

Issued 1969-03
Revised 2006-02

Superseding J386 NOV1997

(R) Operator Restraint System for Off-Road Work Machines**1. Scope**

This SAE Standard establishes the minimum performance requirements for pelvic restraint systems (seat belts, anchorages, and the fastening elements of seat belts) necessary to restrain an operator or rider within a roll-over protective structure (ROPS) in the event of a machine roll-over, as defined in ISO 3471, or tip-over protection structure (TOPS), in the event of a machine tip over as defined in ISO 12117.

This SAE Standard applies to off-road, self-propelled work machines fitted with ROPS as specified in ISO 3471, TOPS as specified in ISO 12117 and operator restraint.

1.1 Rationale

This revision updates external references to industry accepted ISO specifications. The document was reorganized to meet industry request. Additional detail was added to incorporate the current state of the art for restraint systems. The use of referenced documents was minimized to allow a more comprehensive specification.

2. Normative References**2.1 Applicable Publications**

The following standards contain provisions, which, through reference in this text, constitute provisions of this International Standard. At the time of publication the editions indicated were valid. All standards are subject to revision and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2006 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: <http://www.sae.org>

2.1.1 ISO PUBLICATIONS

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 3411:1995—Earth-moving machinery—Human physical dimensions of operators and minimum operator space envelope

ISO 3471:1994—Earth-moving machinery ROPS—Laboratory tests and performance—Amendment 1: 1997 requirements

ISO 5353:1995—Earth-moving machinery—Seat index point

ISO 12117:1997—Earth-moving machinery—Tip-over protection structure (TOPS) for compact excavators—Laboratory tests and performance requirements

3. Definitions

3.1 Adjustment Hardware

Hardware designed for adjusting the belt assembly to fit the user, including such hardware that may be integral with a buckle, attachment hardware, or retractor.

3.2 Seat Belt Anchorage

The point where the seat belt assembly and/or extension (tether) belt is mechanically attached to the seat system and/or the machine structure.

3.3 Seat Anchorage

Parts of the machine structure at which the seat system is secured.

3.4 Attachment Hardware

Parts of the seat belt assembly that consists of the necessary components to secure the seat belt assembly to the seat belt anchorage.

3.5 Attaching Bolts

Threaded fasteners in the attachment hardware used to secure the seat belt assembly to the seat belt anchorage.

3.6 Strap (Webbing)

A flexible belt to restrain the body and for transmission of the forces to the attachment hardware.

3.7 Body Block

The test device used to apply the seat belt force to the seat system (reference Figure 2).

3.8 Buckle and Latchplate

A quick-release connector which fastens the belt assembly into a loop.

3.9 Micro-Slip (Creep)

The amount of unintentional lengthening of the seat belt assembly loop during use that is caused by motion of the machine, the seat, and the seat belted occupant.

3.10 Extension (Tether) Belt

Any strap, belt, wire cable, solid link, or etc., that aids the transfer of seat belt forces from the attachment hardware at the seat to the machine structure.

3.11 Hardware

Any metal or rigid plastic part of the seat belt assembly.

3.12 Loop

Complete seat belt assembly, as it would be installed around the seat occupant.

3.13 Operator Restraint System

Total system composed of the seat belt assembly, seat system, anchorages, and extension (tether) belts, if applicable, which transfers the seat belt force to a machine.

3.14 Polyester Yarn

Yarns spun from polyethylene terephthalate.

3.15 Retractors

Devices for storing all or part of the strap material of a seat belt assembly.

3.16 Automatic Locking Retractor (ALR)

A retractor allowing extraction of the strap to the desired length and which, when the buckle is fastened, automatically adjusts the strap to the wearer. Further extraction of the strap is prevented without voluntary intervention by the wearer.

3.17 Emergency Locking Retractor (ELR)

A retractor, which during normal driving conditions does not restrict the freedom of movement by the wearer of the seat belt. Such a device has length adjusting components which automatically adjust the strap to the wearer and a locking mechanism actuated in an emergency by: Deceleration or rollover of the machine (single sensitivity), a combination of machine deceleration, strapping acceleration or any other locking means (multiple sensitivity).

3.18 Nonlocking Retractor

A retractor from which the strap is extracted to its full length by a small external force and which provides no adjustment for the length of the extracted strap and no means for locking any strap not extracted from the mechanism at any time including an emergency.

3.19 Roping

Tendency of a piece of material to twist upon itself or roll up transversely, remaining in the form of a rope instead of staying in its original strap form.

3.20 Seat Belt Assembly (Pelvic Retraint - Type 1) (Belt, Seat Belt)

Any strap or belt device across the lap or pelvic girdle area designed to provide operator restraint in a machine; includes buckles or other features and may include the seat belt attachment hardware.

3.21 Seat Index Point (SIP)

Point on the central vertical plane of the seat as determined by the SIP-device when installed in the operators seat as defined in ISO 5353:1995.

3.22 Seat System

Total support mechanism providing the interface between machine and operator intended to seat one machine operator; includes, if provided, the seat assembly, seat adjustment mechanisms, seat support and the seat suspension.

4. Machine Related Requirements

4.1 Anchorages

- 4.1.1 Seat belt anchorages shall permit the seat belt assembly to be readily installed or replaced and shall comply with the strength requirements of 4.4..
- 4.1.2 If the seat does not swivel nor has a suspension system, the seat belt assembly may be anchored to the seat or to the machine at any point within the hatched zones shown in Figure 1. For SIP definition, see ISO 5353.
- 4.1.3 Alternatively, the seat belt assembly shall be attached to anchorages on the seat near the corners of the seat cushion within the hatched zone shown in Figure 1, so that the loop size of the seat belt assembly does not change as the seat suspension oscillates.

4.2 Extension (Tether) Belts

- 4.2.1 Belts, cables, or similar flexible devices may be used to transfer the seat belt assembly forces from the seat belt anchorages to the machine. The extension belt length may be adjustable.
- 4.2.2 Extension belts must meet the seat belt assembly force requirements of 4.4 in all operating positions.

