring devices. Maximum error should not exceed ±1°F (±0.5°C).

8.1.3 Manometer to measure enclosure pressurization. Maximum error should not exceed ±0.01 in of water pressure (±2.5 pascals).

8.2 Test Conditions

8.2.1 The heater system shall be completely powered by equipment on the test machine.

8.2.2 All machine accessories pertinent to the operation of the enclosure, enclosure components, filters, and blowers shall be standard production parts or equivalent, adjusted within the machine manufacturer's specification limits.

8.2.3 If a test room is used, the ambient conditions for heating tests shall be:

Dry bulb temperature: 20°F (−7°C) maximum

NOTE: The velocity of air passing the machine shall not exceed 10 mph (4.5 m/s).

8.2.4 If a field test procedure is used, the test conditions shall be a maximum of 30°F (−1°C) dry bulb.

8.2.5 MACHINE LOAD AND SPEED—The machine shall be operated at rated engine speed under no load conditions.

8.3 Measurement Locations

8.3.1 The ambient air temperatures shall be measured at a location where the ambient air is not affected by the machine.

8.3.2 The operator enclosure pressurization with the heater in operation shall be measured according to SAE J1012 and recorded.

8.3.3 Temperatures shall be measured at the following locations (see Fig. 1):

8.3.3.1 Record dry bulb temperatures as close as practical to the following locations:

8.3.3.1.1 Two locations 8 in (203 mm) above floor and within 8 in (203 mm) of the operator's legs.

8.3.3.1.2 Three locations at 90 deg intervals in a horizontal plane 30 in (760 mm) above the machine floor within 8 in (203 mm) of the operator.

8.3.3.1.3 One location 8 in (203 mm) in front of the operator at 48 in (1220 mm) above the enclosure floor.

8.4 Test Procedure

8.4.1 The test conditions described in paragraph 8.2 are to be maintained throughout the duration of the test.

8.4.2 Record the operator environment temperatures as described in paragraph 8.3 at approximately 5 min intervals.

8.4.3 The machine operator environment dry bulb temperatures shall be averaged to obtain an overall enclosure dry bulb temperature at each reading interval.

8.4.4 The test shall be considered terminated when either of the following conditions are fulfilled:

8.4.4.1 The minimum temperature recorded in paragraph 8.4.3 does not raise more than 1°F (0.5°C) in three consecutive 5 min intervals.

8.4.4.2 One hour of test operation.

8.4.5 The following data shall be recorded:

8.4.5.1 The averaged data specified in paragraphs 8.4.3 and 8.4.4.

8.4.5.2 The ambient conditions.

8.4.5.3 Test duration time to achieve final results.

8.4.5.4 Enclosure pressurization.

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR CONSTRUCTION AND INDUSTRIAL MACHINERY—SAE J956

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved June 1966. Reaffirmed without change October 1973.

Purpose and Scope—The purpose of this SAE Recommended Practice is to define common terms relating to remote and automatic control systems so as to facilitate clear understanding as to their meaning and to promote uniformity of nomenclature in engineering discussions, technical papers, and specifications. This report will also cover some of the newer areas in remote and automatic controls, such as ultrasonic techniques and laser beams.

Fig. 1 is a block diagram outlining the design of a basic remote control system for use with construction and industrial machinery. Figs. 2 and 3 show typical installations on construction and industrial machinery.

Nomenclature—Remote and Automatic Control Systems

Actuator—A device for providing positioning power.

Attenuation—The process of reducing the amplitude of a signal.

Automatic Controller—A device or instrument which is capable of measuring and regulating a process or operation.

Barrier—The medium, or resistance path, through which a radio signal is to be transmitted.

Breadboarding—Construction of a system or portion of a system for the purpose of studying characteristics without any regard for size or appearance.

Carrier Frequency—Fixed frequency upon which usable data is superimposed.

Closed Loop—A part of a system characterized by the provision of means for observation or measurement of the output together with a feedback path 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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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.

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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.

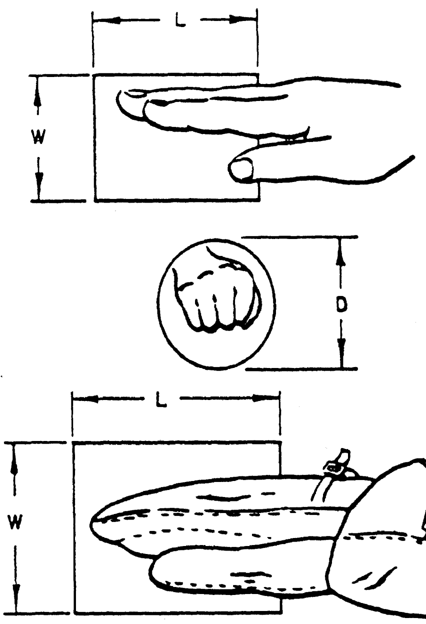
This SAE Recommended Practice is intended to give information to engineers and designers in order that access openings provided in equipment and machinery for purposes of inspection, adjustment, and maintenance are made large enough for efficient performance of the intended function by the man in the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

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.

