NFPA 1931
Standard on Design of and Design Verification Test for Fire Department Ground Ladders

1999 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 1931

Standard on

Design of and Design Verification Tests for Fire Department Ground Ladders

1999 Edition

This edition of NFPA 1931, *Standard on Design of and Design Verification Tests for Fire Department Ground Ladders*, was prepared by the Technical Committee on Fire Department Ground Ladders and acted on by the National Fire Protection Association, Inc., at its May Meeting held May 17–20, 1999, in Baltimore, MD. It was issued by the Standards Council on July 22, 1999, with an effective date of August 13, 1999, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 1931 was approved as an American National Standard on August 13, 1999.

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. It was formally adopted as a standard in 1955.

In 1958, new material covering recommendations for portable ladders, ground ladders, and aerial ladders — their use, maintenance, and testing — was added. In addition, revision was made to the section pertaining to testing aerial ladders.

In 1959, requirements for aluminum ground ladders for fire department use were adopted by the Association.

In May 1972, a complete revision of the 1959 edition was adopted.

In 1975, the document was separated into two standards, NFPA 1931, dealing with ground ladders, and NFPA 1904, *Standard for Aerial Ladder and Elevating Platform Fire Apparatus*, dealing with the testing of aerial devices.

The 1979 edition incorporated extensive revisions, including editorial and style changes to bring the document into line with the NFPA *Manual of Style*.

In 1984, the text of NFPA 1931 was divided into two documents. NFPA 1931 contained the requirements for manufacturers on design and design verification testing for new ground ladders. A companion document, NFPA 1932, *Standard on Use, Maintenance, and Service Testing of Fire Department Ground Ladders*, covered requirements for the ground ladder user.

The 1989 edition of NFPA 1931 included additional requirements for labels, modified rung spacing, added requirements for securing halyards, and required staypoles to be stowable against the base section if they could not be properly deployed.

The 1994 edition added a table of ladder duty ratings, added additional requirements for wood ground ladders, and modified some of the labeling requirements. This 1999 edition incorporates minor editorial revisions to keep the standard current, removes some ambiguous wording, and editorially reorganizes some material.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in membership may have occurred. A key to classifications is found at the back of this document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on the design, inspection, testing, and use of ground ladders for the fire service.

Contents

NFPA 1931

Standard on

Design of and Design Verification Tests for Fire Department Ground Ladders

1999 Edition

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

Information on referenced publications can be found in Chapter 5 and Appendix B.

Chapter 1 Administration

1-1 Scope.

1-1.1* This standard specifies requirements for the design of and the design verification tests for fire department ground ladders. The tests specified herein shall be 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 shall not be used for any other purpose.

1-2* Purpose. This standard shall provide the manufacturer of fire department ground ladders with a set of performance requirements against which ladders shall be certified. It is not the purpose of this standard to specify the details of construction. The limitations imposed are for the purpose of providing reasonable safety requirements and establishing test methods.

1-3 Definitions.

Angle of Inclination. The pitch for portable, non–self-supporting ground ladders.

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 similarly restricted opening.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

Bark Pocket. See *Wood Irregularities, Bark Pocket.*

Base (Bed) Section. The lowest or widest section of an extension ladder.

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

Bedded Position. The position in which the fly section(s) of an extension ladder is fully retracted with the pawls engaged.

Butt. The end of the beam that is placed on the ground, or other lower support surface, when ground ladders are in the raised position. A butt can be the lower end of beams or can be added devices.

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

Check. See *Wood Irregularities, Check.*

Collapsible Ladder. See *Folding Ladder.*

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

Design Verification Tests. Tests of a ladder structure and components thereof to prove conformance to the requirements of this standard.

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.*

Duty Rating. The recommended in-service working load.

Extension Ladder. A non–self-supporting ground ladder that is adjustable in length. An extension ladder consists of two or more sections traveling in guides, brackets, or the equivalent arranged so as to allow length adjustment.

Fire Department Ground Ladder. Any portable ladder specifically designed for fire department use in rescue, fire-fighting operations, or training, and not permanently attached to fire apparatus.

Fly Section(s). The upper section(s) of an extension ladder.

Folding Ladder. A single-section ladder with rungs that can be folded or moved to allow the beams to be brought into a position touching or nearly touching each other.

Halyard. Rope used on extension ladders for the purpose of raising a fly section(s).

Heat Sensor Label. A label that changes 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.

Knot. See *Wood Irregularities, Knot.*

Ladder. A device on which a person climbs for ascending or descending. This device consists 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.)*

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 all pawls are engaged.

Pawls. Devices attached to a fly section(s) for the purpose of anchoring the fly section(s) where 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.

Pitch Pocket. See *Wood Irregularities, Pitch Pocket.*

Pompier Ladder (Scaling Ladder). A ladder having a single center beam only with rungs protruding on either side of the beam and with a large hook on top that is 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 descending.

Scaling Ladder. See *Pompier Ladder.*

Set. See *Permanent Deformation.*

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Side Rail. See *Beam.*

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

Slope of Grain. See *Wood Irregularities, Slope of Grain.*

Split. See *Wood Irregularities, Split.*

Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

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

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

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

Tormentors or Tormentor Poles. See *Staypoles.*

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

Visible Damage. A permanent change in condition that is clearly evident by visual inspection without recourse to optical measuring or observation devices.

Visual Inspection. Observation by eye unaided by optical devices, except prescription eyeglasses or lenses.

Wood Irregularities. Natural characteristics in or on the wood that can lower its durability, strength, or utility.

Wood Irregularities, Bark Pocket.* An opening between annual growth rings that contains bark.

Wood Irregularities, Check. A separation of the wood along the fiber direction that usually extends across the rings of annual growth and commonly results from stresses set up in the wood during seasoning.

Wood Irregularities, Knot.* A portion of a branch or limb embedded in the tree and cut during the process of lumber manufacture.

Wood Irregularities, Pitch Pocket. An opening extending parallel to the annual growth rings that contains, or that has contained, either solid or liquid pitch.

Wood Irregularities, Slope of Grain.* A deviation of the fiber direction from a line parallel to the sides of the piece.

Wood Irregularities, Split. A separation of the wood parallel to the fiber direction due to tearing of the wood fibers.

Working Length. The length of a non–self-supporting portable ladder measured along the beams from the base support point of the ladder to the point of bearing at the top.

Chapter 2 Ladder Design

2-1 Requirements for All Ground Ladders.

2-1.1 Duty Rating. Ground ladders shall have a duty rating as specified in Table 2-1.1 when raised at a $75\,^1/_2$ degree angle of inclination.

Table 2-1.1 Ground Ladder Duty Rating

Type	Maximum Load	
	lb	kg
Folding ladders	300	136
Pompier ladders	300	136
Combination ladders	750	340
Single and roof ladders	750	340
Extension ladders	750	340

2-1.2 Materials of Construction. Materials used in ground ladder construction shall meet the performance requirements of this standard.

2-1.2.1 All structural components of ground ladders shall be constructed of materials that maintain at least 75 percent of their designated design strength at 300°F (149°C).

2-1.2.2 If varying types of metal are used in the construction of ground ladders, then the metals shall be chosen or finished to reduce electrolytic action.