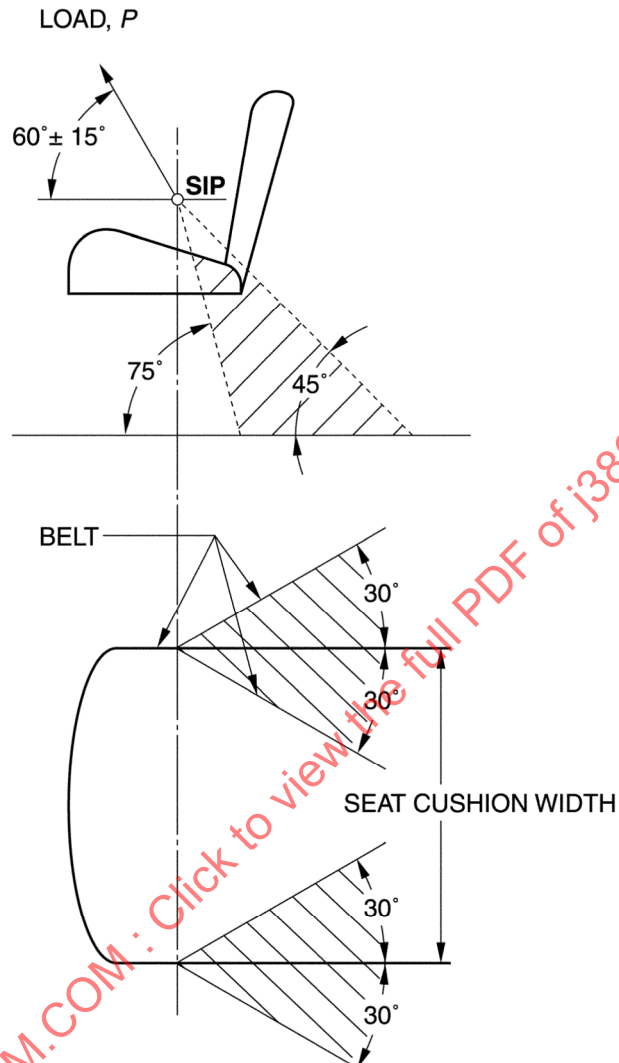


FIGURE 1—LOCATION OF SEAT BELT ANCHORAGE
WITH RESPECT TO SEAT INDEX POINT

4.3 Seat Belt Assembly Installation

- 4.3.1 The seat belt assembly shall be located such that when the seat belts are in a straight line through the SIP, the angle formed from the horizontal will be in the range of 60 degrees $\pm$ 15 degrees as shown in Figure 1 for all operating positions. Where practical, the preferred angle through the SIP is toward the more vertical.
- 4.3.2 The seat belt assembly is intended to remain in the pelvic girdle area under operating, collision, and rollover conditions, thereby restraining the operator's hips and lower torso area to the seat assembly.

- 4.3.3 Seat belt assemblies should be inspected by the user regularly. Replace the seat belt assembly immediately if damage such as worn or damaged hardware, nicked or frayed strap, buckle or retractor malfunction, or loose stitching is found.

4.4 Performance Requirements

- 4.4.1 The operator restraint system shall be tested on-machine or in a manner equivalent to an on-machine condition.
- 4.4.2 The seat shall be adjusted to the operating position, which produces the most severe loading condition to the operator restraint system, prior to any subsequent structural deflection.
- 4.4.3 After the force is applied to the operator restraint system, the force application device shall not be repositioned to compensate for any changes that may occur to the force application angle.
- 4.4.4 The seat belt assembly force shall be applied using a body block similar to that shown in Figure 2. If a retractor is included in the assembly, refer to 5.4.

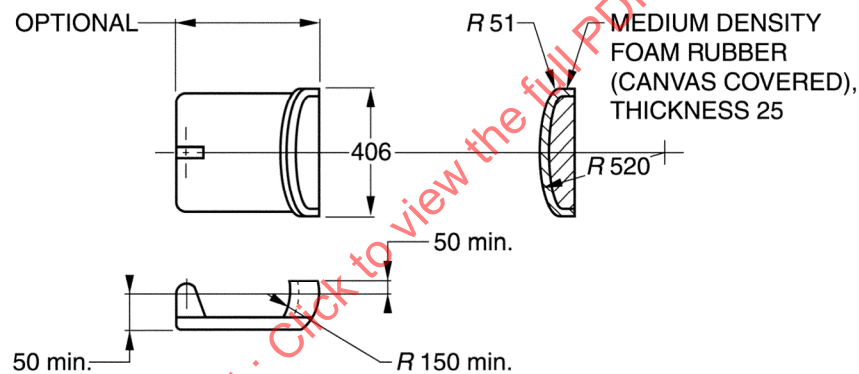


FIGURE 2—BODY BLOCK
(DIMENSIONS IN mm)

- 4.4.5 For machines with seat systems having a mass greater than 70 kg such as those that include add-on control modules, it is necessary that the seat support be designed to withstand an additional force of ten times the mass of the seat system which exceeds the 70 kg mass.
- 4.4.6 With the test set-up free of slack, a force of 15 000 N plus 10 times 9.8 N/kg multiplied by any mass (kg) of the seat system greater than 70 kg shall be applied to the seat belt assembly in the forward and upward direction. The initial angle of force application shall be 60 degrees $\pm$ 15 degrees from the horizontal, with the line of force approximately passing through the SIP. (For the SIP definition, see ISO 5353) (see Figure 3). The force shall be attained in not more than 30 s and maintained for not less than 10 s. Example: If a seat system has a 70 kg mass but an 18 kg seat mounted control is added then the force is:

$$15\,000\text{ N} + (10)(9.8\text{ N/kg})(18\text{ kg}) = 16\,760\text{ N} \quad (\text{Eq. 1})$$

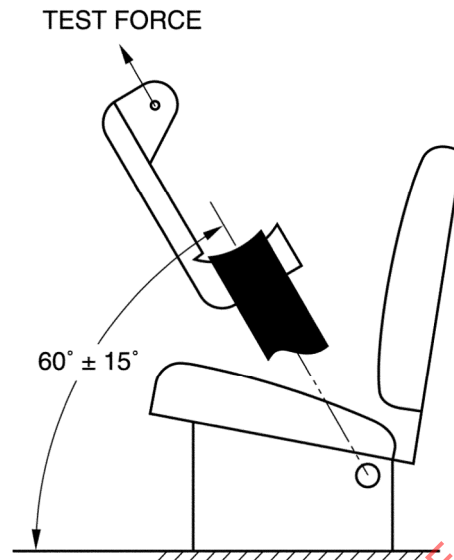


FIGURE 3—CONSTRUCTION AND GENERAL PURPOSE INDUSTRIAL MACHINES TEST PROCEDURE

4.4.7 There must be no rupture, release, or other failure of any element in the operator restraint system. Permanent deformation of any elements shall not constitute failure.