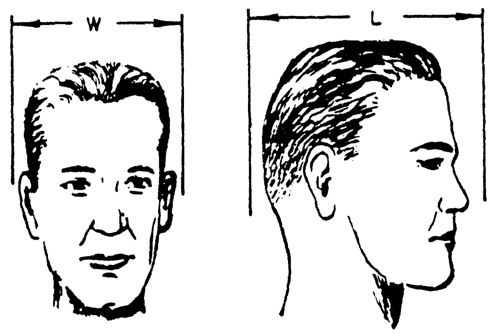
The dimensions shown are the recommended minimum for limited activity through the opening. Larger openings will be needed in specific instances, depending upon nature of task, size and weight of parts, etc. They are based on data from: QM Handbook Series, Human Engineering Guide to Equipment Design,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



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

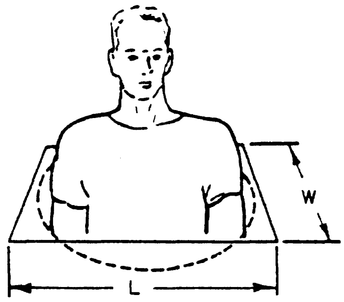
NOTE: OPTIONAL ON ALL CORNERS, MAX. 1 IN. RADIUS

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



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

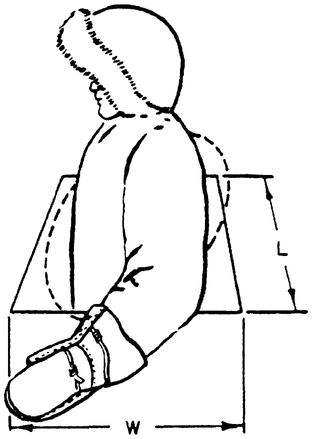
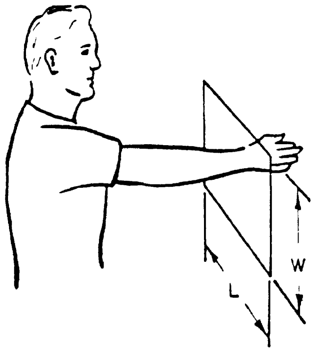


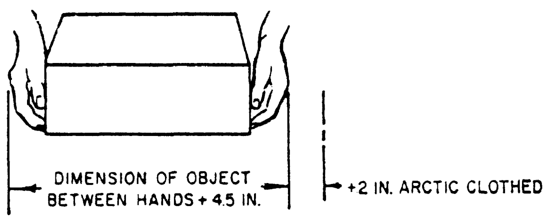
FIG. 3—RECOMMENDED MINIMUM DIMENSIONS FOR BODY ACCESS, 95TH PERCENTILE

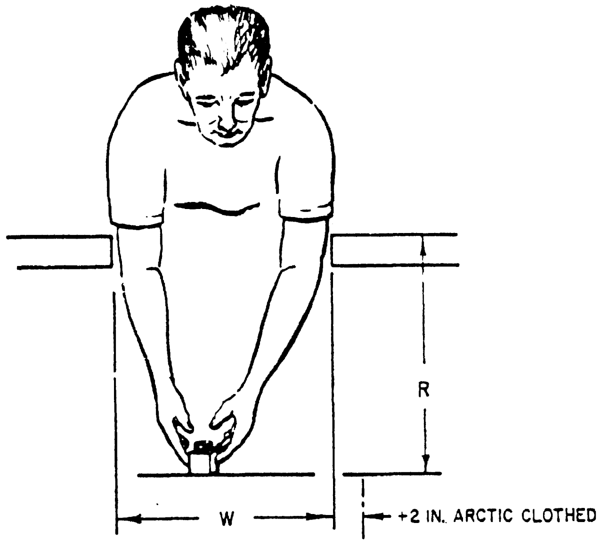


MINIMUM DIMENSIONS ONE ARM, IN.	W	L
ARM BARE	6	8
ARCTIC CLOTHED	8	10

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 $7\frac{1}{2}$ 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.