2-1.2.3 Fiberglass materials shall meet the performance requirements of Chapter 7 of ANSI A14.5, *Ladders — Portable Reinforced Plastic — Safety Requirements.*

2-1.2.4 Wood components shall meet the requirements of Chapter 5 of ANSI A14.1, *Ladders — Portable Wood — Safety Requirements.* Wood irregularities shall not exceed the following:

(1) The general slope of the grain shall not be steeper than 1 in 15.
(2) Knots shall not appear, except that pin knots in rungs shall be permitted.
(3) Pitch and bark pockets shall be permitted, provided that there is not more than one that is $^1/_{32}$ in. (1 mm) in width, 2 in. (51 mm) in length, and $^1/_8$ in. (3 mm) in depth.
(4) Checks shall not be more than 2 in. (51 mm) in length or $^1/_8$ in. (3 mm) in depth.
(5) Splits shall not be more than 2 in. (51 mm) in length or $^1/_8$ in. (3 mm) in depth.
(6) Cracks shall not be permitted.
(7) Compression wood shall not be permitted.
(8) Cross grain shall not be permitted.

(9) Chambers associated with black streaks shall not be permitted.

2-1.3 Ladder Construction.

2-1.3.1 Ground ladders shall be constructed in a manner to ensure that structural and workmanship defects do not exist. Sharp edges, burrs in excess of $^1/_{64}$ in. (0.4 mm), or other defects that cut or tear clothing or skin or that result in inadequate structural strength shall be workmanship defects.

2-1.3.2 The beams at the tip of each section of a ground ladder 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, wall ladders, and pompier ladders shall be excluded from this requirement.

2-1.3.3 Butt spurs shall be provided on the butt end of each beam of single ladders and on the butt end of each beam of the base section of extension ladders.

2-1.3.4 Rungs shall not be less than $1^1/_4$ in. (32 mm) in diameter.

Exception No. 1: Folding and pompier ladder rungs shall be excluded from this requirement.

Exception No. 2: Swell center rungs on wood ladders shall be permitted to taper to $1^1/_8$ in. (28.6 mm).

2-1.3.5* Rungs shall be spaced on between 12-in. and 14-in. (305-mm and 356-mm) centers. Rungs shall be uniformly spaced $\pm\,^1/_8$ in. (±3 mm).

2-1.3.6* The surfaces of rungs that are designed for use while ascending, descending, working, or standing shall be corrugated, serrated, knurled, dimpled, or coated with a skid-resistant material across their entire width.

2-1.4 Ladder Marking.

2-1.4.1 The designated length of the ground ladder shall be marked within 12 in. (305 mm) of the butt of each beam of single ladders and on each beam of the base section of extension ladders.

2-1.4.2 Ground ladders that meet all of the requirements of this standard shall be so certified by the ladder manufacturer. A label stating that the ground ladder meets these requirements shall be affixed to the ladder.

2-1.4.3 All ground ladders shall bear a unique identification number or alphanumeric code and the month and year of manufacture. This identification shall be branded or metal-stamped on the ground ladder or stamped on a metal plate that is permanently attached to the ground ladder.

2-1.4.4 All metal ground ladders shall bear the electrical hazard warning label that is shown in Figure 2-1.4.4. The label shall be placed on the outside of each beam between $4^1/_2$ ft and 6 ft (1.37 m and 1.83 m) from the butt.

2-1.4.5 All fiberglass and wood ground ladders shall bear the electrical hazard warning label that is shown in Figure 2-1.4.5. The label shall be placed on the outside of each beam between $4^1/_2$ ft and 6 ft (1.37 m and 1.83 m) from the butt.

2-1.4.6 All ground ladders shall bear the ladder positioning label that is shown in Figure 2-1.4.6. The label shall be placed between $4^1/_2$ ft and 6 ft (1.37 m and 1.83 m) from the butt on the outside of both beams.

Exception: Single ladders that are designed to be asymmetrical shall be permitted to have the label without the word "out" and the directional arrow.

2-1.5 Heat Sensor Labels.

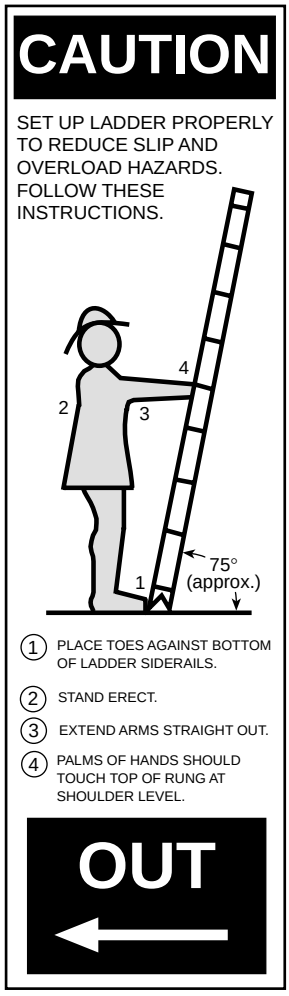
2-1.5.1 All metal and fiberglass ground ladders shall bear heat sensors that are preset for 300°F (149°C) ± 5 percent. Each heat sensor label shall bear an expiration year and wording that indicates that the expiration date is at the end of that year.

2-1.5.2 Heat sensor labels shall be located on the inside of each beam of each section of the ladder immediately below the second rung from the tip of each section and immediately below the center rung of that section.

Figure 2-1.4.4 Electrical hazard warning label for metal ground ladders.

Figure 2-1.4.5 Electrical hazard warning label for fiberglass and wood ground ladders.

Figure 2-1.4.6 Ladder positioning label.



2-2 Additional Requirements for Single Ladders Only. These design requirements shall be in addition to the design requirements specified in Section 2-1.

2-2.1* Length. 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.

2-2.2 Width. The minimum inside width between beams for single ladders shall be 16 in. (406 mm).

2-3 Additional Requirements for Roof Ladders Only. These design requirements shall be in addition to the design requirements specified in Sections 2-1 and 2-2.

2-3.1 Ladders with double-tapered beams shall not be used in roof operations.

2-3.2 Folding Roof Hook Assemblies.

2-3.2.1* Folding roof hooks shall be provided on all roof ladders. The roof hooks shall be directionally spring-locked and shall have tapered points to reduce slippage. The roof hooks shall meet the design verification tests of Section 3-3 and have a minimum opening of not less than 6 in. (150 mm), measured perpendicular from the outside of the beam to the point.

2-3.2.2 Folding roof hook assemblies shall be attached to the beams in a manner that does not appreciably weaken the beams.

2-4 Additional Requirements for Extension Ladders Only. These design requirements shall be in addition to the design requirements specified in Section 2-1.

2-4.1 Construction.

2-4.1.1 Extension ladders shall be constructed with a permanently affixed stop that is installed by the manufacturer. The stop shall prevent ladders from overextending. The manufacturer shall determine the location of this permanently affixed stop to ensure that the test requirements of this standard are met when the ladder is extended to maximum extended length.

2-4.1.2 Extension ladders shall not be constructed in a manner or method that necessitates the elimination of a rung on any section.

Exception: One of the lower two rungs of the fly section shall be permitted to be replaced by the steel cross bar of a halyard-actuated rung lock system.

2-4.1.3 Extension ladders shall be constructed in a manner so that the rungs of each section shall align with the rungs of other sections when the ladder is extended and pawls are engaged.

2-4.2* Length.

2-4.2.1 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. (152 mm).