5. **Restraint System Component Requirements**

5.1 **Seat Belt Assembly Specifications**

5.1.1 SINGLE OCCUPANCY

A seat belt assembly shall be designed for use by one, and only one, person at any time.

5.1.2 RELEASE

The seat belt assembly shall be provided with a buckle or latch readily accessible to the occupant and designed to provide easy and rapid release of the assembly with a single motion. It shall also be capable of being released with either hand, bare or mittened. The buckle shall be designed to minimize the possibility of accidental release due to operator movement, inertia, or external forces. The buckle shall meet all the requirements described in 5.3.

5.1.3 ADJUSTMENT HARDWARE

The seat belt shall be self-adjusting or readily adjustable by a means within easy reach of the occupant. Any adjustment of the seat belt shall be capable of being made with mittened hands.

5.1.4 STRAP

The strap length shall be adjustable for the 5th percentile to the arctic clothed 95th percentile operator. See ISO 3411.

5.1.5 MICRO-SLIP

Two seat belt assemblies of the same part number, with adjusting devices included, shall be tested in accordance with the requirements outlined below. The micro-slip shall not exceed 25 mm for each adjusting device in the assembly. The sum of micro-slip amounts for all adjusting devices in the belt assembly shall not exceed 40 mm.

5.1.5.1 Conditions

Two seat belt assemblies of the same part number shall be conditioned for 24 h at a temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ and $65\% \pm 5\%$ relative humidity. The test shall be conducted at a temperature between $15\text{ }^{\circ}\text{C}$ and $30\text{ }^{\circ}\text{C}$. The test apparatus shall conform to that shown in Figure 4.

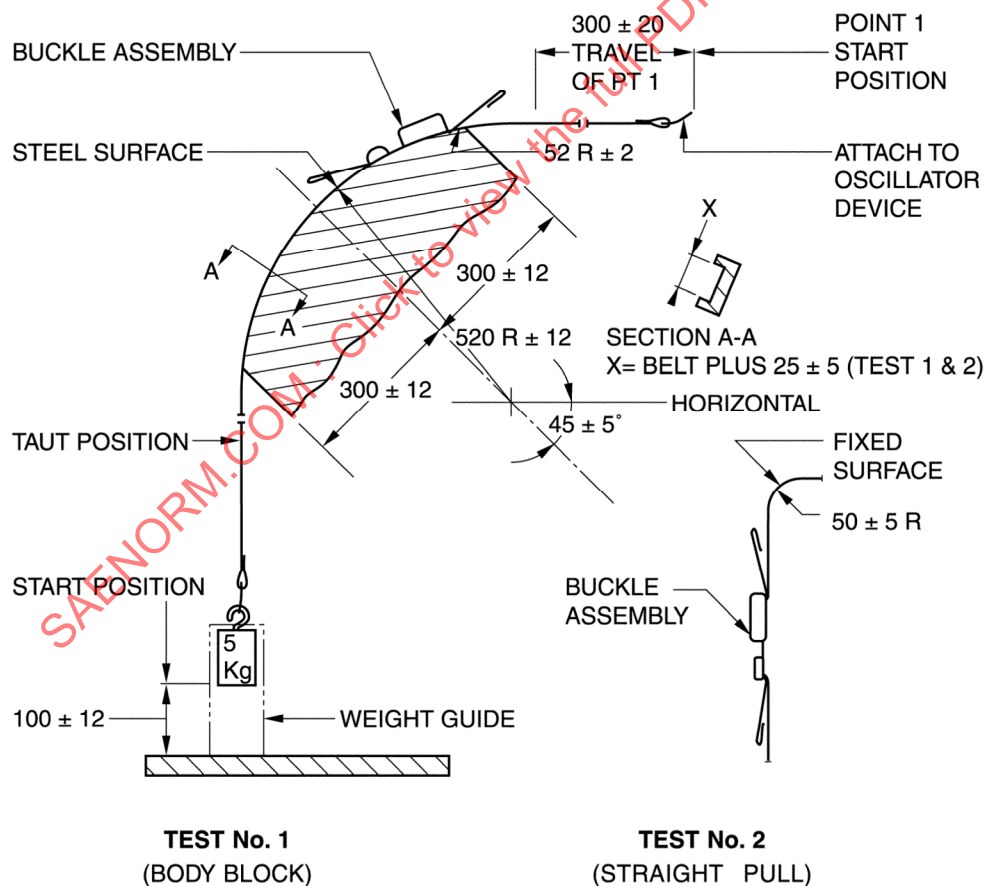


FIGURE 4—MICRO-SLIP TEST APPARATUS
(DIMENSIONS IN mm)

5.1.5.2 Test Procedure

Mount the belts as shown in Figure 4 for Test 1 and Test 2. Apply the following procedure:

- a. Apply a 5 kg mass to the lower end of each belt assembly;
- b. Apply a reciprocating motion, total amplitude of $300 \text{ mm} \pm 20 \text{ mm}$ to the top end of each belt assembly;
- c. If there is a free end serving as reserve strap, it shall not be fastened or clipped to the section subjected to the 5 kg mass;
- d. Ensure that on the test bench, the strap in the slack position maintains contact with the full length of the body block;
- e. Guide the 5 kg mass vertically in a manner to prevent swaying of the mass and twisting of the belt during test;
- f. The attachment shall be fixed to the 5 kg mass as in the machine;
- g. Before start of test, complete 20 cycles of the reciprocating motion to remove initial slack;
- h. Mark the force-bearing strap material at each adjuster in preparation for measuring creep;
- i. Complete 1000 cycles at a frequency of 0.5 Hertz at the reciprocating motion of $300 \text{ mm} \pm 20 \text{ mm}$. The 5 kg mass shall be applied only during the time corresponding to a shift of $100 \text{ mm} \pm 12 \text{ mm}$ of each half cycle. (Refer to Figure 4.);
- j. Measure the distance the strap material has moved at each adjusting device.

