NFPA 1936
Standard on Powered Rescue Tool Systems

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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Powered Rescue Tool Systems

1999 Edition

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Origin and Development of NFPA 1936

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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 related to the design, inspection, testing, and use of rescue tools for the fire services.

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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 7 and Appendix B.

Chapter 1 Administration

1-1 Scope.

1-1.1 This standard shall specify the minimum requirements for the design, performance, testing, and certification of powered rescue tool systems and the individual components of spreaders, rams, cutters, combination tools, power units, and power transmission cables, conduit, or hose.

1-1.2 This standard shall apply to the design, manufacturing, and certification of newly manufactured powered rescue tool systems.

1-1.3 This standard shall not apply to manually powered tools and shall not apply to small multipurpose tools including, but not limited to, saws, drills, chisels, pry bars, shoring systems, and similar tools.

1-1.4 This standard shall not apply to powered rescue tool systems or rescue tools that are manufactured prior to the effective date of this standard or to powered rescue tool systems or rescue tools that are manufactured in accordance with other specifications or standards of other organizations.

1-1.5 The requirements of this standard shall not apply to accessories that might be attached to powered rescue tool systems unless such accessories are specifically addressed herein.

1-1.6 Nothing herein shall restrict any jurisdiction from specifying or shall restrict a manufacturer from producing powered rescue tool systems that exceed the minimum requirements of this standard.

1-2 Purpose.

1-2.1 The purpose of this standard shall be to establish minimum performance requirements for powered rescue tool systems that are utilized by emergency services personnel to facilitate the extrication of victims from entrapment.

1-2.2 Controlled laboratory environmental and physical tests are used to determine compliance with the performance requirements of this standard only; however, such tests shall not be deemed as establishing powered rescue tool systems' performance levels for all situations.

1-2.3 This standard is not intended to serve as a detailed manufacturing or purchase specification but shall be permitted to be referenced in purchase specifications as minimum acceptable requirements.

1-3 Definitions.

Accessories. Those items that are attached to the rescue tool (RT) or RTS but are not necessary for the RT or RTS to meet the requirements of this standard. Such accessories include, but are not limited to, chain, cable, hook-end connectors, U-end connectors, and wide surface tip plates.

Approved.* Acceptable to the authority having jurisdiction.

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

Cable Assembly. Cables that connect the RT to the power unit and all permanently attached connectors.

Certification/Certified. A system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of this standard, authorizes the manufacturer to use a label on listed products that comply with the requirements of this standard, and establishes a follow-up program conducted by the certification organization as a check on the methods the manufacturer uses to determine continued compliance of labeled and listed products with the requirements of this standard.

Certification Organization. An independent third-party organization that determines product compliance with the requirements of this standard with a labeling/listing/follow-up program.

Combination Tool. A system component of an RTS; an RT that is capable of at least spreading and cutting.

Compliance/Compliant. Certified as meeting or exceeding all applicable requirements of this standard.

Components. See the definition for *System Components.*

Cutter. A system component of an RTS; an RT with at least one movable blade that is used to cut/shear/sever material.

Cycle. See the definition for *Operational Cycle.*

Dump Valve. A device on a power unit to redirect all of the system flow to the reservoir.

Follow-Up Program. The sampling, inspections, tests, or other measures conducted by the certification organization on a periodic basis to determine the continued compliance of listed products that are being produced by the manufacturer to the requirements of this standard.

Highest Pulling Force (HPF). The pulling force that is achieved by the RT while operating at the rated system input at the position of the arms or piston where the tool generates its greatest amount of force.

Highest Spreading Force (HSF). The spreading force that is achieved by the RT while operating at the rated system input at the position of the arms or piston where the tool generates its greatest amount of force.

Hose Assembly. A hose and all permanently attached fittings.

HPF. An abbreviation for highest pulling force. *(See also the definition for Highest Pulling Force.)*

HSF. An abbreviation for highest spreading force. *(See also the definition for Highest Spreading Force.)*

Identical RT. RTs that are produced to the same engineering and manufacturing specifications.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Listed.* Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Lowest Pulling Force (LPF). The pulling force that is achieved by the RT while operating at the rated system input at the position of the arms or piston where the tool generates its least amount of force.

Lowest Spreading Force (LSF). The spreading force that is achieved by the RT while operating at the rated system input at the position of the arms or piston where the tool generates its least amount of force.

LPF. An abbreviation for lowest pulling force. *(See also the definition for Lowest Pulling Force.)*

LSF. An abbreviation for lowest spreading force. *(See also the definition for Lowest Spreading Force.)*

Operational Cycle. The movement of the tool from the fully closed or retracted position to the fully open or extended position to the fully closed or retracted position.

Power Unit. A component of a powered RTS consisting of a prime mover and the principal power output device used to power an RT.