2-4.2.2 Attic extension ladders shall not exceed 16 ft (4.9 m) in length.

2-4.3 Width.

2-4.3.1 Extension ladders shall have a minimum inside width between beams on any section of at least 16 in. (406 mm).

2-4.3.2 Attic extension ladders shall have a minimum inside width between beams on any section of not less than $7\frac{1}{2}$ in. (190 mm).

2-4.4 Hardware. Hardware shall meet the minimum strength requirements of the ground ladder's component parts. Hardware shall be corrosion resistant or protected against corrosion.

2-4.5 Halyard and Pulley.

2-4.5.1 Extension ladders over l6 ft (4.9 m) in designated length shall be equipped with a halyard and pulley system.

2-4.5.2 The pulley shall be attached to the ladder in a manner so as not to appreciably weaken either the rungs or the beams.

2-4.5.3 The pulley shall not be less than $1\frac{1}{4}$ in. (32 mm) in diameter, measured at the base of the sleeve.

2-4.5.4 The halyard shall not be less than $\frac{3}{8}$ in. (9.5 mm) in diameter and shall have a minimum breaking strength of 825 lb (374 kg). Splices shall not be permitted.

2-4.5.5 On three- and four-section extension ladders, all fly sections beyond the first fly section shall be permitted to be extended by wire rope. Such wire rope shall have a 5 to 1 safety factor while supporting 2 times the dead load weight of the fly section(s) that the cable is intended to raise. If wire rope is used, a means for adjusting the length of wire rope shall be provided. Splices shall not be permitted.

2-4.5.6* If a continuous halyard is used, a secondary means to secure the halyard from the ground prior to climbing shall be provided. The secondary means of securing the halyard shall be capable of supporting the pull on the halyard in case the pawl disengages while persons are on the ladder.

2-4.6 Pawls.

2-4.6.1 Pawls shall be of a positive, mechanical-action type and shall engage a rung of the supporting section.

2-4.6.2 Pawls shall be fastened or secured to beams in a manner such that vibration and use will not cause bolts and nuts to loosen.

2-4.6.3 Pawls shall be constructed to engage without cutting the rung.

2-4.6.4 The hooks on pawls shall be finished without sharp edges or points.

2-4.6.5 Pawls shall be designed and attached so that they rest on the rungs as near to the beams as possible.

2-4.7 Staypoles.

2-4.7.1 Staypoles shall be furnished on all extension ladders of over 40 ft (12.2 m) designated length.

2-4.7.2 All staypoles shall be permanently attached to the ground ladder and shall not be removed for ladder nesting.

2-4.7.3 Staypole spikes shall not project beyond the butt of the base section when the extension ladder is in the bedded position.

2-4.7.4 A means shall be provided to hold the staypoles in a secure position against the base section when the staypoles are not in use.

2-4.7.5 A label shall be provided on each staypole. The label shall be positioned between $4\frac{1}{2}$ ft and 6 ft (1.37 m and 1.83 m) from the butt of the pole. The label shall read:

CAUTION

Only place staypoles when both poles can be placed properly.

2-5 Additional Requirements for Combination Ladders Only. These design requirements shall be in addition to the design requirements specified in Section 2-1.

2-5.1 Length.

2-5.1.1 The designated length of combination ladders shall be determined in the single or extension configuration.

2-5.1.2 The designated length of combination ladders shall not exceed 16 ft (4.9 m).

2-5.2 Width. The minimum inside width between beams for combination ladders shall be 12 in. (305 mm).

2-6 Additional Requirements for Folding Ladders Only. These design requirements shall be in addition to the design requirements specified in Section 2-1.

2-6.1 Construction.

2-6.1.1 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.

2-6.1.2 Folding ladders shall have a positive locking device to hold the ladder in the open position.

2-6.2 Length. The designated length of folding ladders shall not exceed 14 ft (4.3 m).

2-6.3 Width. The minimum inside width between beams for folding ladders in the open position shall be $7\frac{1}{2}$ in. (190 mm).

2-7 Additional Requirements for Pompier Ladders. These design requirements shall be in addition to the design requirements specified in Section 2-1.

2-7.1 Construction.

2-7.1.1 Pompier ladders shall be equipped with a serrated steel hook that is permanently fastened to the center beam of the ladder.

2-7.1.2 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. (178 mm) between the centerline of the rung and the portion of the bracket that contacts the wall.

2-7.2 Length. The designated length of pompier ladders shall not exceed 16 ft (4.9 m).

2-7.3 Width. The minimum overall width of the ladder shall be 12 in. (305 mm).

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 shall be repeated thereafter whenever there is a change in the design, method of manufacturing, or material. The design verification tests shall be the responsibility of the manufacturer and shall be performed only on new, unused ladders. 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 have been subjected to prior damage, misuse, or abuse.

3-1.3 Test loads shall remain in place for a minimum of 5 minutes.

3-1.4 Conformance to the design verification test requirements shall be determined 1 minute after removal of the 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 shall be tested as shown in Figure 3-2.1.1. The ladder shall be placed in

a flat, horizontal position and 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 3-2.1.1 Position of ladder during design verification horizontal bending test.

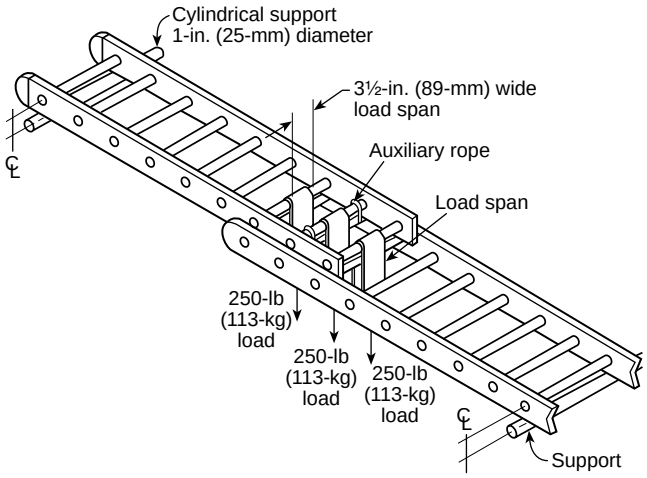
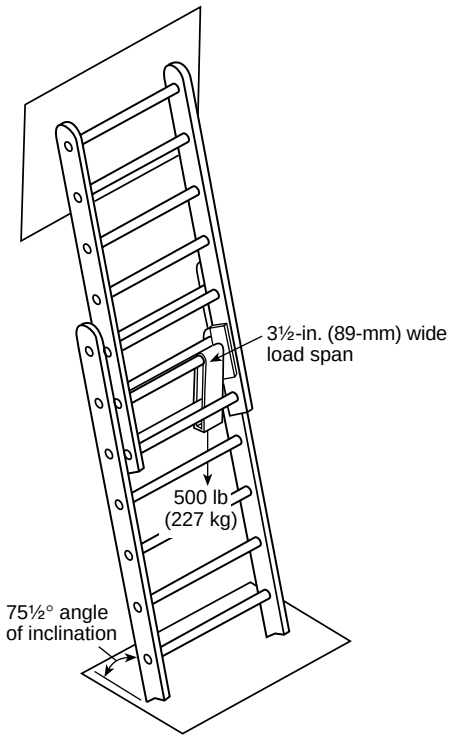


Figure 3-2.2.1 Position of ladder during design verification deflection test.