5.1.6 BREAKING STRENGTH

- 5.1.6.1 The complete seat belt assembly, including strapping, straps, buckles, adjustment and attachment hardware, and retractors, shall withstand a tensile force of not less than 11.1 kN, that is, each structural component of the assembly shall withstand a force of 11.1 kN when tested by the procedures specified in 5.1.6.2.
- 5.1.6.2 All components of three seat belt assemblies shall be tested as specified in 5.1.6.2.1 and 5.1.6.2.2.
 - 5.1.6.2.1 The pelvic restraint between seat belt anchorages shall be adjusted to a length between 914 mm and 1219 mm, or as near to this length as possible if the design of the pelvic restraint does not permit its adjustment to this length. An automatic locking or emergency locking retractor, when included in a seat belt assembly, shall be locked at the start of the test with a tension in the strapping slightly in excess of the retractile force in order to keep the retractor locked. The attachment hardware shall be oriented to the strapping as specified in 5.1.6.2.2 and illustrated in Figure 5. A tensile force of $11.1 \text{ kN} \pm 0.1 \text{ kN}$ shall be applied to the components in any convenient manner and the extension between anchorages under this force shall not increase more than 500 mm. The force shall be reduced and the buckle release force shall meet the requirements of 5.3.6.

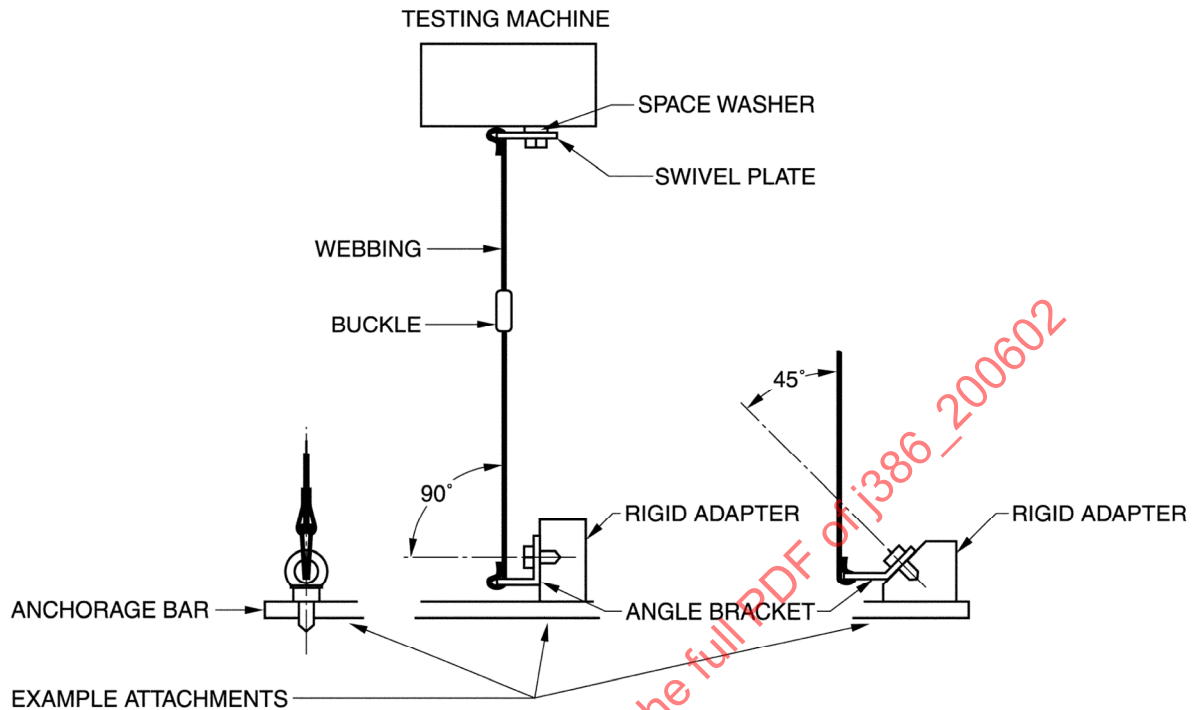


FIGURE 5—TENSILE FORCE TESTING MACHINE

5.1.6.2.2 The attachment hardware furnished with the seat belt assembly shall be attached to the anchorage bar. The attaching bolt, with the listed exceptions, shall be parallel, or at an angle of 45 degrees or 90 degrees to the strapping, whichever results in the greatest angle between strapping and attachment hardware. Eye bolts shall be vertical, and attaching bolts of a seat belt assembly designed for use in specific models of machines shall be installed to produce the maximum angle in use indicated by the installation instructions.

5.1.7 MARKING (LABELLING)

Each seat belt assembly or the individual sections of an assembly shall be permanently and legibly labelled with year of manufacture, model or style number, and name or trademark of manufacturer or importer, and shall state compliance with SAE J386.

5.1.8 USAGE AND MAINTENANCE INSTRUCTIONS

Seat belt assemblies, shall be accompanied by written instructions for:

- Proper installation, including the proper manner of threading the strap into the attachment hardware when threadable hardware is supplied.
- Proper wearing of the installed assembly.
- Proper maintenance (including cleaning procedures) and periodic inspection for wear or damage (as described in 4.3.3).

5.2 Strap Material Specifications

5.2.1 MATERIAL

The strap material shall have resistance to abrasion, temperature, mild acids, alkalies, mildew, aging, moisture and sunlight equal to or better than that of untreated polyester fiber.

5.2.2 STIFFNESS

To minimize roping, the strap material shall be woven and/or treated to produce stiffness in the transverse direction. The stiffness shall be effective for the usable life of the strap. The strap shall be flexible in the longitudinal direction to permit adjustment at -40°C .

5.2.3 COLOR

Preferred colors are those which are recommended by the strap material manufacturer as being less sensitive to ultraviolet rays.

5.2.4 WIDTH

The strap material shall not be less than 46 mm in width when measured under a no-force condition.

5.2.5 ENDS

The ends shall be protected or treated to prevent unraveling, and shall not pull out of the adjustment hardware at maximum size adjustment.

