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NFPA 1931 Design, and Design Verification Tests for Fire Department Ground Ladders 1984 Edition

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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NFPA 1931

Standard on

Design, and Design Verification Tests for

Fire Department Ground Ladders

1984 Edition

This edition of NFPA 1931, *Standard on Design, and Design Verification Tests for Fire Department Ground Ladders*, was prepared by the Technical Committee on Fire Department Equipment, and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 21-24, 1984 in New Orleans, Louisiana. It was issued by the Standards Council on June 14, 1984, with an effective date of July 5, 1984, and supersedes all previous editions.

The 1984 edition of this standard has been approved by the American National Standards Institute.

Origin and Development of NFPA 1931

NFPA 193, *Standard on Fire Department Ladders, Ground and Aerial*, was first presented to the Association in 1954 and was tentatively adopted as a standard on aerial ladder testing. In 1955 it received final adoption.

In 1957, a subcommittee of the NFPA Committee on Fire Department Equipment prepared new material covering recommendations for portable ladders, ground ladders and aerial ladders — their use, maintenance and testing. In addition, revision was made in the section pertaining to testing aerial ladders. These changes were approved at the 1958 Annual Meeting and were adopted by the NFPA Board of Directors June 30, 1958.

In 1959, Article 100, covering specifications for aluminum ground ladders for fire department use, was adopted by the Association on recommendations by the Committee on Fire Department Equipment. No other change was made.

In May 1972, a complete revision of the 1959 edition of NFPA 193 was approved. During 1974 and 1975, NFPA 193 was studied in detail by a subcommittee of the NFPA Technical Committee on Fire Department Equipment and it was felt that NFPA 193 should be separated into two documents since the conditions of use of ground ladders and aerial ladders were so widely divergent. The subcommittee also recommended that the material on aerial ladders be made a recommended practice rather than a standard.

Due to a renumbering of fire service standards, the *Standard on Fire Department Ground Ladders* was designated as NFPA 1931 in 1975.

The 1979 edition once again made the document a standard rather than a recommended practice and incorporated extensive revision including editorial and style changes to bring the document into line with the NFPA Manual of Style, and to allow easier use by persons in the field.

In 1984, the Committee did a complete rewrite of the text and divided the requirements into two documents. NFPA 1931 now covers only requirements for manufacturers on the design, and design verification testing of new ground ladders. A new document, NFPA 1932, *Standard on Use, Maintenance and Service Testing of Fire Department Ground Ladders* now covers requirements for users of fire department ground ladders and the only testing, i.e., service testing, that is to be performed by users.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Chapter 5.

Chapter 1 Administration

1-1 Scope.

1-1.1* This standard specifies requirements for the design, and the design verification tests for fire department ground ladders. The tests specified herein are the responsibility of ladder manufacturers only and SHALL NOT be performed by fire departments.

1-1.2* This standard shall apply to all new ground ladders intended for use by fire department personnel for rescue, fire fighting operations, and training. These ladders are not intended for, and shall not be used for any other purpose.

1-2* Purpose.

1-2.1 This standard shall provide the manufacturer of fire department ground ladders with a set of performance and dimensional requirements against which the product shall be checked. It is not the purpose of this standard to specify the details of construction. Limitations imposed are for the purpose of providing reasonable safety requirements and establishing test methods.

1-2.2 Fire department ground ladders constructed to, and certified as meeting the requirements of this standard will provide reasonable safety for fire fighters and victims during use provided that the requirements of NFPA 1932, *Standard on Use, Maintenance, and Service Testing of Fire Department Ground Ladders*, are complied with by the fire departments who purchase or use ground ladders meeting the requirements of this standard.

1-3* Definitions.

Angle of Inclination. The preferred pitch for portable, non-self-supporting ground ladders which is 75½ degrees.

Approved.* Acceptable to the authority having jurisdiction.

Attic Extension Ladder. An extension ladder that is specifically designed to be used to gain entry through a scuttle, hatch, or other similar restricted opening.

Authority Having Jurisdiction.* The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

Base (Bed) Section. The lowest, or widest, section of non-self-supporting ground ladders.

Beam (Side Rail). The main structural side of the ground ladder.

Bedded Position. The position in which fly section(s) of extension ladders are stored in the nonextended position with the pawls resting on a rung of the supporting section.

Butt. The end of the beam placed on the ground, or other lower support surface when ground ladders are in the raised position. It may be the lower end of beams or added devices.

Butt Spurs (Foot). That component of ground ladder support which is in contact with the lower support surface to reduce slippage. It may be the lower end of beams or added devices.

Collapsible Ladder. See Folding Ladder.

Combination Ladder. A ground ladder capable of being used both as a step ladder, and single or extension ladder.

Design Verification Tests. Tests of the design ladder structure and components thereof. These design verification tests are the responsibility of the ladder manufacturer and are only to be performed on new, unused ladders.

Designated Design Strength. The necessary strength to pass all test requirements in this standard.

Designated Length. The length marked on the ladder.

Dogs. See Pawls.

Extension Ladder. A non-self-supporting ground ladder adjustable in length. It consists of two or more sections traveling in guides, brackets, or equivalent so arranged as to permit length adjustment.

Fire Department Ground Ladder. All ground ladders specifically designed for fire service use that are in the possession of a fire department or other fire service organization, and that are used for, or intended to be used for rescue, fire fighting operations, or training.

Fly Section. Upper section(s) of an extension ladder. The first section above the base section is the first fly section, the second section above the base section is the second fly section, etc.

Folding Ladder. A single ladder designed so that the rungs can be folded or moved in a manner to allow the beams to be brought into a position of touching each other, or nearly touching each other, for storage or carrying purposes.

Ground Ladder. Ladders not mechanically or physically attached permanently to fire apparatus, and not requiring mechanical power from the apparatus for ladder use and operation.

Halyard. Rope used on extension ladders for the purpose of raising fly section(s). A wire cable may be referred to as a halyard when used on the uppermost fly section(s) of three or four section extension ladders.

Heat Sensor Label. A label that turns color at a preset temperature to indicate a specific heat exposure.

Inside Ladder Width. The distance measured from the inside edge of one beam to the inside edge of the opposite beam. (See also: Outside Ladder Width).

Ladder. A device on which a person climbs for accending or decending. This device shall consist of two beams (side rails) joined at regular intervals by cross pieces called rungs on which a person is supported during this climb. (See also: Pompier Ladder, an exception to this definition.)

Ladder Nesting. The procedure whereby ladders of different sizes are positioned partially within one another to reduce the amount of space required for their storage on the apparatus.

Maximum Extended Length. The total length of the extension ladder when all fly sections are fully extended and pawls engaged.

May. This term is used to state a permissive use, or an alternative method to a specified requirement.

Outside Ladder Width. The distance measured from the outside edge of one beam to the outside edge of the opposite beam, or the widest point of the ladder including staypoles when provided, whichever is greater. (See also: Inside Ladder Width.)

Pawls. Devices attached to fly section(s) for the purpose of anchoring fly section(s) when extension ladders are used in the extended position. Pawls engage ladder rungs near the beams for anchoring purposes.

Permanent Deformation (Set). That deformation remaining in any part of a ladder or its components after all test loads have been removed from the ladder.

Pompier Ladder (Scaling Ladder). A ladder having a single center beam only and with a large hook on top used for scaling.

Roof Ladder. A single ladder equipped with hooks at the top end of the ladder.

Rungs. The ladder cross pieces on which a person steps while ascending or decending.

Scaling Ladder. See Pompier Ladder.

Set. See Permanent Deformation.

Shall. Indicates a mandatory requirement.