3-2.1.2 Auxiliary means shall be permitted to 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 (340 kg) shall be distributed equally over a three-rung span at the center of the ladder. The load shall be applied to the center $3\frac{1}{2}$ in. (89 mm) 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 shall be tested as shown in Figure 3-2.2.1. The ladder shall be extended to the maximum extended length and set to an angle of inclination of $75\frac{1}{2}$ degrees by positioning the base section at a horizontal distance from the vertical wall that is equal to one-fourth the effective working length of the ladder.

3-2.2.2 A test load of 500 lb (227 kg) shall be applied to the rung at the vertical center of the ladder adjacent to one of the beams over a span of $3\frac{1}{2}$ in. (89 mm).

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

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

3-2.3 Rung-Bending Strength Test.

3-2.3.1 The rung-bending strength test shall be conducted on a test unit that consists 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 shall be tested as shown in Figure 3-2.3.1. The test unit shall be supported and the test load shall be applied using a standard loading block that is located in the center of the rung. The rung being tested shall not be braced.

3-2.3.2 A downward test load of 1000 lb (454 kg) shall be applied on the standard loading block.

3-2.3.3 When the test load is removed, the permanent deformation shall be measured with a straight edge and a rule, as shown in Figure 3-2.3.1. The permitted permanent deformation shall not exceed $L/50$ for rung length (L), measured between the beams.

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

Figure 3-2.3.1 Design verification rung-bending test.

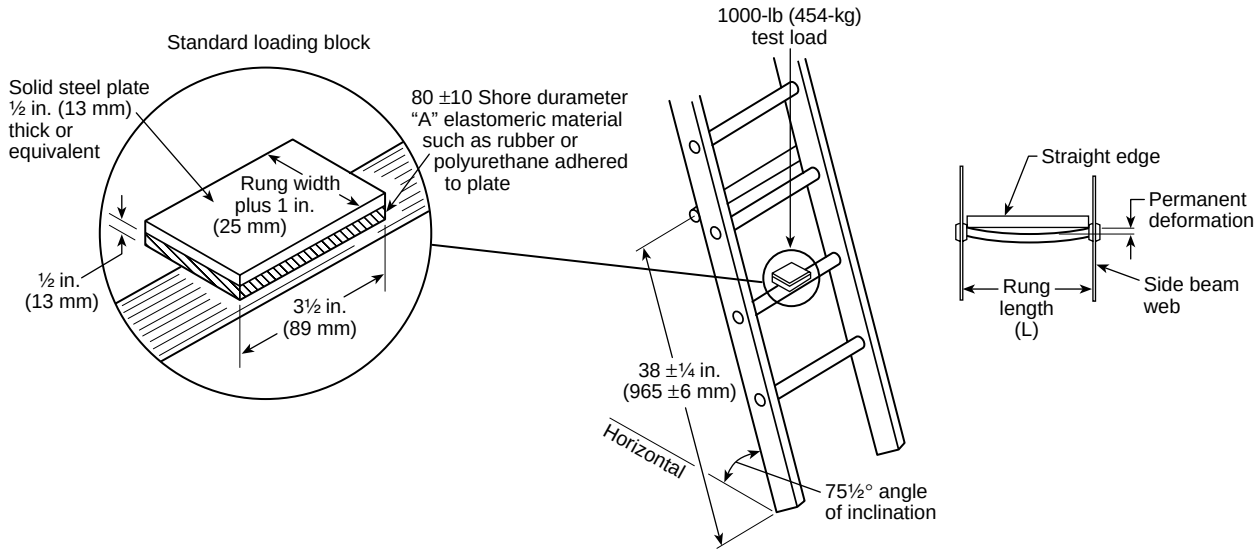
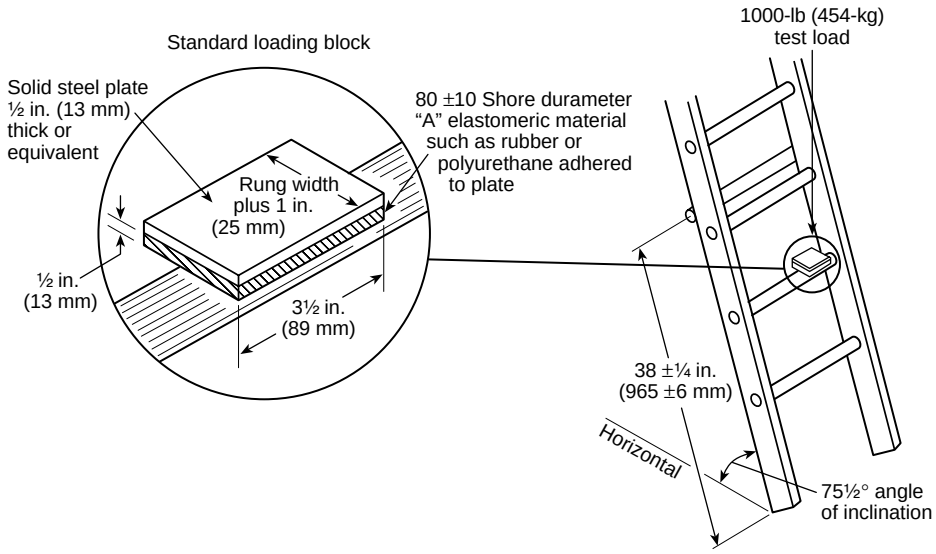


Figure 3-2.4.1 Design verification rung-to-beam shear strength test.



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

3-2.4.1 The rung-to-beam shear strength test shall be conducted on a test unit that consists of either a single section of the ladder or on a three-rung 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 shall be tested as shown in Figure 3-2.4.1. The test unit shall be set at an angle of inclination of $75^1/_2$ degrees.

3-2.4.2 A downward test load of 1000 lb (454 kg) shall be applied on the widest like cross section, on both braced and unbraced test rungs, as near the beam as possible. If a three-rung test section is used, the test shall be applied to the center rung. If 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 When the test load is removed, 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 rung torque test shall be conducted on a test unit that consists of either a single section of the ladder or on a short test section that comprises at least one rung and two beams. The test unit shall be positioned for testing and shall be tested as shown in Figure 3-2.5.1.

Figure 3-2.5.1 Design verification rung torque test.