5.2.6 STRENGTH

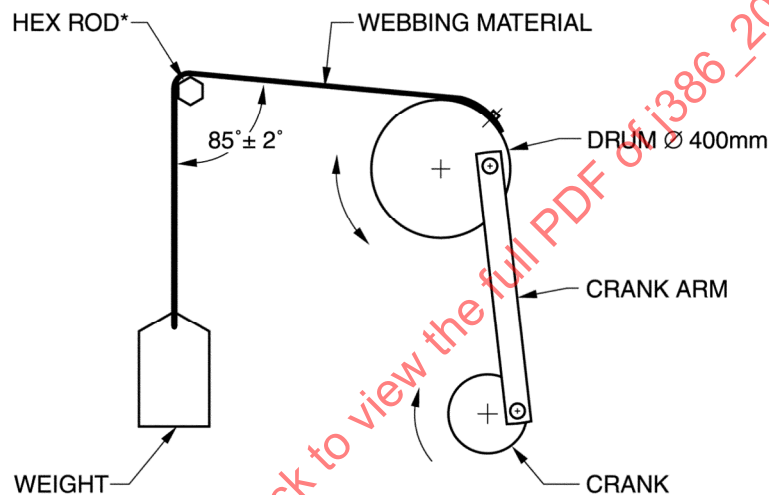
Condition three specimens for at least 24 h in an atmosphere having a relative humidity between 48% and 67% and a temperature of $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$. After conditioning three specimens, the new material shall have a tensile breaking strength of not less than 26.7 kN. The testing machine shall be verified to have an error of not more than 1% in the range of the tensile strength of the strap material. The distance between centers of the grips of the machine at the start of the test shall be between 100 and 250 mm. After placing the specimen in the grips, the strap material shall be stretched continuously at a uniform rate to failure. The rate of grip separation shall be 50 to 100 mm/min. Each failure force value shall not be less than 26.7 kN tensile breaking strength requirement.

5.2.7 ELONGATION

Elongation shall not exceed 20% at 11.1 kN when measured during the test for strap material breaking strength as in 5.2.6.

5.2.8 ABRASION

The strap material from three seat belt assemblies shall be tested for resistance to abrasion by rubbing over the hexagon bar prescribed in Figure 6 in the following manner. The strap material shall be mounted in apparatus shown schematically in Figure 6. One end of the strap material, A, shall be attached to a weight, B, which has a mass of $2.3 \text{ kg} \pm 0.05 \text{ kg}$. The strap material shall be passed over the new abrading edges of the hexagon bar, C, and the opposite end attached to an oscillating drum, D, which has a stroke of 330 mm. Suitable guides shall be used to prevent movement of the strap material along the axis of the hexagonal bar, C. The drum shall be oscillated for 5000 strokes (2500 cycles) at a rate of $60 \text{ strokes} \pm 2 \text{ strokes}$ ($30 \text{ cycles} \pm 1 \text{ cycle}$) per minute. The median value for the breaking strength determined on three abraded specimens shall be not less than 20 kN tensile strength.



* STEEL, SAE 51416 ROCKWELL HARDNESS, B-97 TO B-101 SURFACE, COLD DRAWN FINISH SIZE, 6.35 ± 0.1

FIGURE 6—ABRASION TEST FOR STRAP MATERIAL
(DIMENSIONS IN mm)

5.3 Buckle Specifications

5.3.1 BUCKLE COMPONENTS

Applicable buckle components shall meet the corrosion requirements of Appendix A and shall meet the temperature requirements of Appendix D.

5.3.2 BUCKLE COMPRESSION

5.3.2.1 A buckle shall withstand a compressive force of $1780 \text{ N} \pm 90 \text{ N}$ applied as prescribed below. Upon removal of the compressive force, it shall be operable and meet the applicable requirements of 5.3.4 and the requirements for release effort after tensile force in 5.3.6.

5.3.2.2 The buckle shall be subjected to the specified compressive force applied anywhere on the longitudinal centerline of the buckle and anywhere along lines at approximately 60 degrees to this centerline, with the point of intersection of these lines centered over the release mechanism. The force shall be applied through a cylindrical bar 19 mm in diameter, at least 100 mm long, and curved to a radius of 150 mm. The bar shall be placed with the longitudinal centerline of the bar directly above the lines through the longitudinal centerline of the buckle and at 60 degrees to it (Figure 7).

5.3.2.3 The buckle and latch plate shall be assembled and a tensile force of $333\text{ N} \pm 22\text{ N}$ shall be applied to the connected assembly during the application of the compressive force.

5.3.2.4 The latch plate shall be disengaged from the buckle and the compressive force applied to the buckle again.

5.3.3 BUCKLE LATCH OPERATION

5.3.3.1 The buckle-latch plate assembly of a seat belt assembly when tested by the procedure as prescribed in 5.3.3.2 shall not fail, gall, nor wear to an extent that normal latching and unlatching is impaired. The buckle-latch plate assembly shall be separable by a force of not more than 22 N when tested according to the procedure specified in 5.3.3.2.

5.3.3.2 The buckles from three seat belt assemblies shall be fully latched with their latch plates and unlatched at least 10 times. Each buckle shall then, with the latch plate withdrawn from the buckle, be clamped or firmly held against a solid surface so as to permit normal movement of buckle parts without movement of the buckle assembly. The release mechanism shall be moved 200 times through the maximum possible travel against its stop with a force of $133\text{ N} \pm 13\text{ N}$ at a rate not to exceed 30 cpm, actuating the mechanism in a manner which simulates actual usage. After completion of this portion of the test, the 133 N force shall be reduced to a force of just sufficient magnitude to assure full travel to the stop for an additional 10 000 cycles. The performance of each buckle shall then be evaluated with respect to 5.3.3.1.

5.3.4 ADJUSTMENT FORCE

5.3.4.1 The buckle or other manual-adjusting device normally used to adjust the length of the assembly shall be subjected to the adjustment force test. This force shall not exceed 50 N when measured by the procedure specified in 5.3.4.2.

5.3.4.2 Three buckles or other manual adjusting devices normally used to adjust the length of the assembly shall be tested. This test shall be conducted within 1 h after conditioning under laboratory ambient conditions. With no load on the anchor end, the strapping shall be drawn through the adjusting device at a rate of $500\text{ mm} \pm 50\text{ mm}$ per minute, and the maximum force shall be measured to the nearest 1 N after the first 25 mm of strapping movement. The strapping shall be precycled 10 times prior to measurement.