Should. This term, as used in Appendix A, indicates a recommendation or that which is advised but not required.

Side Rail. See Beam.

Single Ladder. A non-self-supporting ground ladder, non-adjustable in length, consisting of only one section.

Staypoles (Tormentors). Poles attached to each beam of the base section of extension ladders and used to assist in the raising of the ladder and to help provide stability of the raised ladder.

Tested. Verification of compliance with test requirements as specified in this standard.

Test Failure. Failure of the ground ladder structure, or components thereof, to pass the required tests.

Tip. The end of the beam opposite the ladder butt.

Tormentors or Tormentor Poles. See Staypoles.

Ultimate Failure. Collapse of a ground ladder structure or component thereof.

Visible Damage. Damage that is clearly evident by visual inspection without recourse to optical measuring devices.

Visual Inspection. Inspection by the eye without recourse to any optical devices, except prescription eyeglasses.

Chapter 2 Ladder Design

2-1 Requirements for All Ground Ladders.

2-1.1 Ground ladders shall be constructed in a manner so as to ensure that structural and workmanship defects do not exist. Sharp edges, burrs in excess of $\frac{1}{64}$ in., or other defects that may cut or tear clothing or skin, or resulting in inadequate structural strength, shall be considered workmanship defects.

2-1.2 Materials used in ground ladder construction shall be of sufficient strength to meet the performance requirements of this standard.

2-1.3 The beams, at the tip of each section of ground ladders, shall be rounded to allow the ladder to slide on irregular surfaces without catching or snagging during placement or operations.

Exception: Combination ladders, folding ladders, and pompier ladders shall be excluded from this requirement.

2-1.4 Rungs shall not be less than 1¼ in. in diameter.

Exception: Folding and pompier ladder rungs shall be excluded from this requirement.

2-1.5 Rungs shall be spaced on 14 ± ⅛ in. centers.

2-1.6 Butt spurs shall be provided on the butt end of each beam of single ladders, and the butt end of each beam of the base section of extension ladders.

2-1.7 Ladder Marking.

2-1.7.1 The designated length of the ground ladder shall be marked within 12 in. of the butt of each beam of single ladders, and each beam of the base section of extension ladders. Such markings shall be visible when ground ladders are in the bedded position and mounted on fire apparatus.

2-1.7.2 Ground ladders meeting all requirements of this standard shall be so certified by the ladder manufacturer, and a label stating that the ground ladder meets these requirements shall be affixed to the ladder.

2-1.7.3 All ground ladders shall bear a unique individual identification number or alpha-numeric code, and month and year of manufacture. This identification shall be branded, or metal stamped on the ground ladder, or to a metal plate permanently attached to the ground ladder by welding, riveting, or bolting.

2-1.7.4 All ground ladders shall bear an electrical hazard warning label.

2-1.8 Additional Requirements for Metal Ground Ladders Only.

2-1.8.1 When varying types of metal are used in construction of metal ground ladders, they shall be chosen or finished so as to avoid or minimize electrolytic action.

2-1.8.2 All structural components of metal ground ladders shall be constructed of materials that maintain at least 75 percent of their designated design strength at a minimum of 300°F.

2-1.8.3* Rungs on metal ground ladders shall be constructed of a heavy-duty corrugated, serrated, knurled, or dimpled material, or coated with a skid-resistant material.

2-1.8.4 Heat Sensor Labels.

2-1.8.4.1 All metal ground ladders shall bear heat sensor labels preset for 300°F.

2-1.8.4.2 Heat sensor labels shall be located on the inside of each beam of each section immediately below the second rung from the tip of each section, and immediately below the third rung above the ladder butt.

2-1.9 Additional Requirements for Fiberglass Ground Ladders Only.

2-1.9.1 All structural components of fiberglass ground ladders shall be constructed of materials that maintain at least 75 percent of their designated design strength at a minimum of 300°F.

2-1.9.2* Rungs on fiberglass ground ladders shall be constructed of a heavy-duty corrugated, serrated, knurled, or dimpled material, or coated with a skid-resistant material.

2-1.9.3 Heat Sensor Labels.

2-1.9.3.1 All fiberglass ground ladders shall bear heat sensor labels preset for 300°F.

2-1.9.3.2 Heat sensor labels shall be located on the inside of each beam of each section immediately below the second rung from the tip of each section, and immediately below the third rung above the ladder butt.

2-2 Additional Requirements for Single Ladders Only.

2-2.1 These design requirements shall be in addition to the design requirements specified in Section 2-1 of this chapter.

2-2.2 Length.

2-2.2.1* The designated length of a single ladder shall be the length of one beam excluding any butt spur. The actual length of the beam shall not be less than the designated length.

2-2.3 Width.

2-2.3.1 The minimum inside width between beams for single and roof ladders shall not be less than 16 in.

2-3 Additional Requirements for Roof Ladders Only.

2-3.1 These design requirements shall be in addition to the design requirements specified in Sections 2-1 and 2-2 of this chapter.

2-3.2 Only single ladders may be provided with folding roof hook assemblies for use in roof operations.

2-3.3 Folding Roof Hook Assemblies.

2-3.3.1* Folding roof hooks shall be solid steel and directionally spring locked. The point of the roof hook that engages the roof shall be tapered to reduce slippage.

2-3.3.2 Folding roof hook assemblies shall be attached to the beams in an manner that does not appreciably weaken the beams.

2-4 Additional Requirements for Extension Ladders Only.

2-4.1 These design requirements shall be in addition to the design requirements specified in Section 2-1 of this chapter.

2-4.2 Construction.

2-4.2.1 Extension ladders shall be constructed with a permanently affixed stop installed by the manufacturer to prevent their overextension. The manufacturer shall determine the location of this permanently affixed stop to assure that the test requirements of this standard are met when the ladder is extended to maximum extended length.

2-4.2.2 Extension ladders shall not be constructed in a manner or method which necessitates the elimination of a rung on any section.

2-4.2.3 Extension ladders shall be constructed in a manner so that rungs of each section shall align with the rungs of other sections when the ladder is extended and pawls are engaged.

2-4.3 Length.

2-4.3.1* The designated length of an extension ladder shall be the maximum extended length along the beams on one side excluding any butt spur. The minus tolerance of the designated length shall not exceed 6 in.

2-4.4 Width.

2-4.4.1 Extension ladders shall have a minimum inside width between beams on any section of not less than 16 in.

2-4.4.2 Attic extension ladders shall have a minimum inside width between beams on any section of not less than 7½ in.

2-4.5 Hardware.

2-4.5.1 Hardware shall meet the minimum strength requirements of the ground ladder's component parts, and shall be corrosion resistant or protected against corrosion.

2-4.6 Halyard and Pulley.

2-4.6.1 Extension ladders over l6 ft in designated length shall be equipped with a halyard and pulley system.

2-4.6.2 The pulley shall be attached to the ladder in a manner so as not to appreciably weaken either the rungs or the beams.

2-4.6.3 The pulley shall not be less than 1¼ in. in diameter measured at the base of the sleeve.

2-4.6.4 The halyard shall not be less than ⅜ in. in diameter having a minimum breaking strength of 825 lb and shall be of sufficient length for the purpose intended. Splices shall not be allowed.

2-4.6.5 On three and four section extension ladders, all fly sections beyond the first fly section may be extended by wire rope. Such wire rope shall not be less than 5/16 in. in diameter. When wire rope is used, a means for adjusting the length of wire rope shall be provided. Splices shall not be allowed.

2-4.7 Pawls.

2-4.7.1 Pawls shall be of a positive mechanical action type and shall engage a rung of the supporting section.