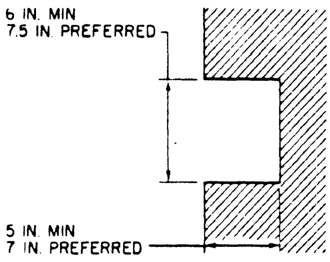


FIG. 1

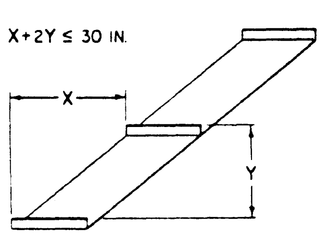


FIG. 2

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 $1\frac{1}{2}$ in. The minimum diameter should be $\frac{3}{4}$ 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.

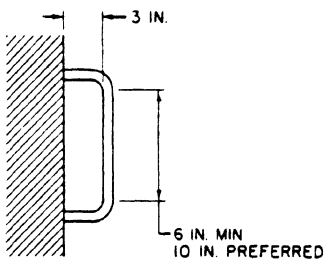


FIG. 3

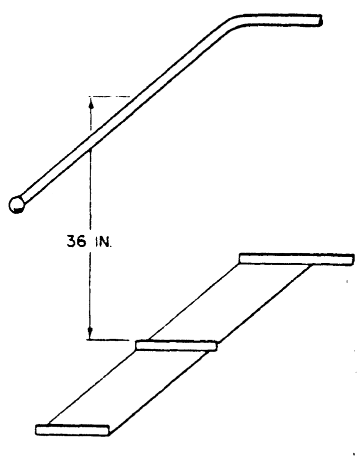


FIG. 4

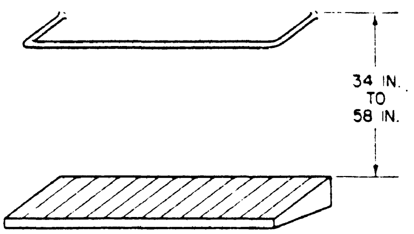


FIG. 5

7. Guardrails

7.1 A rigid guardrail should be placed above the edge of walkways and platforms 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 top 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 resistance 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 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 18 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 J925.

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.

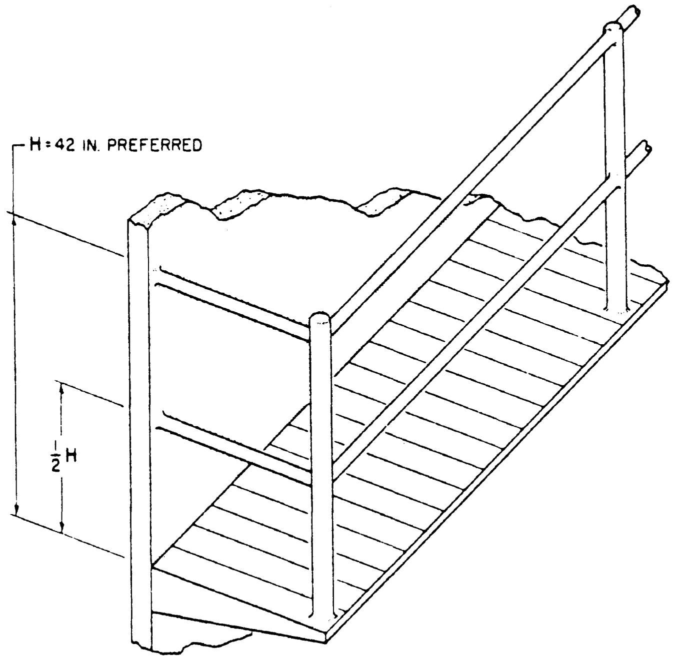


FIG. 6

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.

FORCE-DEFLECTION MEASUREMENTS OF SEAT AND BACK CUSHIONS FOR AGRICULTURAL, CONSTRUCTION, AND INDUSTRIAL EQUIPMENT—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) fo[r] the particular material.

3.3 Test Method

3.3.1 Mount the test specimen with the top surface parallel to and centere[d] with the indentor, unless otherwise specified by mutual agreement of th[e] manufacturer and customer. In the case of cushions with unusual shapes o[r]

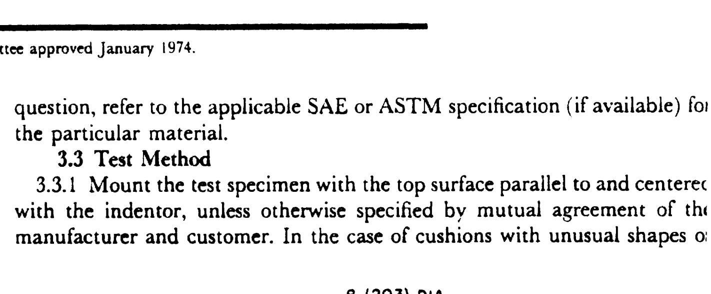


FIG. 1—FLAT INDENTOR