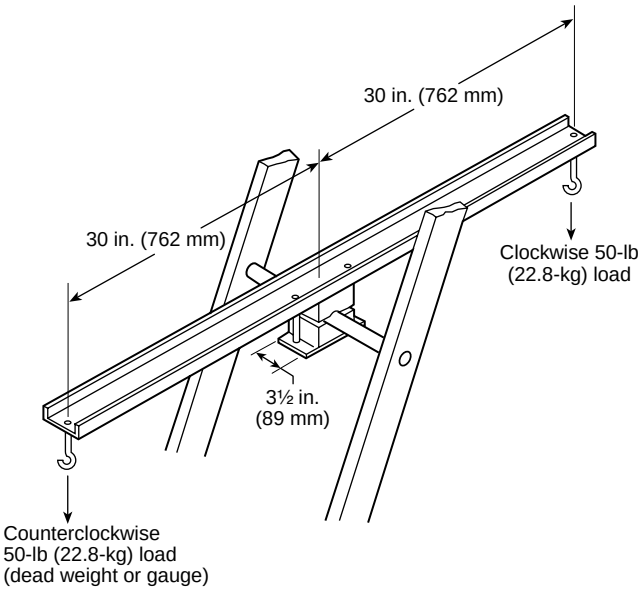
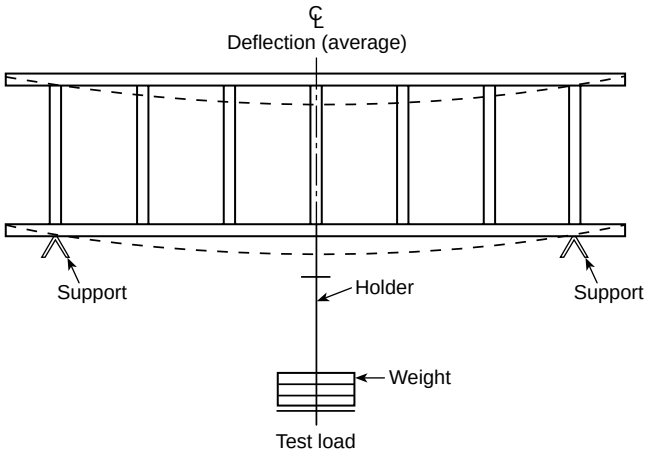


Figure 3-2.6.2 Position of ladder for design verification side sway test.



Note: 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).

3-2.5.2 A torque test load of 1500 in.-lb (169.5 N·m) shall be applied in a clockwise and then a 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 $^1/_{16}$-in. (1.6-mm) maximum movement for a $1^1/_4$-in. (32-mm) diameter round rung.

3-2.6 Side Sway Test.

3-2.6.1 The side sway test shall be conducted on a test unit that consists 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 shall be tested as shown in Figure 3-2.6.2. The test unit shall be placed on edge, resting on level supports that are located directly under the top and bottom rungs. The beams shall be in a horizontal plane, and the rungs shall be in a vertical plane and perpendicular to the ground.

3-2.6.3 A preload of 60 lb (27.2 kg) shall be applied at the center of the span over a $3^1/_2$-in. (89-mm) length of the bottom beam. The preload shall be held for a period of 1 minute and then unloaded.

3-2.6.4 A test load of 140 lb (63.5 kg) shall then be applied to the center of the span over a $3^1/_2$-in. (89-mm) length of the bottom beam. The test load shall be applied by hanging weights from the bottom of the lower beam. The test load shall be 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.

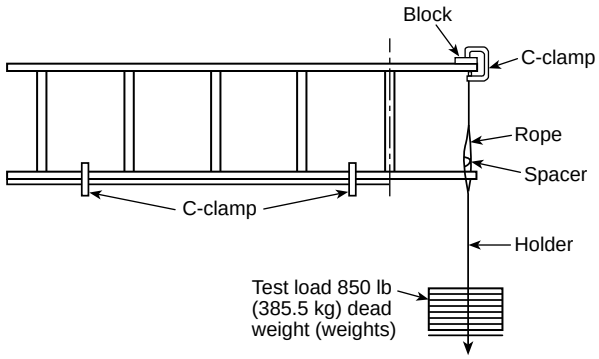
3-2.7 Beam Cantilever Bending Tests.

3-2.7.1 The beam cantilever bending test shall be conducted on a test unit that consists 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 For the cantilever-in bending test, the test unit shall be positioned for testing and shall be tested as shown in Figure 3-2.7.2. The test load shall be applied by means of a weight of 850 lb (385.5 kg) to the extreme bottom end of the upper beam. The test load shall be applied to a 1-in. (25-mm) thick block that rests on the full width of the beam and is held in place by a clamp. The block shall be 2 in. (51 mm) 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.

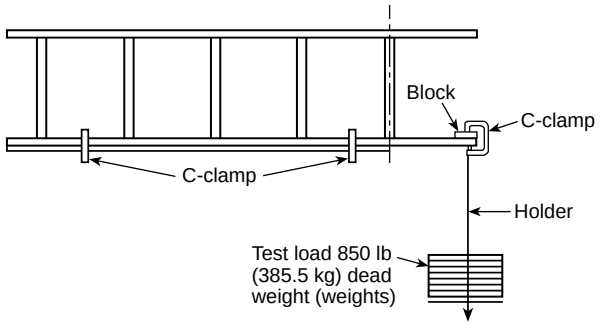
3-2.7.3 The allowable permanent deformation of the upper beam shall not exceed $^1/_2$ in. (12.7 mm).

Figure 3-2.7.2 Position of ladder for design verification beam cantilever-in bending test.



3-2.7.4 For the cantilever-out bending test, the test unit shall be positioned for testing and shall be tested as shown in Figure 3-2.7.4. The test load shall be applied to the extreme bottom end of the lower beam as specified in 3-2.7.2.

Figure 3-2.7.4 Position of ladder for design verification beam cantilever-out bending test.

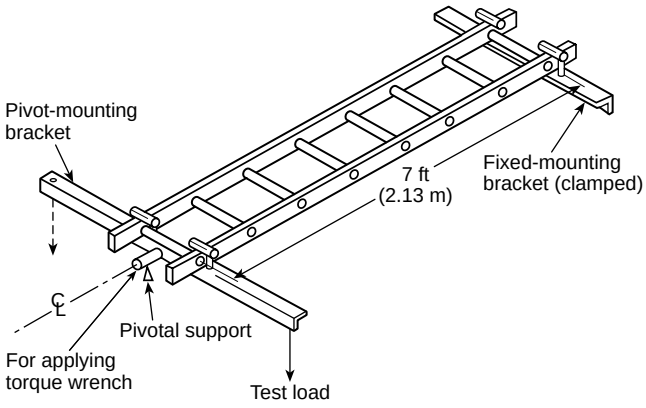


3-2.7.5 The allowable permanent deformation of the lower beam shall not exceed $^1/_2$ in. (12.7 mm).

3-2.8 Ladder Section Twist Test.

3-2.8.1 The ladder shall be positioned for testing and shall be tested as shown in Figure 3-2.8.1. The ladder section twist test shall be conducted on a ladder base section of at least 7 ft (2.1 m) in length, supported over a 7-ft (2.1-m) test span. The ladder shall be placed in a flat horizontal position and support for the ladder on one end shall be fixed. The ladder shall be tightly clamped onto the test fixtures during this test.

Figure 3-2.8.1 Position of ladder for design verification ladder section twist test.



3-2.8.2 A preload of 600 in.-lb (68 N·m) 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 1 minute, after which the ladder shall be unloaded.

3-2.8.3 A test torque of 1200 in.-lb (135 N·m) then shall be applied in a clockwise direction. The test torque shall be permitted to be applied by either a torque wrench or test loads that are applied on the 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 A preload of 600 in.-lb (68 N·m) then shall be used again to establish a reference for angular deflection. The preload shall be applied to the ladder in a counterclockwise direction for a minimum period of 1 minute, after which the ladder shall be unloaded.