2-4.7.2 Pawls shall be fastened or secured to beams in a manner so that vibration and use will not cause bolts and nuts to loosen.

2-4.7.3 Pawls shall be contructed so that the hook portion of the pawl that engages or rests on the rung shall have sufficient bearing surface or area so as to prevent the hook from cutting into the rung(s) when engaged.

2-4.7.4 The hooks on pawls shall be finished in a manner to avoid sharp edges and points.

2-4.7.5 Pawls shall be designed and attached so that they will rest on the rungs as near the beams as possible.

2-4.8 Staypoles.

2-4.8.1 Staypoles shall be furnished on all extension ladders of 40 ft or greater designated length.

2-4.8.2 All staypoles shall be permanently attached to the ground ladder with universal swivel mounts and shall not be removed for ladder nesting.

2-4.8.3 Staypole spikes shall not project beyond the butt of the base section when the extension ladder is in the bedded position.

2-5 Additional Requirements for Combination Ladders Only.

2-5.1 These design requirements shall be in addition to the design requirements specified in Section 2-1 of this chapter.

2-5.2 Length.

2-5.2.1 The designated length of combination ladders shall be determined in the single or extension configuration.

2-5.2.2 The designated length of combination ladders shall not exceed 16 ft.

2-5.3 Width.

2-5.3.1 The minimum inside width between beams for combination ladders shall not be less than 16 in.

2-6 Additional Requirements for Folding Ladders Only.

2-6.1 These design requirements shall be in addition to the design requirements specified in Section 2-1 of this chapter.

2-6.2 Construction.

2-6.2.1 All folding ladders shall be equipped with foot pads to prevent slippage. The pads shall have a nonskid or skid reducing material on the bottom side of the foot pad.

2-6.2.2 Folding ladders shall have a positive locking device to hold the ladder in the open position.

2-6.3 Length.

2-6.3.1 The designated length of folding ladders shall not exceed 14 ft.

2-6.4 Width.

2-6.4.1 The minimum inside width between beams for folding ladders in the open position shall not be less than 7½ in.

2-7 Additional Requirements for Pompier Ladders.

2-7.1 These design requirements shall be in addition to the design requirements specified in Section 2-1 of this chapter.

2-7.2 Construction.

2-7.2.1 Pompier ladders shall be equipped with a serrated steel hook permanently fastened to the center beam of the ladder.

2-7.2.2 Pompier ladders shall be equipped with a minimum of two stand-off brackets. Each stand-off bracket shall maintain a minimum distance of 7 in. between the center line of the rung and the portion of the bracket that contacts the wall.

2-7.3 Length.

2-7.3.1 The designated length of pompier ladders shall not exceed 16 ft.

2-7.4 Width.

2-7.4.1 The minimum overall width of the rungs shall be 12 in.

Chapter 3 Design Verification Tests

3-1 Requirements for All Design Verification Tests.

3-1.1 Design verification tests shall be conducted during the initial evaluation of a specific product design and thereafter whenever there is a change in the design, method of manufacturing, or material. Ladders subjected to design verification tests shall be destroyed after testing is completed.

3-1.2 Design verification tests shall not be conducted on ladders that have been in use or subjected to prior damage, misuse, or abuse.

3-1.3 Diligent effort and close attention to all details shall be exercised in setting up and conducting the tests as subtle variations in test techniques may introduce significant testing errors that can bias the testing results. Personnel inexperienced in ladder testing, even though otherwise professionally qualified, shall be especially careful to follow the test methods specified in this chapter.

3-1.4 Test loads shall be applied slowly, using extreme care to avoid impact loading during the test. Test loads shall remain in place for a minimum of one minute.

3-1.5 Conformance to the design verification test requirements shall be determined one minute after removal of test load.

3-2 Single, Extension, and Combination Ladder Design Verification Tests.

3-2.1 Horizontal Bending Tests.

3-2.1.1 The ladder shall be positioned for testing and tested as shown in Figure 3-2.1. The ladder shall be placed in a flat, horizontal position supported under the first rung from each end of the ladder. When extension and combination ladders are tested, the ladder shall be extended to the maximum extended length with pawls engaged.

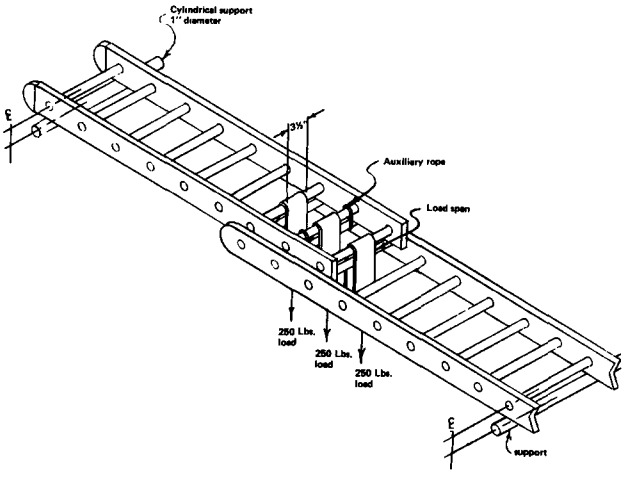


Figure 3-2.1 Design Verification Horizontal Bending Test.

3-2.1.2 Auxiliary means may be used to ensure that the ladder pawls remain engaged during the test to prevent movement of the fly section relative to the base section during the test.

3-2.1.3 A test load of 750 lb shall be distributed equally over a three-rung span at the center of the ladder. The load shall be applied to the center 3½ in. of each of the three rungs.

3-2.1.4 The ladder shall sustain the test load without ultimate failure.

3-2.2 Deflection Test.

3-2.2.1 The ladder shall be positioned for testing and tested as shown in Figure 3-2.2. The ladder shall be extended to the maximum extended length and set to the proper angle of inclination of 75½ degrees by positioning the base section a horizontal distance from the vertical wall equal to ¼ the effective working length of the ladder.

3-2.2.2 A test load of 500 lb shall be applied to the rung at the vertical center of the ladder adjacent to the beam over a span of 3½ in.

3-2.2.3 The butt spur on the beam opposite the test load shall remain in contact with ground or other supporting surface.

3-2.2.4 The test load shall be reapplied to area of rung adjacent to opposite beam, and the test repeated.

3-2.3 Rung Bending Strength Test.

3-2.3.1 The test shall be conducted on a test unit consisting of either a single section of the ladder, or on a three-rung test sample taken from the maximum width portion of a like ladder section with a like rung. The test unit shall be positioned for testing and tested as shown in Figure 3-2.3. The test unit shall be supported and the test load shall be applied using a standard loading block located in the center of the rung. The rung being tested shall not be braced.