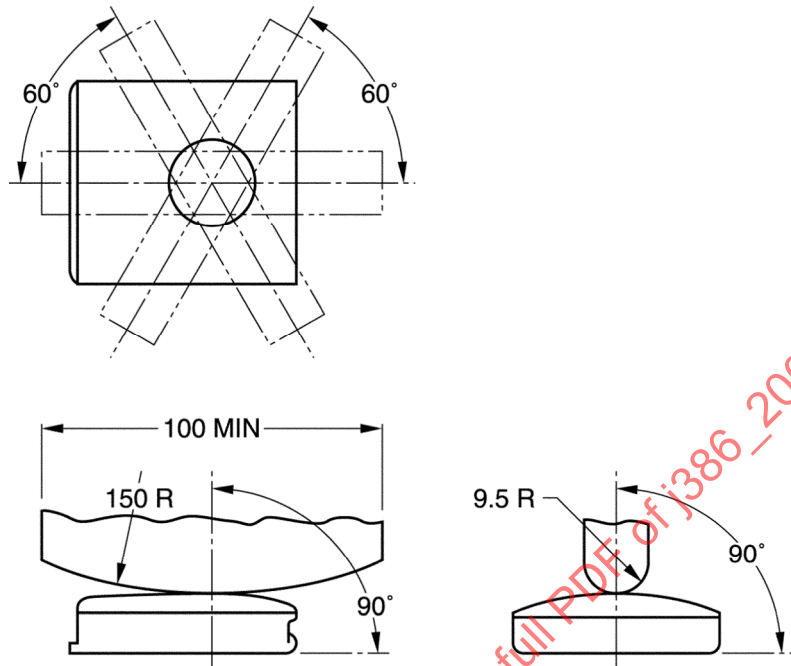


FIGURE 7—BUCKLE COMPRESSION
(DIMENSIONS IN mm)

5.3.5 TILT LOCK ADJUSTMENT

- 5.3.5.1 Buckles or other manual adjustment devices having tilt lock adjustment normally used to adjust the length of the assembly shall lock the strapping when tested by the procedure specified below at an angle of not less than 30 degrees between the buckle and the anchor strapping.
- 5.3.5.2 This test shall be conducted on buckles or other manual adjusting devices employing a tilt-lock feature to adjust the length of the assembly, using strapping intended for use in the adjusting device. Three buckles or devices shall be tested within 1 h after conditioning the strapping for 4 h at laboratory ambient conditions. The base of the adjustment mechanism and the anchor end of the strapping shall be oriented in planes normal to one another with the strapping vertical as in Figure 8. The buckle base shall be horizontal and downward at the start of the test. The strapping shall be drawn through the adjustment mechanism so as to increase belt length at a rate of $500 \text{ mm} \pm 50 \text{ mm}$ per minute, while the plane of the base is rotated at a speed of $1.1 \text{ rpm} \pm 0.2 \text{ rpm}$ in a direction so as to lock the strapping. Rotation shall be stopped when the strapping locks and subsequently supports a 9 kg mass, but the pull on the strapping shall be continued until there is a resistance of at least 89 N. The locking angle between the anchor end of the strapping and the base of the adjustment mechanism shall then be measured to the nearest degree. The strapping shall be precycled 10 times prior to measurement.

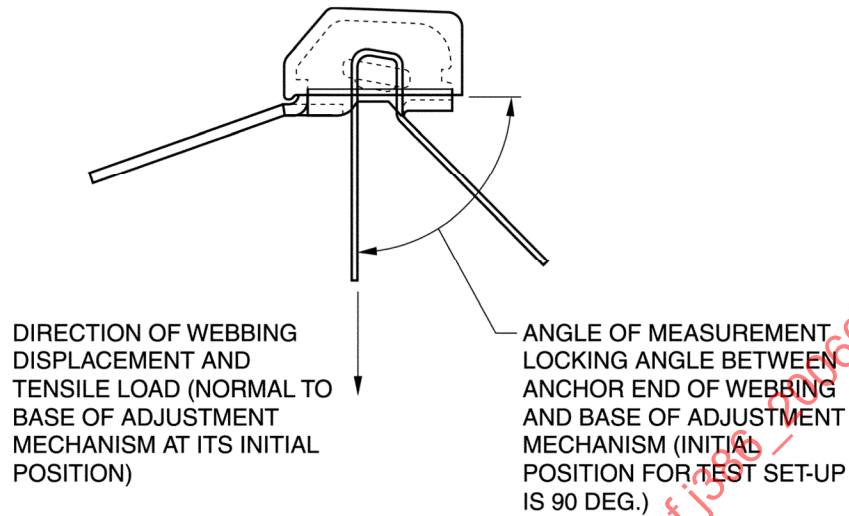


FIGURE 8—TILT LOCK ADJUSTMENT

5.3.6 RELEASE

- 5.3.6.1 The buckle of the seat belt assembly shall release when a force of not more than 130 N is applied to the releasing mechanism.
- 5.3.6.2 Three samples of a given buckle shall be tested. After subjection to the force described in 5.1.6, the force shall be reduced and maintained at a tensile force of 335 N. The buckle release force shall be measured by applying a force on the buckle in a manner and direction typical of that employed by a seat belt user.
- 5.3.6.3 A buckle designed for lift lever application of buckle release shall at least permit the insertion of a cylinder 10 mm in diameter and 38 mm in length to at least the midpoint of the cylinder along the lift lever's entire length in the actuating portion of the buckle release. The release force shall be applied on the centerline of the buckle lever or finger tab in a direction that produces maximum releasing effect.
- 5.3.6.4 Buckles having other designs for release shall have adequate access to actuate release with the mittened hand.

5.3.7 PADDING

If a buckle is used which is less than the width of the strap material, and in an area that may be uncomfortable to the operator, a pad must be provided under the buckle. This pad must cover the entire buckle area and is to be the full width of the strap. It shall be permanently fastened to the assembly in such a manner that it is not injurious or uncomfortable to the operator, does not hinder operation of any part of the seat belt, and does not expose any rough surfaces to the operator's clothing.

5.4 Retractors (If Equipped)

5.4.1 GENERAL

Retractors shall meet the seat belt assembly strength requirements of 5.1.6. When an automatic locking or emergency locking retractor is included in a seat belt assembly, it shall be locked at the start of the test with a tension in the strapping slightly in excess of the retractile force in order to keep the retractor locked. A seat belt assembly utilizing a nonlocking retractor shall have the strap material fully extended from the retractor at the start of the strength test.

5.4.2 AUTOMATIC LOCKING RETRACTORS (ALR)

ALRs shall comply with the following requirements:

- a. The retracting force of the strap shall be not less than 3 N. Begin the measurement with no strapping on the retractor and continue to monitor the retraction force until there is 300 mm on the retractor. Compute the average of the reading from 0 mm to 300 mm.
- b. After the corrosion resistance test given in Appendix A, the strap shall be withdrawn from the retractor and allowed to retract at a rate of not more than 30 cycles per minute, until 2500 cycles have been completed.
- c. The retractor shall then be subjected to the temperature resistance conditioning as described in Appendix D. It shall be subjected to an additional 2500 cycles of webbing withdrawal and retraction.
- d. The retractor shall then be subjected to the dust resistance test as described in Appendix C. It shall then satisfactorily complete a further 5000 cycles of withdrawal and retraction.