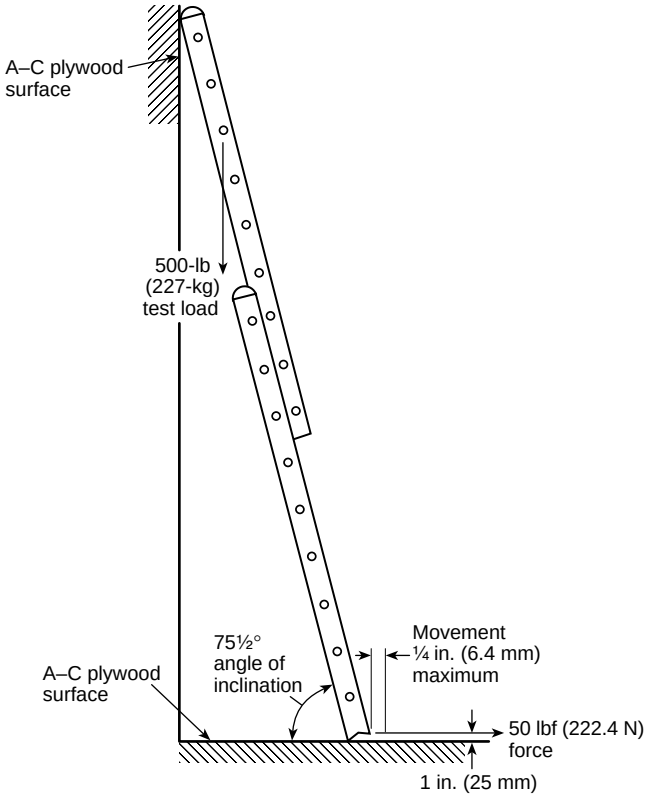
3-2.8.6 A test torque of 1200 in.-lb (135 N·m) then shall be applied in a counterclockwise direction. The test torque shall be permitted to be applied by either a torque wrench or test loads that are applied on the end of the arm.

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 shall be tested as shown in Figure 3-2.9.1. The test unit shall consist of a 16-ft (4.9-m) extension ladder extended to the maximum extended length and set at an angle of inclination of 75 $^1/_2$ degrees.

Figure 3-2.9.1 Design verification butt spur slip test.



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 also shall be the "A" surface and shall also be presanded using No. 320 fine wet/dry sandpaper.

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

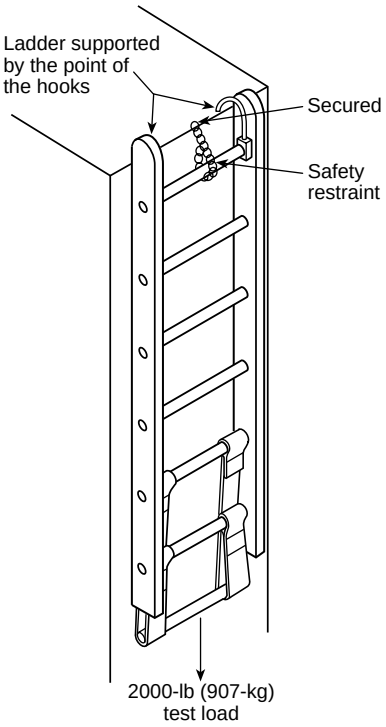
3-2.9.4 A test load of 500 lb (227 kg) shall be attached to the third rung from the tip of the fly section.

3-2.9.5 A horizontal pulling force of 50 lbf (222.4 N) applied to the bottom of the test unit 1 in. (25 mm) above the test surface shall not cause movement in excess of $^1/_4$ in. (6.4 mm) across the test surface.

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

3-3.1 The roof ladder shall be positioned for testing and shall be tested as shown in Figure 3-3.1. The ladder shall be hung solely by the roof hooks in a vertical position from a fixture that is capable of supporting the entire test load and weight of the ladder. The roof hooks shall be supported only by the points of the hooks. The ladder shall be secured in such a manner so as to retain the ladder in the test position in order to prevent injury to test personnel if the hooks fail during the test.

Figure 3-3.1 Design verification roof hook test.



3-3.2 A test load of 2000 lb (907 kg) shall be placed over as many rungs as needed. The test load shall consist of weight increments consistent with safety and ease of handling.

3-3.3 The test load shall be applied for a minimum of 1 minute.

3-3.4 Ladder and roof hook assemblies shall sustain this test load with no damage to the structure. Any deformation to the hooks shall not exceed 5 degrees.

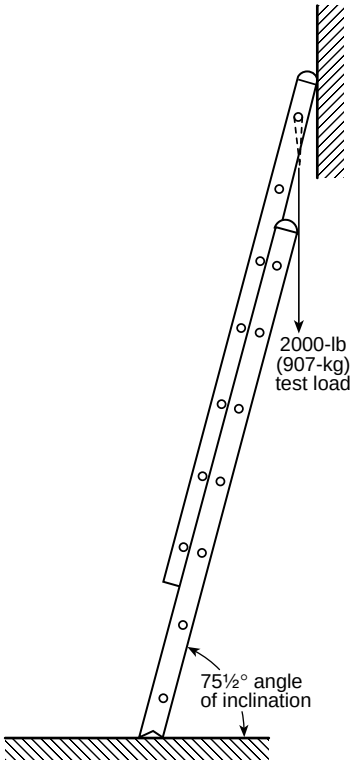
3-4 Additional Design Verification Tests for Extension and Combination Ladders Only. These design verification tests shall be performed in addition to the design verification tests specified in Section 3-2 and the testing requirements specified in Section 3-1.

3-4.1 Beam and Hardware Load Test.

3-4.1.1 The beam and hardware load test shall be conducted on a test unit that consists of either the shortest full-size ladder manufactured or of 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.

3-4.1.2 The test unit shall be positioned for testing and shall be tested as shown in Figure 3-4.1.2. The test unit shall be placed at an angle of inclination of $75^1/_2$ degrees with both pawls engaged.

Figure 3-4.1.2 Design verification beam and hardware load test.



3-4.1.3 A downward distributed test load of 2000 lb (907 kg) shall be applied to the top rung of the fly section.

3-4.1.4 The test unit shall sustain this test load with no permanent deformation or other visible weakening of the beams and hardware.

3-4.2 Single Pawl Load Test.

3-4.2.1 The ladder shall be positioned for testing and shall be tested as shown in Figure 3-4.2.1. The single pawl load test shall be conducted on a test unit that consists of a single pawl attached in its normal configuration to a sufficient length of beam for test purposes with the test unit set at an angle of inclination of $75^1/_2$ degrees. The pawl shall be engaged over a fixed steel rod of the same diameter as a rung.

Figure 3-4.2.1 Design verification single pawl load test.