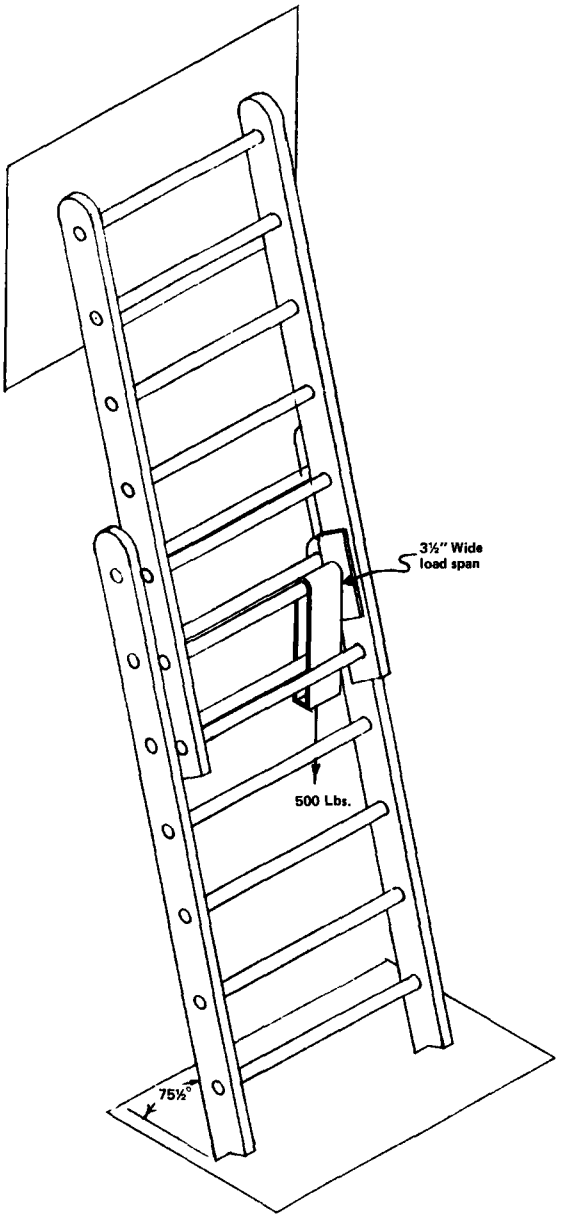


Figure 3-2.2 Design Verification Deflection Test.

3-2.3.2 A downward test load of 1000 lb shall be applied on the standard loading block.

3-2.3.3 Upon removal of the test load, the permanent deformation shall be measured with a straight edge and a rule, as shown in Figure 3-2.3. The allowable permanent deformation shall not exceed $\frac{L}{50}$ for rung length (L) measured between the beams.

3-2.3.4 There shall not be any permanent deformation greater than the allowed deformation as specified in 3-2.3.3, and there shall not be any other visible damage.

3-2.4 Rung-to-Beam Shear Strength Test.

3-2.4.1 The test shall be conducted on a test unit consisting of a single section of the ladder, or a three-rung

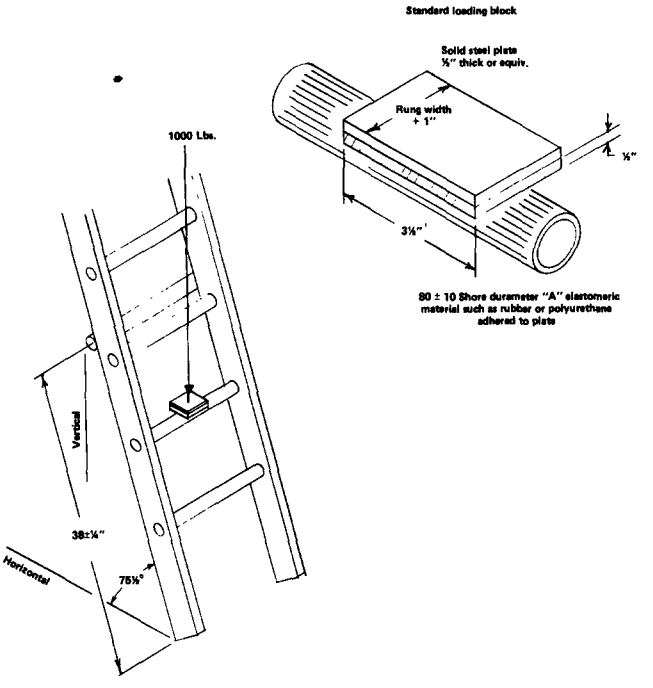


Figure 3-2.3 Design Verification Rung Bending Test.

test section taken from a like ladder having the same rung cross section and rung joint. The test unit shall be positioned for testing and tested as shown in Figure 3-2.4. The test unit shall be set at the proper angle of inclination of 75½ degrees.

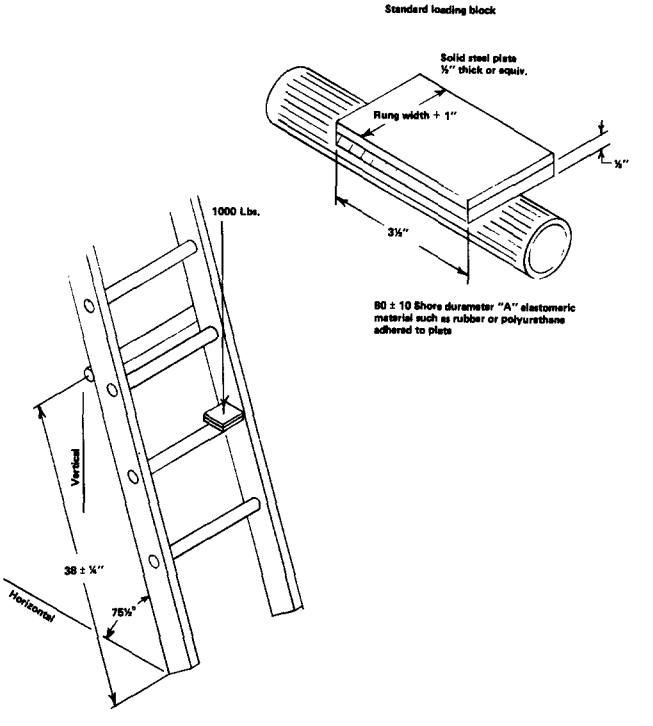


Figure 3-2.4 Design Verification Rung-to-Beam Shear Strength Test.

3-2.4.2 A downward test load of 1000 lb shall be applied on the widest like cross section, on both braced and unbraced test rungs, as near the beam as possible. When a 3-ft test section is used, the test shall be applied to the center rung. When single sections of a ladder are tested, the test load shall be applied to the third or fourth rung from the butt.

3-2.4.3 Upon removing the test load, the test unit shall show no permanent deformation or ultimate failure either in the fastening means attaching the rung or in the beam.

3-2.5 Rung Torque Test.

3-2.5.1 The test shall be conducted on a test unit consisting of either a single section of the ladder, or a short test section comprising at least one rung and two beams. The test unit shall be positioned for testing and tested as shown in Figure 3-2.5.

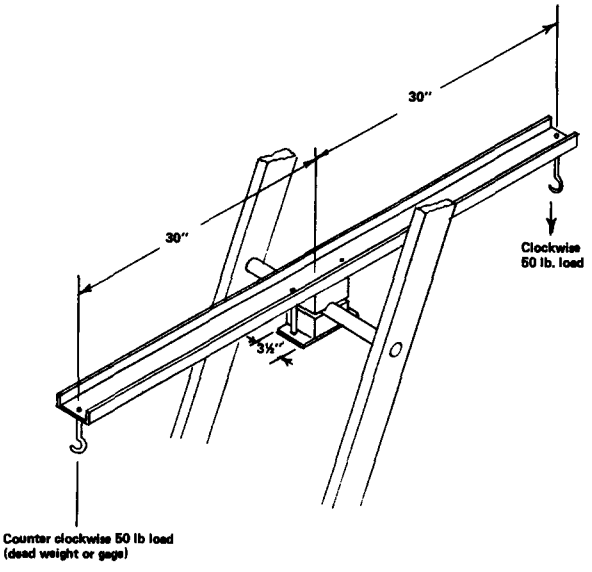


Figure 3-2.5 Design Verification Rung Torque Test.

3-2.5.2 A torque test load of 1500 inch-pounds shall be applied in a clockwise and then counterclockwise direction, alternately, for 10 cycles.