After the above tests the retractor shall operate correctly and still meet the requirements of a) above.

5.4.3 EMERGENCY LOCKING RETRACTORS (ELR)

5.4.3.1 An emergency locking retractor, when tested in accordance with 5.4.3.2 shall satisfy the conditions below:

- a. The locking shall have occurred when the deceleration of the machine reaches 0.7 g.
- b. The retractor shall not lock for values of acceleration of the strap measured in the direction of the extraction of the strap of less than 1 g.
- c. The retractor shall not lock when its sensing device is tilted 12° or less in any direction from the installation position specified by its manufacturer.
- d. The retractor shall lock when its sensing device is tilted by more than 40°.
- e. In cases where the operation of the retractor depends on an external signal or power source, the design shall ensure that the retractor locks automatically upon failure or interruption of that signal or power source.
- f. Retractors sensitive to strap acceleration only shall not be used for pelvic restraint.
- g. Retractors sensitive to vehicle tilt must function at the machines extreme operating angles when the machine is idle.

- 5.4.3.2 In the case of the requirements mentioned in 5.4.3.1 above, the amount of strap movement which may occur before the retractor locks shall not exceed 50 mm. Also, locking must not occur during the 50 mm of strap movement in the case of the test mentioned in 5.4.3.1.(b) above. These tests are conducted when the strap has been unwound to full length less 300 mm $\pm$ 3 mm.
- a. In case of a retractor actuated by strap movement, the extraction shall be in the direction in which it normally occurs when the retractor is installed in a machine.
 - b. When retractors are being tested for sensitivity to machine deceleration they shall be tested at the above extraction along two perpendicular axes, which are horizontal if the retractor is installed in a machine. One of these axes shall be in the direction giving the most adverse conditions with respect to actuation of the locking mechanism.
- 5.4.3.3 The retracting force of the strap shall be not less than 3 N when measured as follows. Start the measurement with no strapping on the retractor and continue to monitor the retraction force until there is 300 mm on the retractor. Compute the average of the reading from 0 mm to 300 mm.
- 5.4.3.4 The emergency locking retractor shall comply with the following:
- a. After completion of the corrosion resistance test given in Appendix A, the strap shall be withdrawn from the retractor and allowed to retract at a rate of not more than 30 cycles per minute, until 2500 cycles have been completed.
 - b. The retractor shall then be subjected to the temperature resistance conditioning as described in Appendix D. It shall be subjected to an additional 2500 cycles of webbing withdrawal and retraction.
 - c. The retractor shall then be subjected to the dust resistance test as described in Appendix C.
 - d. It shall then satisfactorily complete a further 45 000 cycles of withdrawal and retraction between 50 and 100 percent extension. The locking mechanism of emergency locking retractor shall be actuated at least 10 000 times within 50 to 100 percent extension during the 50 000 cycles.
 - e. After completing the conditioning of item (a) through (d) above, the retractor shall operate correctly and still meet the requirements of 5.4.3.1 through 5.4.3.3.
- 5.4.3.5 A suitable apparatus for the tests specified in 5.4.3.2 above is described in Appendix E to this Standard. The design of any such test apparatus shall ensure that the required acceleration is given before the strapping is withdrawn out of the retractor by more than 5 mm and that the withdrawal takes place at an average rate of increase of acceleration of at least 25 g/s and not more than 150 g/s ($g = 9.81 \text{ m/s}^2$).
- 5.4.3.6 To check conformity with the requirements of 5.4.3.1.(c) and 5.4.3.1.(d), the retractor shall be mounted on a horizontal table and the table tilted with a speed not exceeding 2° per second until locking has occurred. The test shall be repeated with tilting in other directions to ensure that the requirements are fulfilled.

5.5 Hardware Specifications

5.5.1 GENERAL

All hardware which contacts, under normal usage, an occupant, the occupant's clothing, or the seat belt assembly strap shall be free from burrs and sharp edges, and shall be designed and located in the assembly such that the possibility of injury to the occupant shall be minimized.

5.5.2 CORROSION RESISTANCE

Applicable hardware components shall meet the corrosion requirements of Appendix A.

5.5.3 TEMPERATURE RESISTANCE

Plastic or other nonmetallic hardware parts of a seat belt assembly when subjected to the conditions specified in Appendix D, shall not deteriorate in any manner to cause the seat belt assembly to operate improperly or fail to comply with applicable requirements of clause 5.

5.5.4 ATTACHMENT HARDWARE

5.5.4.1 The attachment hardware shall be designed to prevent attaching bolts and other parts from becoming inadvertently disengaged from the machine.

5.5.4.2 Attaching bolts shall have threads, having a fit equivalent to or tighter than 7/16-20 UNF-2A or ½-13 UNC-2A or the metric equivalent, M12.

5.5.4.3 Applicable test procedures 5.5.4.4 shall be used to determine attachment hardware strength. When more than one attachment bolt is used to secure a single piece of hardware to the machine, they shall be tested as a system and shall withstand the following applicable specified forces.

5.5.4.3.1 Attachment hardware other than the attaching bolts shall withstand the following tensile forces:

- a. One end of the pelvic portion of a seat belt assembly, 11.1 kN;
- b. Ends of two separate seat belt assemblies, 26.7 kN;

5.5.4.3.2 Attaching bolts used to secure the ends of seat belts to the seat belt anchorages shall withstand the following tensile forces:

- a. One end of the pelvic portion of a seat belt assembly, 22.2 kN.
- b. Ends of two separate seat belt assemblies, 40 kN.

- 5.5.4.4 Attaching bolts or other substitute attachment means used to secure the pelvic restraint of a seat belt assembly to a machine shall be tested in a manner similar to that shown in Figure 9. The force shall be applied at an angle of 45 degrees to the axis of the bolt through attachment hardware from the seat belt assembly, or through a special fixture, which simulates the loading, applied by the attachment hardware. When bolts are used, the attachment hardware or simulated fixture shall be fastened by the bolt to the anchorage shown in Figure 9, which has a standard 7/16-20 UNF-2A or 1/2-13 UNC-2A or the metric equivalent, M12 threaded hole in a hardened steel plate of at least 10 mm in thickness. The bolt shall be tested when installed two full turns from the fully seated position, see Figure 9. The appropriate force required by 5.5.4.3 shall be applied. The bolts or other attachment means from each of three seat belt assemblies shall be tested. Other attachment means shall be tested in a manner, which simulates usage.