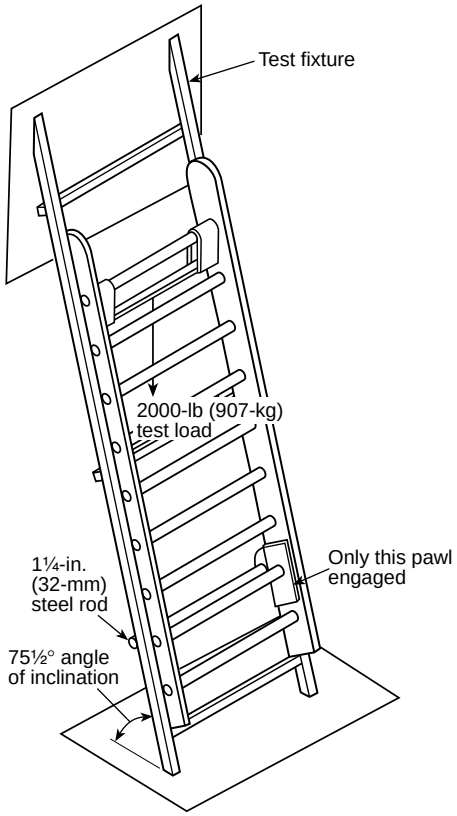
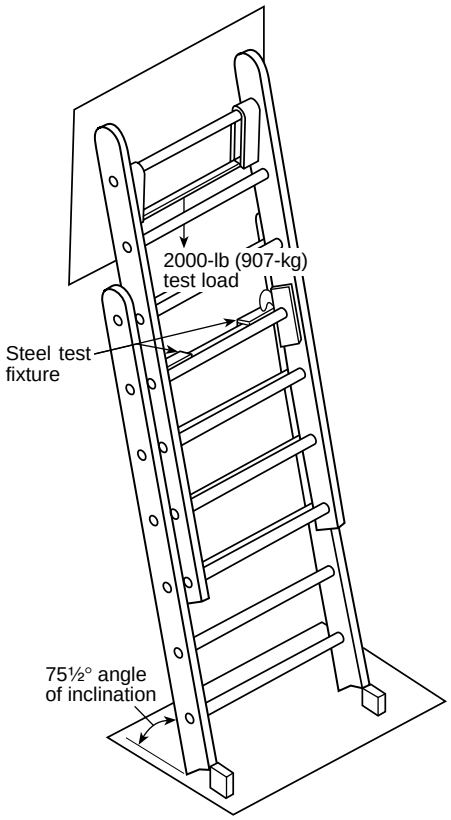


Figure 3-4.3.2 Design verification pawl tip load test.



3-4.2.2 A downward test load of 2000 lb (907 kg) shall be exerted on the end of the beam. The beam shall be permitted to be guided to prevent it from turning.

3-4.2.3 The test unit shall sustain this test load without disengagement of the pawl or disengagement of the pawl attachment to the beam.

3-4.3 Pawl Tip Load Test.

3-4.3.1 The pawl tip load test shall be conducted on a test unit that consists of either the shortest full-size ladder manufactured or of 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.

3-4.3.2 The test unit shall be positioned for testing and shall be tested as shown in Figure 3-4.3.2. The test unit shall be set at an angle of inclination of $75^1/_2$ degrees with both 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 that is 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 that means of preventing pivoting shall not in any way affect that portion of the pawl under test.

3-4.3.3 A downward distributed test load of 2000 lb (907 kg) shall be applied.

3-4.3.4 The test unit and components shall sustain the test load without ultimate failure.

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

3-5.1 Cyclic Rung–Pawl Test.

3-5.1.1 The cyclic rung–pawl test shall not apply to fixed-type or manually operated pawls used on extension ladders or combination ladders.

3-5.1.2 A machine equivalent to that shown in Figure 3-5.1.2(a) shall be used to operate the pawl through the following cycle, as shown in Figure 3-5.1.2(b):

(1) One 6-in. (152-mm) upstroke to allow the pawl to engage the rung

(2) A full 6-in. (152-mm) downstroke to allow the pawl onto the rung

(3) A full 12-in. (305-mm) upstroke to disengage the pawl

(4) A full 12-in. (305-mm) downstroke to return the pawl to the starting position

Figure 3-5.1.2(a) Design verification cyclic rung–pawl test.

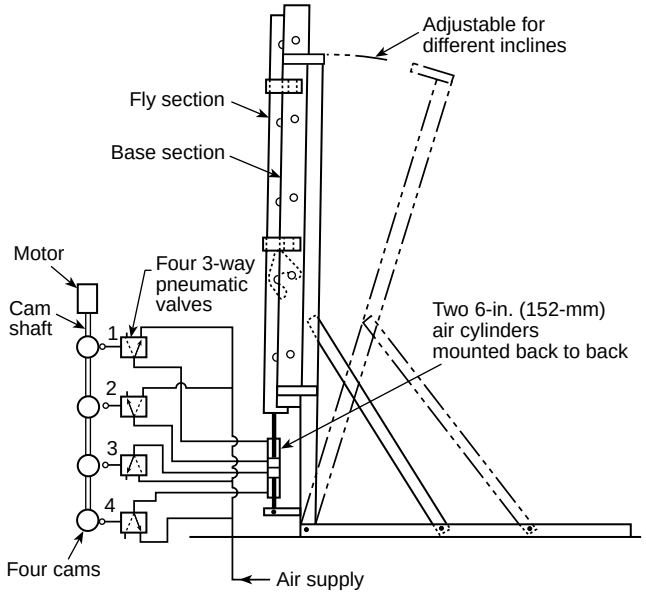
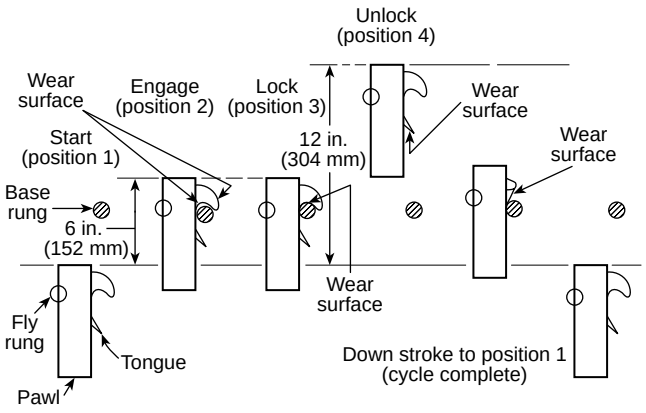


Figure 3-5.1.2(b) Design verification rung–pawl testing cycle.



3-5.1.3 Pawls shall be tested with the ladder set at an angle of inclination of 75 $^1/_2$ degrees. The pawl shall be permitted to be manually lubricated prior to or during the test.

3-5.1.4 The stroke speed shall be between 7 in. and 14 in. (78 mm and 356 mm) per second. A minimum of 6000 cycles shall be imposed.

3-5.1.5 Any malfunction of the pawl or fracture of its components, including springs, shall be a failure of this test. The presence of wear that does not affect the functioning of the pawl shall not constitute failure.

3-5.2 Multisection Extending Force Test.

3-5.2.1 The multisection extending force test shall be conducted on a complete extension ladder. The ladder shall be set at a 90 degree vertical position in the bedded position. The base section shall be permitted to be braced or otherwise held to maintain vertical alignment.

3-5.2.2 A measured downward test force shall be applied to the rope if the ladder has a halyard and a pulley system installed. The test force shall be smoothly applied to cause vertical extension of the fly section of 2 ft (610 mm) or more, at a rate of between 6 in. and 12 in. (152 mm and 305 mm) per second. For those ladders not equipped with a halyard and a pulley, the measured test force shall be applied vertically to the bottom rung of the fly section.

3-5.2.3 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.

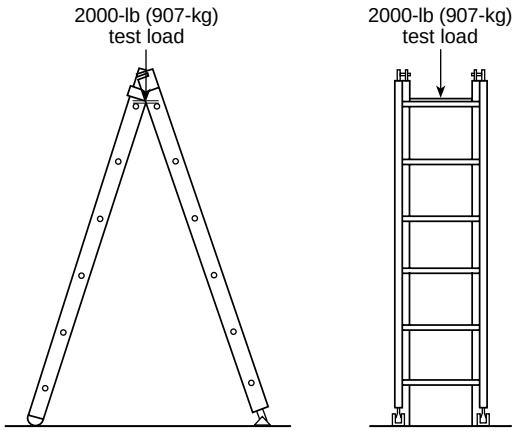
3-5.2.4 The average maximum pounds of pull shall not exceed two times the weight of one of the ladder fly sections.