3-2.5.3 The rung joint shall be secured to the beams so that the alternating torque load shall not cause relative motion between the rung and the beams in excess of 9 degrees, based on a $\frac{1}{16}$-in. maximum movement for a $1\frac{1}{4}$-in. diameter round rung.

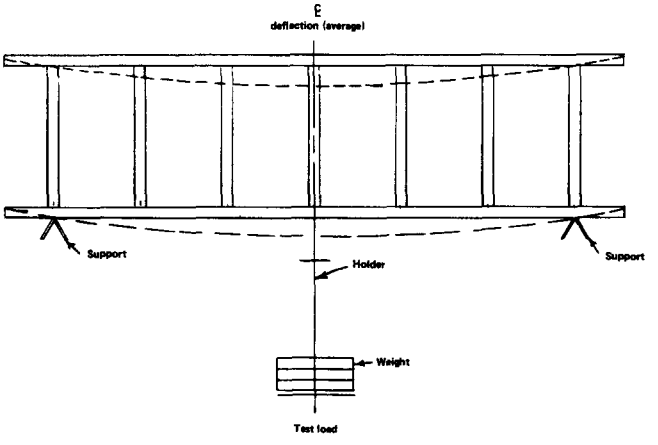
3-2.6 Side Sway Test.

3-2.6.1 The test shall be conducted on a test unit consisting of a single ladder, individual sections from an extension ladder, or individual sections from a combination ladder.

3-2.6.1.1 All sections of an extension ladder shall be individually tested.

3-2.6.1.2 Both sections of a combination ladder shall be individually tested.

3-2.6.2 The test unit shall be positioned for testing and tested as shown in Figure 3-2.6. The test unit shall be placed on edge, resting on level supports located directly under the top and bottom rungs. The beams shall be in an approximately horizontal plane, and the rungs shall be in the vertical plane and perpendicular to the ground.



The deflection is the difference between the height of the lower edge of the ladder side when unloaded (solid line) and when loaded (dotted line).

Figure 3-2.6 Design Verification Side Sway Test.

3-2.6.3 A preload of 60 lb shall be applied at the center of the span over a $3\frac{1}{2}$-in. length of the bottom beam, held for a period of 1 minute, and unloaded.

3-2.6.4 A test load of 140 lb shall then be applied to the center of the span over a $3\frac{1}{2}$-in. length of the bottom beam. The test load shall be applied by hanging weights from the bottom of the lower beam. Care shall be taken to ensure that the test load is centered with respect to the width of the beam.

3-2.6.5 Each test unit shall withstand this test without any permanent deformation in excess of 1/1000 of the effective span of the beams.

3-2.7 Beam Cantilever Bending Tests.

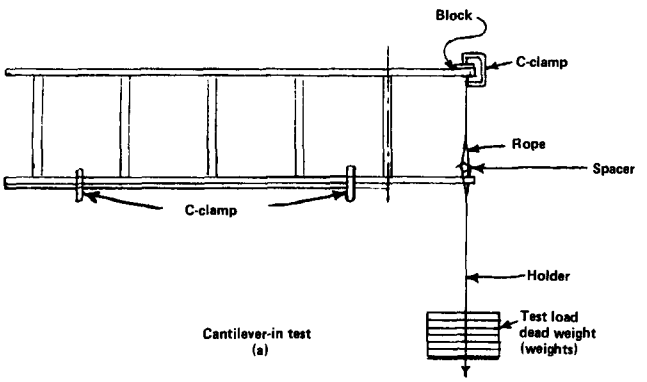
3-2.7.1 The test shall be conducted on a test unit consisting of either a single ladder section or the base section of an extension ladder; any butt spurs affixed to the section shall be removed before the test is conducted. The test unit shall be placed on edge with the rungs in a vertical plane. The lower beam shall be unsupported from the butt end to the midpoint of the lowest rung.

3-2.7.2 The test unit shall be positioned for testing and tested as shown in Figure 3-2.7(a). The test load shall be applied by means of a weight of 850 lb to the extreme bottom end of the upper beam. The test load shall be applied to a 2-in. wide, 1-in. thick block resting on the full width of the beam and held in place by a clamp. The block shall be 1 in. thick, 2 in. long measured along the

beam, and of width equal to the clear distance between flanges. The test load shall be suspended so that it is acting through the vertical neutral axis of the beam.

3-2.7.3 The allowable permanent deformation of the upper beam shall not exceed ½ in.

3-2.7.4 The test unit shall be positioned for testing and tested as shown in Figure 3-2.7(b). The test load shall then be applied to the extreme bottom end of the lower beam as specified in 3-2.7.2.



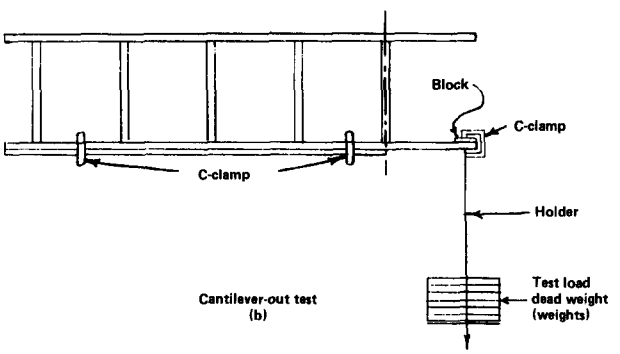


Figure 3-2.7(a) and (b) Design Verification Beam Cantilever Bending Test.

3-2.7.5 The allowable permanent deformation of the lower beam shall not exceed ½ in.

3-2.8 Ladder Section Twist Test.

3-2.8.1 The ladder shall be positioned for testing and tested as shown in Figure 3-2.8. The test shall be conducted on a ladder base section of at least 7 ft in length, supported over a 7-ft test span. The ladder shall be placed in a flat horizontal position and support for the ladder on one end shall be fixed. Attention shall be given to ensure that the ladder is tightly clamped onto the test fixtures during this test.

3-2.8.2 A preload of 600 inch-pounds shall be used to establish a reference for angular deflection, and shall be applied to the ladder in a clockwise direction for a minimum period of one minute after which the ladder shall be unloaded.

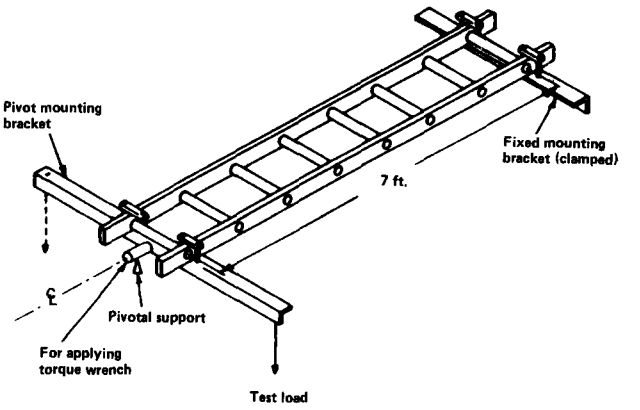


Figure 3-2.8 Design Verification Ladder Section Twist Test.

3-2.8.3 A test torque of 1200 inch-pounds shall then be applied in a clockwise direction. The test torque may be applied by either a torque wrench, or test loads applied alternately on each end of the arm.

3-2.8.4 The angle of twist measured from the horizontal position in the clockwise direction shall not be greater than 14 degrees.

3-2.8.5 Next, a preload of 600 inch-pounds shall be used again to establish a reference for angular deflection, and shall be applied to the ladder in a counterclockwise direction for a minimum period of one minute after which the ladder shall be unloaded.