Prime Mover. The energy source that drives the principal power output device of the power unit.

Product Label. A label or marking affixed to the RTS components by the manufacturer containing general information, care, maintenance, or similar data. This product label is not the certification organization's label, symbol, or identifying mark; however, the certification organization's label, symbol, or identifying mark is attached to it or part of it. *(See also the definition for Labeled.)*

Pulling Force. The force to pull that is generated by an RT and that is measured or calculated at the standard production pulling attachment points on the tool.

Ram. A system component of the RTS; an RT that has a piston or other type extender that generates extending forces or both extending and retracting forces.

Rated System Input. The maximum input pressure/electrical power at which the RTS is designed to operate.

Rescue Tool (RT). A system component of an RTS that is the tool used by the operator to perform one or more of the functions of spreading, lifting, holding, crushing, pulling, or cutting. Herein identified as RT. *(See also the definition for Rescue Tool System.)*

Rescue Tool System (RTS). A system that uses power to generate the output forces or power of an RT; the compatible combination of system components that consists of an RT, power unit, and hose or cable assembly. Self-contained systems might exclude the hose or cable assembly. Herein identified as RTS. *(See also the definition for Rescue Tool.)*

RT. An abbreviation for rescue tool. *(See also the definition for Rescue Tool.)*

RTS. An abbreviation for rescue tool system. *(See also the definition for Rescue Tool System.)*

Shall. Indicates a mandatory requirement.

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

Spreader. A system component of an RTS; an RT that has at least one movable arm that opens to move material.

Spreading Force. The force to push or pull that is generated by an RT and that is measured or calculated at the very tips of the spreader arms or ram.

System Components. The major components of the RTS including the RTs, power units, hose assemblies, and cables. The individual parts that are assembled in a system component, such as seals, screws, valves, and switches, are not themselves considered as system components for the purposes of this standard.

System Input. The input pressure or electrical power that the RT is subjected to at any given moment.

Tool. See the definition for *Rescue Tool.*

Vendor Confirmation. A written statement by the original manufacturer of a component that states the specification or performance range, or both, of the component.

1-4 Units.

1-4.1 Values for measurement in this standard are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement.

1-4.2 Equivalent values in parentheses shall not be considered as the requirement as these values might be approximate.

Chapter 2 Certification

2-1 General.

2-1.1 All individual system components of the RTS that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

2-1.2 All certification shall be performed by an approved certification organization that meets at least the requirements specified in Section 2-2.

2-1.3 All individual compliant system components of the RTS shall be labeled and listed. Each compliant system component of the RTS shall also have a product label(s) that meets the applicable requirements specified in Section 3-1.

2-1.4* The certification organization's label, symbol, or identifying mark shall be attached to the product label or shall be part of the product label.

2-2 Certification Organization.

2-2.1* The certification organization shall not be owned or controlled by manufacturers or vendors of the product that is being certified. The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability.

2-2.2 The certification organization shall refuse to certify products to this standard that do not comply with all applicable requirements of this standard.

2-2.3* The contractual provisions between the certification organization and the manufacturer shall specify that certification is contingent on compliance with all applicable requirements of this standard. There shall be no conditional, temporary, or partial certifications. Manufacturers shall not be authorized to use any label or reference to the certification organization on products that are not manufactured in compliance with all applicable requirements of this standard.

2-2.4* The certification organization shall have laboratory facilities and equipment that are available for conducting proper tests, a program for the calibration of all instruments shall be in place and operating, and procedures shall be in use to ensure the proper control of all testing. Good practice shall be followed regarding the use of laboratory manuals, form data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

2-2.5 The certification organization shall require the manufacturer to establish and maintain a program of production inspection and testing that at least meets the requirements specified in Section 2-4. The certification organization shall audit the manufacturer's quality assurance program to ensure that the quality assurance program provides continued product compliance with this standard.

2-2.6 The certification organization and the manufacturer shall evaluate any changes that affect the form, fit, or function of the certified product to determine the product's continued compliance to this standard.

2-2.7* The certification organization shall have a follow-up inspection program of the manufacturing facilities of the certified product, with at least one random, unannounced visit per 12-month period. As part of the follow-up inspection program, the certification organization shall select sample product at random from the manufacturer's production line, from the manufacturer's in-house stock, or from the open market. Sample product shall be evaluated by the certification organization to verify the product's continued compliance.

2-2.8 The certification organization shall have a program for investigating field reports that allege malperformance or failure of listed products.

2-2.9 The certification organization's operating procedures shall provide a mechanism for the manufacturer to appeal decisions. The procedures shall include provisions for the presentation of information from representatives of both sides of a controversy to a designated appeals panel.

2-2.10 The certification organization shall be in a position to use legal means to protect the integrity of its name and label. The name and label shall be registered and shall be capable of being legally defended.