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

3-6.1 Compression Test.

3-6.1.1 The combination ladder shall be positioned for testing and shall be tested as shown in Figure 3-6.1.1. The ladder shall be tested in its A-frame position, with the test load of 2000 lb (907 kg) applied uniformly to the top rungs.

Figure 3-6.1.1 Design verification combination ladder compression test.



3-6.1.2 The ladder shall sustain the test load without ultimate failure.

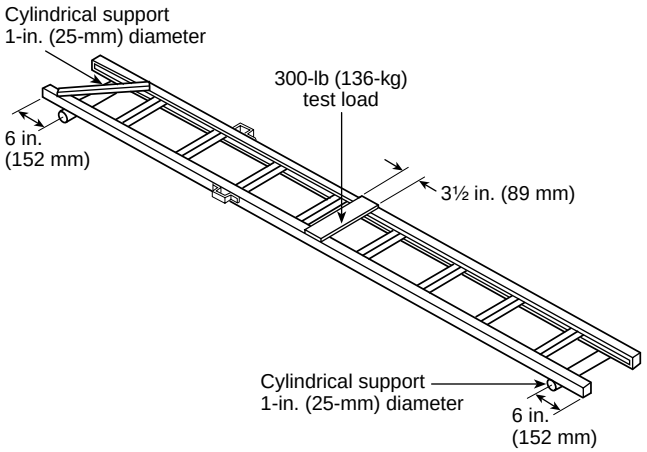
3-7 Design Verification Tests for Folding Ladders Only. These design verification tests shall be performed in accordance with the design verification testing criteria specified in Section 3-1.

3-7.1 Horizontal Bending Test.

3-7.1.1 The ladder shall be positioned for testing and shall be tested as shown in Figure 3-7.1.1. The folding ladder shall be placed in a flat, horizontal position and supported 6 in. (152 mm) from each end.

3-7.1.2 A test load of 300 lb (136 kg) shall be applied at the center of the ladder span and shall be equally distributed across both beams over an area 3 $^1/_2$ in. (89 mm) wide.

Figure 3-7.1.1 Design verification folding ladder horizontal bending test.

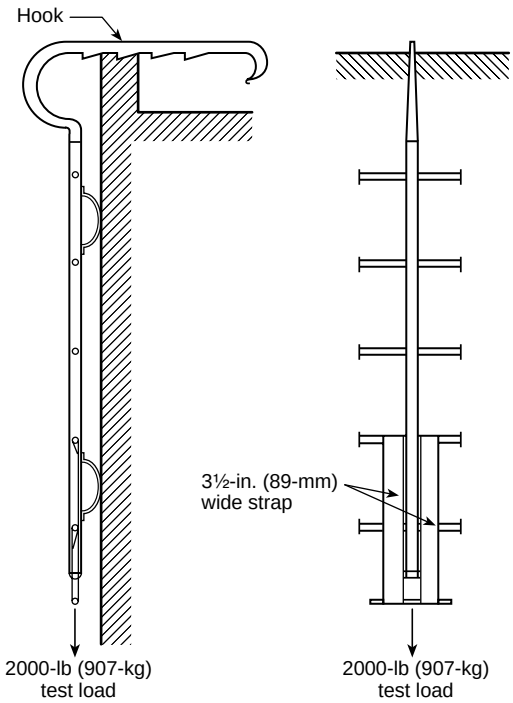


3-7.1.3 The ladder shall withstand this test without ultimate failure.

3-8 Design Verification Tests for Pompier Ladders Only. These design verification tests shall be performed in accordance with the design verification testing criteria specified in Section 3-1.

3-8.1 The ladder shall be positioned for testing and shall be tested as shown in Figure 3-8.1. The ladder shall be tested in the vertical hanging position supported only by the hook.

Figure 3-8.1 Design verification pompier ladder test.



3-8.2 A test load of 2000 lb (907 kg) shall be applied.

3-8.3 The ladder shall sustain this test load without ultimate failure.

Chapter 4 Label Tests

4-1 Labels to Be Tested. All labels required for ground ladders in 2-1.4.2, 2-1.4.4, 2-1.4.5, 2-1.4.6, 2-1.5, and 2-4.7.5 shall meet the requirements of this chapter.

4-2 Performance Requirements.

4-2.1 Legibility. When tested as specified in 4-3.2, the label shall retain its original color, readability, and clarity without any darkening, fogging, or blistering.

4-2.2 Adhesion. When tested as specified in 4-3.3.1, the label shall have an average adhesion of not less than 2 pounds-force per linear inch (0.35 N per linear mm) of label width, and not less than 50 percent of the average adhesion measured for 4-3.3.1 when tested as specified in 4-3.3.2.

4-3 Testing.

4-3.1 Preconditioning.

4-3.1.1 The sample labels shall be applied to a surface material of the same type to which the label will be affixed, and this shall constitute the test sample. The test sample shall be exposed for 72 hours at 73°F ± 2°F (23°C ± 1°C) and 50 ± 2 percent relative humidity.

4-3.1.2 The sample labels shall be applied to a surface material of the same type to which the label will be affixed, and this shall constitute the test sample. First, the test sample shall be exposed for 72 hours at 73°F ± 2°F (23°C ± 1°C) and 50 ± 2 percent relative humidity. Then, the test sample shall be exposed for 24 hours at −40°F (−40°C).

4-3.1.3 The sample labels shall be applied to a surface material of the same type to which the label will be affixed, and this shall constitute the test sample. First, the test sample shall be exposed for 72 hours at 73°F ± 2°F (23°C ± 1°C) and 50 ± 2 percent relative humidity. Then, the test sample shall be exposed for 6 weeks at 140°F ± 4°F (60°C ± 2°C) and 97 ± 3 percent relative humidity.

4-3.1.4 The sample labels shall be applied to a surface material of the same type to which the label will be affixed, and this shall constitute the test sample. First, the test sample shall be exposed for 72 hours at 73°F ± 2°F (23°C ± 1°C) and 50 ± 2 percent relative humidity. Then, the test sample shall be exposed for 90 days of aging at 190°F ± 2°F (87°C ± 1°C) in a mechanical convection air oven.

4-3.1.5 The sample labels shall be applied to a surface material of the same type to which the label will be affixed, and this shall constitute the test sample. First, the test sample shall be exposed for 72 hours at 73°F ± 2°F (23°C ± 1°C) and 50 ± 2 percent relative humidity. Then, the test sample shall be exposed for 720 hours of ultraviolet light and water. The ultraviolet light shall be obtained from two stationary, enclosed carbon-arc lamps. The arc of each lamp shall be formed between two vertical carbon electrodes, $^1/_2$ in. (12.7 mm) in diameter, located at the center of a revolvable, vertical metal cylinder, 31 in. (787 mm) in diameter and 17 $^3/_4$ in. (450.9 mm) in height. Each arc shall be enclosed with a No. 9200-PX clear Pyrex™ glass globe. The samples shall be mounted vertically on the inside of the revolvable cylinder, facing the lamps, and the cyl-