3-2.8.6 A test torque of 1200 inch-pounds shall then be applied in a counterclockwise direction. The test torque may be applied by either a torque wrench, or test loads applied alternately on each end of the arm.

3-2.8.7 The angle of twist measured from the horizontal position in the counterclockwise direction shall not be greater than 14 degrees.

3-2.9 Butt Spur Slip Test.

3-2.9.1 All butt spurs for single and extension ladders shall be tested for skid resistance. The ladder shall be positioned for testing and tested as shown in Figure 3-2.9. The test unit shall consist of a 16-ft extension ladder extended to the maximum extended length and set at the proper angle of inclination of 75½ degrees.

3-2.9.2 The test surfaces shall be A-C plywood, the "A" surface of which shall be presanded using No. 320 fine wet/dry sandpaper. The "A" surface of the plywood shall be placed in contact with the butt of the test unit. The surface that the tip of the fly section rests against shall also be the "A" surface similarly treated.

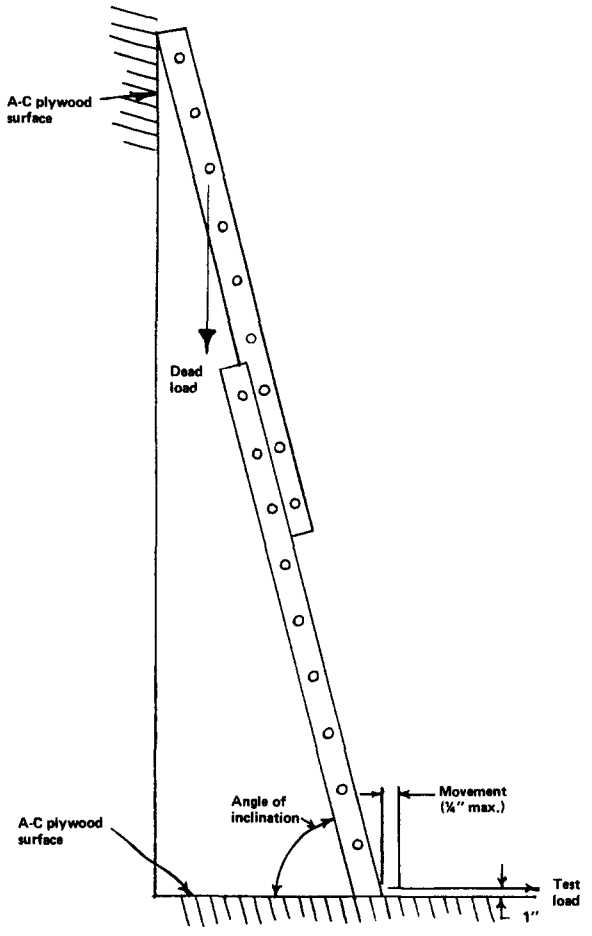


Figure 3-2.9 Design Verification Butt Spur Slip Test.

3-2.9.3 The grain on the vertical sheet under the upper end of the fly section shall run in a vertical direction, and the grain on the horizontal sheet under the base shall be parallel to the test load.

3-2.9.4 A test load of 500 lb shall be attached to the third rung from the tip of the fly section.

3-2.9.5 A horizontal pulling force of 50 lb applied to the bottom of the test unit at 1 in. above the test surface shall not cause movement in excess of ¼ in. across the test surface.

3-3 Additional Design Verification Tests for Roof Ladders Only.

3-3.1 These design verification tests shall be performed in addition to the design verification tests specified in Section 3-2 and the testing requirements specified in Section 3-1 of this chapter.

3-3.2 The ladder shall be positioned for testing and tested as shown in Figure 3-3.2. The ladder shall be hung solely by the roof hooks, with the hooks supported only by the points of the hooks, in a vertical position from a fixture capable of supporting the entire test load and weight of the ladder. The ladder shall be secured in such a manner to retain the ladder in the test position to prevent injury to test personnel if the hooks fail during the test.

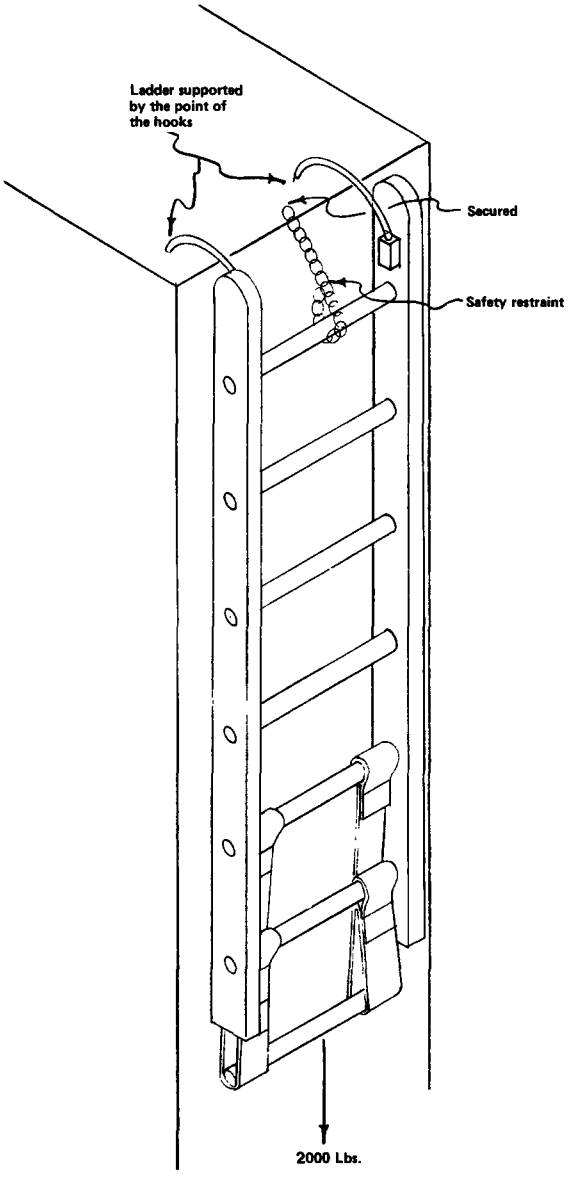


Figure 3-3.2 Design Verification Roof Hook Test.

3-3.3 A test load of 2,000 lb shall be placed over as many rungs as needed. The test load shall consist of weight increments consistent with safety and ease of handling.

3-3.4 Test load shall be applied for a minimum of one minute.

3-3.5 Ladder and roof hook assemblies shall sustain this test load with no damage to the structure, and any deformation to the hooks shall not exceed 5 degrees.

3-4 Additional Design Verification Tests for Extension and Combination Ladders Only.

3-4.1 These design verifications tests shall be performed in addition to the design verification tests specified in Section 3-2 and the testing requirements specified in Section 3-1 of this chapter.

3-4.2 Beam And Hardware Test.

3-4.2.1 The test shall be conducted on a test unit consisting of either the shortest full-size ladder manufactured, or a test section of sufficient length for test purposes. If a full-size ladder is used, the fly section shall be extended a minimum of one rung beyond the bedded position. Short test sections of extension ladders shall consist of portions of the base and fly sections with all the hardware or fittings attached.

3-4.2.2 The test unit shall be positioned for testing and tested as shown in Figure 3-4.2. The test unit shall be placed at the proper angle of inclination of 75½ degrees with both pawls engaged.