2-3 Inspection and Testing.

2-3.1 Sampling levels for testing and inspection shall be established by the certification organization and the manufacturer to ensure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified to this standard are compliant, unless such sampling levels are specified herein. Information about sampling levels shall be provided to the purchaser on request.

2-3.2 Inspection by the certification organization shall include a review of all product labels to ensure that the required product label format, content, arrangement, and attachment are as specified in Section 3-1.

2-3.3 Inspection by the certification organization shall include a review of all product labels to ensure that all required worded statements and other information specified in Section 3-1 are correctly stated and presented on the product label(s) as applicable for the specific product.

2-3.4 Inspection by the certification organization shall include a review of the user information that is required by Section 3-2 to ensure that the information has been developed by and is supplied to the user by the manufacturer.

2-3.5 Inspection by the certification organization to determine compliance with the design requirements specified in Chapter 4 shall be performed on whole or complete systems or products.

2-3.6 Testing conducted by the certification organization to determine product compliance with the applicable performance requirements specified in Chapter 5 shall be performed on samples that are representative of materials and components used in the actual construction of RTS or RT components. Where applicable, the certification organization shall be permitted to also use sample materials that are cut or taken from a representative component.

2-3.7 The certification organization shall evaluate any change in the design, construction, or material of compliant products to verify continued compliance to all applicable requirements of this standard. Products that are determined to be compliant shall retain their certification. Products that are determined to be noncompliant shall be decertified.

2-3.8 The certification organization shall not allow the substitution, repair, or modification, other than as specifically permitted herein, of any product during testing.

2-4 Manufacturer's Quality Assurance Program.

2-4.1* The manufacturer shall provide and maintain a quality assurance program that includes a documented inspection and product recall system. The manufacturer shall have an inspection system to substantiate conformance to this standard.

2-4.2 The manufacturer shall maintain written inspection and testing instructions. The instructions shall prescribe the inspection and testing of materials, work in process, and completed articles. The criteria for the acceptance and rejection of materials, processes, and final products shall be part of the instructions.

2-4.3 The manufacturer shall maintain records of all pass/fail tests. Pass/fail records shall indicate the disposition of the failed material or product.

2-4.4 The manufacturer's inspection system shall provide for procedures that assure that the most current applicable drawings, specifications, and instructions are used for fabrication, inspection, and testing.

2-4.5 The manufacturer shall, as part of the quality assurance program, maintain a calibration program of all instruments that are used to ensure proper control of testing. The calibration program shall be documented as to the date of calibration and performance verification.

2-4.6 The manufacturer shall maintain a system for identifying the appropriate inspection status of component materials, work in process, and finished goods.

2-4.7 The manufacturer shall establish and maintain a system for controlling nonconforming material, including procedures for the identification, segregation, and disposition of rejected material. All nonconforming materials or products shall be identified to prevent their use, shipment, and intermingling with conforming materials or products.

2-4.8 The manufacturer's quality assurance program shall be audited by the third-party certification agency to determine that the program is sufficient to ensure continued product compliance with this standard.

Chapter 3 Product Labeling and Information

3-1 Product Labeling Requirements.

3-1.1 Each RT, RTS, and system component shall have a product label(s) permanently and conspicuously attached to the tool or system.

3-1.2 More than one label piece shall be permitted in order to carry all statements and information required of the product label; however, all label pieces comprising the entire product label shall be located adjacent to each other.

3-1.3 At least the following statement and information shall be legibly printed on the product label(s). All letters shall be at least 2 mm ($^{3}/_{32}$ in.) high.

"THIS (state name of tool/system/system component) MEETS THE REQUIREMENTS OF NFPA 1936, STANDARD ON POWERED RESCUE TOOL SYSTEMS, 1999 EDITION."

(1) Certification organization's label, symbol, or identifying mark
(2) Manufacturer's name, identification, or designation
(3) Manufacturer's product identification number or lot number, or serial number
(4) Month and year of manufacture (not coded)
(5) Model name, number, or design
(6) Rated system pressure, where applicable
(7) Manufacturer's specified hydraulic fluid for power unit, where applicable
(8) Fluid capacity of the hydraulic reservoir of the power unit, where applicable
(9) Operating voltage and current type, where applicable
(10) Operating amperage at no load, where applicable
(11) Operating amperage at maximum load, where applicable

3-1.4 All worded portions of the required product label shall be printed at least in English.

3-1.5 Symbols and other pictorial graphic representations shall be permitted to be used to supplement worded statements on the product labels.

3-1.6 Where the required product labels are self-adhesive, the label material shall be suitable for outdoor use.