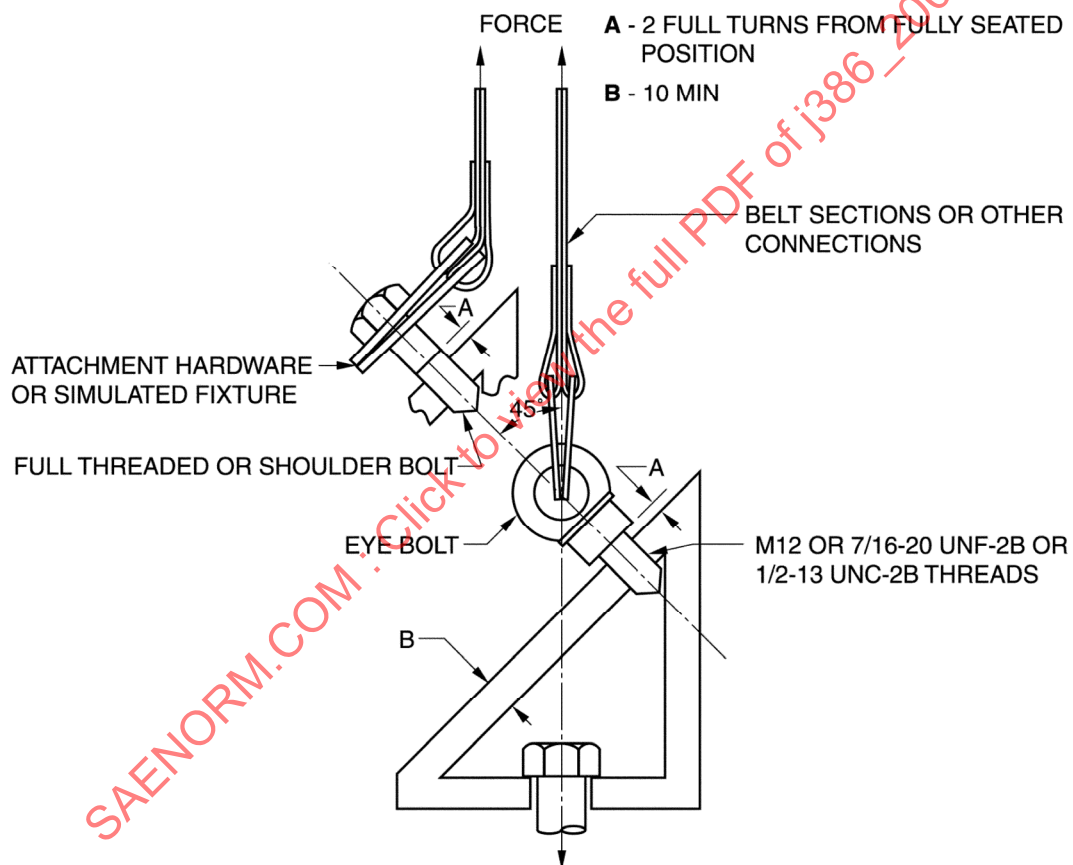


FIGURE 9—ATTACHING BOLTS TEST FIXTURE
(DIMENSIONS IN mm)

- 5.5.4.5 A seat belt assembly, having single attachment hooks of the quick disconnect type of connecting strap to an eye bolt, shall be provided with a retaining latch or keeper which shall not move more than 2 mm in either the vertical or horizontal direction when tested. The test shall be performed using three single attachment hooks for connecting strapping to an eye bolt. The test shall be conducted as follows:

- The hook shall be held rigidly so that the retainer latch or keeper, with cotter pin or other locking device in place, is in a horizontal position as shown in Figure 10;
- A force of $665 \text{ N} \pm 9 \text{ N}$ shall be applied vertically upward as near as possible to the free end of the retainer latch, and the movement of the latch at the point of force application shall be measured;
- The vertical force shall be released, and a force of $665 \text{ N} \pm 9 \text{ N}$ shall be applied horizontally as near as possible to the free end of the retainer latch;
- The movement of the latch at the point of force application shall be measured;
- Alternatively, the hook may be held in other positions, provided that the forces and the movements of the latch are measured at the points indicated in Figure 10.

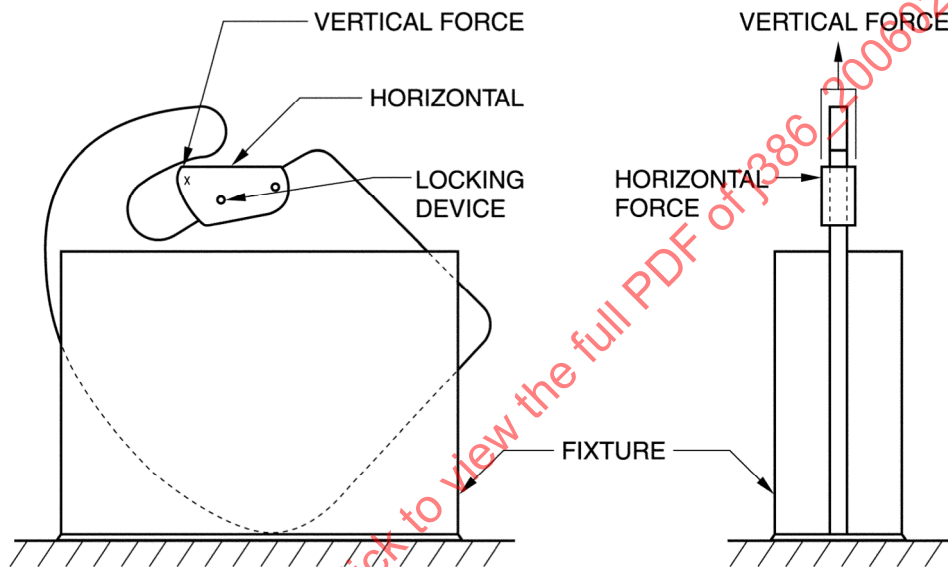


FIGURE 10—SINGLE ATTACHMENT HOOK RETENTION

6. Notes

6.1 Marginal Indicia

The change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE SUBCOMMITTEE SC4—SEATING AND RIDE
OF THE SAE HUMAN FACTORS TECHNICAL COMMITTEE