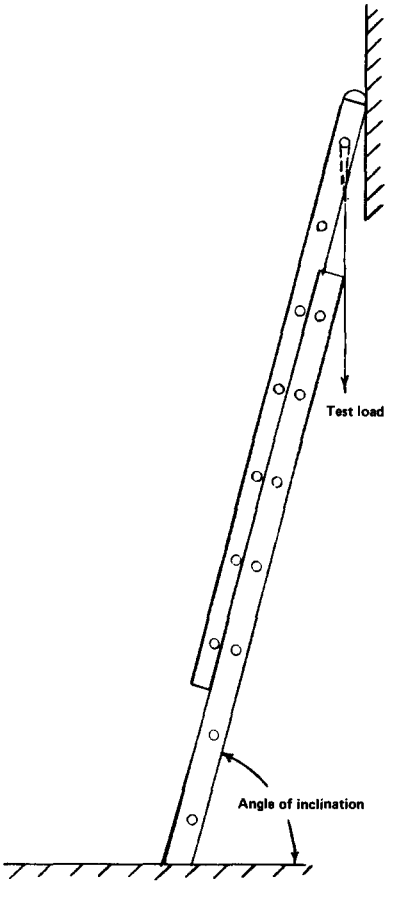


Figure 3-4.2 Design Verification Beam and Hardware Load Test.

3-4.2.3 A downward distributed test load of 2000 lb shall be applied to the top rung of the fly section.

3-4.2.4 The test unit shall sustain this test load with no permanent deformation or other visible weakening of the beams and hardware.

3-4.3 Single Pawl Load Test.

3-4.3.1 The ladder shall be positioned for testing and tested as shown in Figure 3-4.3. The test shall be conducted on a test unit consisting of a single pawl attached in its normal configuration to a sufficient length of beam for test purposes with the test unit set at the proper angle of inclination of 75½ degrees. The pawl shall be engaged over a fixed steel rod of the same diameter as a rung.

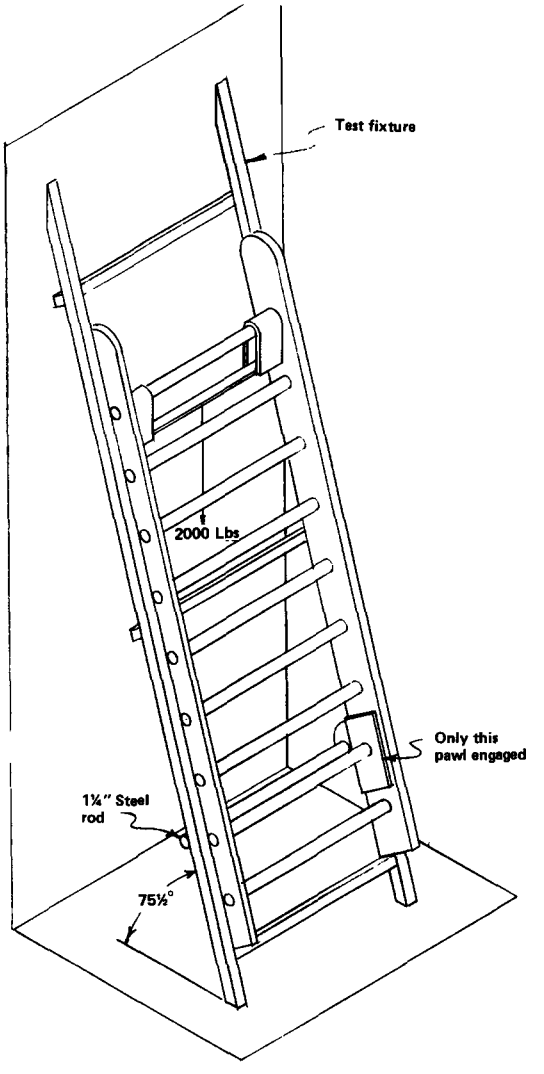


Figure 3-4.3 Design Verification Single Pawl Load Test.

3-4.3.2 A downward test load of 2000 lb shall be exerted on the end of the beam. The beam may be guided to prevent it from turning.

3-4.3.3 The test unit shall sustain this test load without disengagement of the pawl or disengagement of the pawl attachment to the beam.

3-4.4 Pawl Tip Load Test.

3-4.4.1 The test shall be conducted on a test unit consisting of either the shortest full-size ladder manufactured or a test section of sufficient length for test purposes. If a

full-size ladder is used, the fly section shall be extended a minimum of one rung beyond the bedded position. Short test sections shall consist of portions of the base and fly sections of the extension ladder with the pawls attached.

3-4.4.2 The test unit shall be positioned for testing and tested as shown in Figure 3-4.4. The test unit shall be set at the proper angle of inclination of 75½ degrees with oth pawls partially engaged. The butt end of the test unit shall be prevented from slipping by a block or equivalent means. The tip of each pawl shall bear on the center of a steel test fixture placed over the top of a rung. During the test, each pawl shall be prevented from pivoting by a means located adjacent to the pivot point of the pawl, but which shall not in any way affect that portion of the pawl under test.

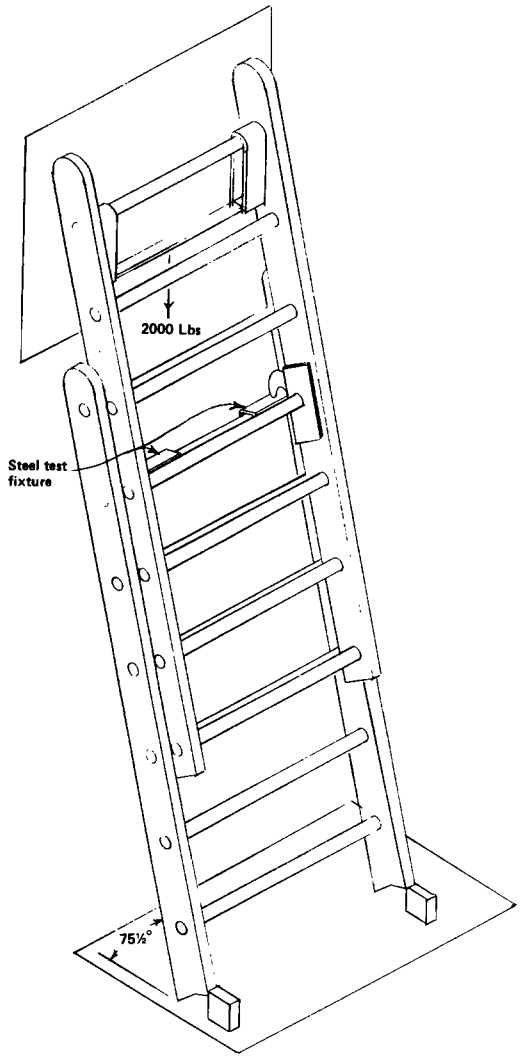


Figure 3-4.4 Design Verification Pawl Tip Test.

3-4.4.3 A downward distributed test load of 2000 lb shall be applied.

3-4.4.4 The test unit and components shall sustain the test load without ultimate failure.

3-5 Additional Design Verification Tests for Extension Ladders Only.

3-5.1 These design verification tests shall be performed in addition to the design verification tests specified in Sections 3-2 and 3-4, and the testing requirements specified in Section 3-1 of this chapter.

3-5.2 Cyclic Rung-Pawl Test.

3-5.2.1 This test shall not apply to fixed-type pawls used on extension ladders or combination ladders.

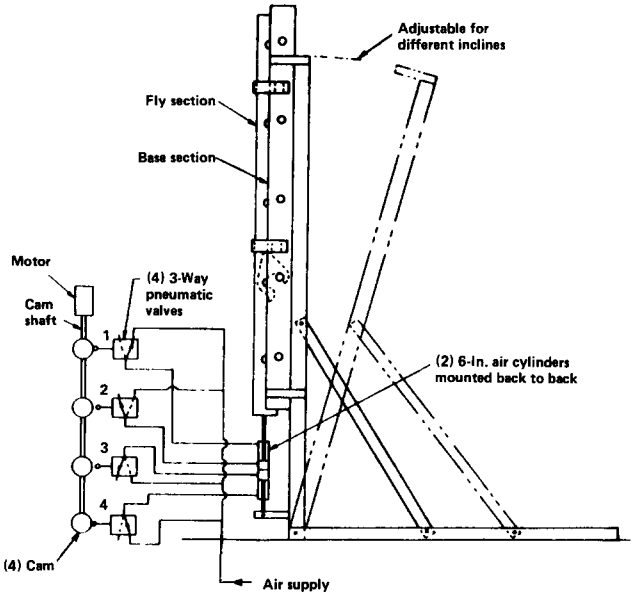
3-5.2.2 A machine equivalent to that shown in Figure 3-5.2(a) shall be used to operate the rung pawl through the following cycle, as shown in Figure 3-5.2(b).

(a) One 7-in. upstroke to allow rung pawl to engage rung,

(b) Full 7-in. downstroke to allow rung pawl on rung,

(c) Full 14-in. upstroke to disengage rung pawl,

(d) Full 14-in. downstroke to return rung pawl to starting position.



	Air-Valve Position			
Operating Cycle	No. 1	No. 2	No. 3	No. 4
Full upstroke	O	C	C	O
Full downstroke	C	O	O	C
One-half downstroke to latch	O	C	O	C
Downstroke to lock	C	O	O	C

Figure 3-5.2(a) Design Verification Cyclic Rung-Pawl Test.

3-5.2.3 Pawls shall be tested with the ladder set at the proper angle of inclination of 75½ degrees. The rung pawl may be manually lubricated prior to or during the test.

3-5.2.4 The stroke speed shall be 7 to 14 in. per second. A minimum of 6000 cycles shall be imposed.

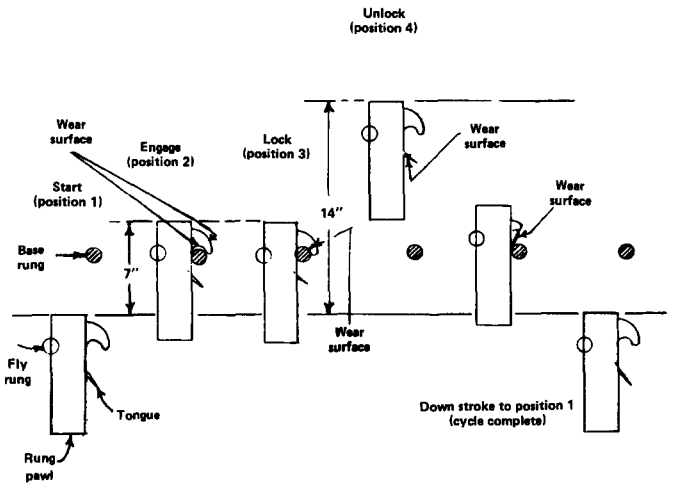


Figure 3-5.2(b) Design Verification Rung-Pawl Testing Cycle.

3-5.2.5 Any malfunction of the rung pawl or fracture of its components, including springs, shall be considered as a failure to meet this requirement. The presence of wear that does not affect the proper functioning of the pawl shall not constitute failure.

3-5.3 Multisection Extending Force Test.

3-5.3.1 The test shall be conducted on a complete extension ladder. The ladder shall be set in a 90-degree vertical position, in the bedded position. The base section may be braced or otherwise held to maintain vertical alignment.

3-5.3.2 A measured downward test force shall be applied to the rope if the ladder has a halyard and pulley system installed. The test force shall be smoothly applied to cause vertical extension of the fly section of 2 ft or more, at a rate of 6 to 12 in. per second. For those ladders not equipped with a halyard and pulley, the measured test force shall be applied vertically to the bottom rung of the fly section.

3-5.3.3 The maximum measured test force that occurs during each pull shall be recorded in pounds of pull. Three test pulls shall be done for each ladder and the maximum forces shall be averaged for the three pulls.

3-5.3.4 The average maximum pull pounds shall not exceed two times the weight of one ladder fly section.

3-6 Additional Design Verification Tests for Combination Ladders Only.

3-6.1 These design verification tests shall be performed in addition to the design verification tests specified in Sections 3-2 and 3-4, and the testing requirements specified in Section 3-1 of this chapter.

3-6.2 Compression Test.

3-6.2.1 The combination ladder shall be positioned for testing and tested as shown in Figure 3-6.2. The ladder shall be tested in its A-frame position, with the test load of 2000 lb applied uniformly to the top rungs.

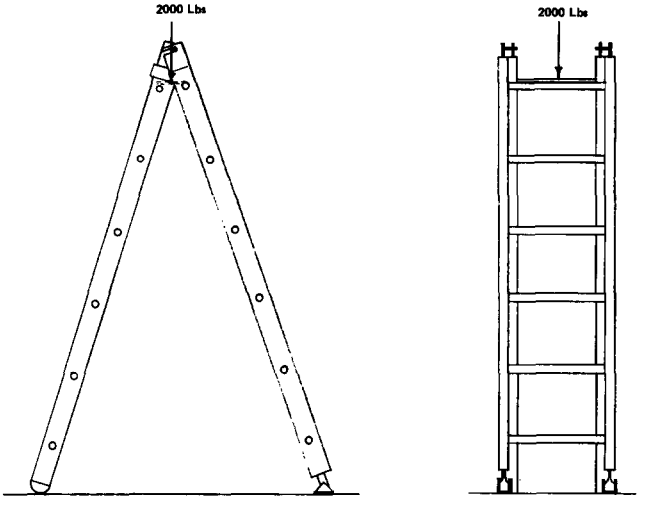


Figure 3-6.2 Design Verification Combination Ladder Compression Test.

3-6.2.2 The ladder shall sustain the test load without ultimate failure.

3-7 Design Verification Tests for Folding Ladders Only.

3-7.1 These design verification tests shall be performed in accordance with the design verification testing criteria specified in Section 3-1 in this chapter.

3-7.2 Horizontal Bending Test.

3-7.2.1 The ladder shall be positioned for testing and tested as shown in Figure 3-7.2. The folding ladder shall be placed in a flat, horizontal position supported 6 in. from each end.

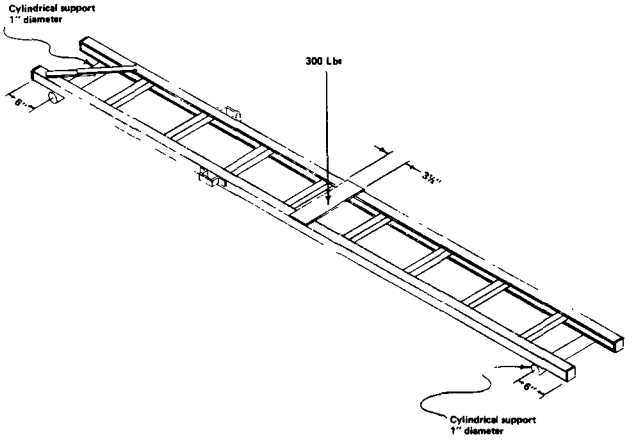


Figure 3-7.2 Design Verification Folding Ladder Horizontal Bending Test.

3-7.2.2 A test load of 300 lb shall be applied at the center of the ladder span equally distributed across both beams over an area of 3½ in.

3-7.2.3 The ladder shall withstand this test without ultimate failure.