3-1.7 All product labels shall meet the requirements of UL 969, *Standard for Marking and Labeling Systems*, for resistance to damage from temperatures between –35°C and 71°C (–30°F and 160°F) and exposure to oil, fuel, water, and the hydraulic fluids used in the RTS.

3-2 User Information.

3-2.1 The RTS or RT manufacturer shall provide training documentation for users with each RTS or RT. The documentation shall address at least inspection, maintenance, cleaning, decontamination, and storage. Such documentation shall be permitted to be in the form of printed material, audio visual material, or a combination of both.

3-2.2 The RTS or RT manufacturer shall provide a manual(s) with each RTS or system component. The manual(s) shall provide at least the following information:

(1) Manufacturer's name and address
(2) Country of manufacture
(3) Source for service and technical information
(4) How or where parts can be obtained
(5) Set-up procedures
(6) Operating instructions
(7) Safety considerations
(8) Limitations of use
(9) Inspection procedures
(10) Recommended maintenance procedures
(11) Troubleshooting guide
(12) Manufacturer's warranty
(13) Special requirements or data required by this standard

3-2.3 The RTS or RT manufacturer shall specify the length, width, and height dimensions of all components in order to establish the minimum storage dimensions. This data shall be provided in the manual.

3-2.4 The data for the opening distance of cutters and the opening and closing travel distance and times for tools as established in 4-1.2.3, 4-1.3.1, 4-1.4.2, 4-1.4.5, and 4-1.5.1 shall be provided in the manual.

3-2.5 The data on HSF, LSF, HPF, and LPF ratings of the tools as established in 5-1.1.4, 5-1.1.5, 5-1.2.5, 5-1.2.6, 5-1.3.6, and 5-1.3.7 shall be provided in the manual.

3-2.6 The weight of the system component in a ready-to-use configuration shall be established and published in the manual. The weight of the power unit shall include the hydraulic fluid, fuel, and engine oil, if applicable. The weight of tools, hose, and hose reels shall be determined with the tools and hose filled with hydraulic fluid and configured so that they would be operational by attachment to a power source.

3-2.7 The manufacturer of the power unit shall provide copies of any owner's manuals that are provided by the manufacturer of the prime mover.

3-2.8 A material safety data sheet (MSDS) shall be provided for each hydraulic fluid that is specified for use in the RTS.

Chapter 4 Design Requirements

4-1 Rescue Tools.

4-1.1 Requirements for all Rescue Tools.

4-1.1.1 Where hydraulic fluid is used, the manufacturer of seals, valves, and fittings that will come into contact with hydraulic fluid in the RT shall supply the RT manufacturer with written documentation that such seals, valves, and fittings are compatible with the specified hydraulic fluid for the RT and that they will function properly at a maximum hydraulic fluid temperature of 71°C (160°F).

4-1.1.2 Handles and controls shall be located on the RT to allow the RT to be safely carried and operated by personnel wearing gloves that are certified as compliant with the glove requirements of NFPA 1971, *Standard on Protective Ensemble for Structural Fire Fighting*. All handles and controls shall be designed to prevent the user's hand(s) from being caught or crushed by the moving parts of the tool during the tool operation.

4-1.1.3 The RT's controls shall be designed to return to the neutral position automatically in the event that the control is released. When the control is in the neutral position, the RT shall not operate by itself. The operation of the control shall be clearly indicated on the tool.

4-1.1.4 Where the RT has an extension area of the activating piston rod assembly that is greater than 1.5 times the retract area of the piston rod assembly, the RT shall be equipped with a built-in automatic safety relief device to prevent overpressurization.

4-1.1.5 Where hydraulic fluid is used, the hydraulic fluid specified for use with the RT shall not be classified as either a flammable liquid or a combustible fluid unless classified as a Class IIIB combustible liquid in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

4-1.1.6 Where hydraulic fluid is used, all RT hydraulic fittings and quick-connect couplers shall be rated for at least the rated system input and shall have a safety factor of at least 2:1.

4-1.1.7* RTs shall be equipped with quick-connect couplers. Where hydraulic fluid is used, each female and male quick-connect coupler shall have a check valve that can withstand the specified rated system input when disconnected.

4-1.1.8 All RT quick-connect couplers shall be equipped with a locking feature to prevent accidental uncoupling during operation.

4-1.1.9 All controls that are required for the safe operation of the RT shall be marked to indicate their function.

4-1.1.10 The length, width, and height dimensions of the RT, stated in the commercially printed material as supplied by the tool manufacturer, shall be verified in order to establish minimum storage dimensions.

4-1.1.11 All electric components shall be listed and labeled for the intended application. Where labeled and listed electric components are not available for a specific application, the electric components that are used shall be suitable for the intended application.

4-1.1.12 Where RTs are equipped with attachments, such attachments shall be secured against accidental release.

4-1.1.13 An RT that utilizes electric power shall comply with the applicable and appropriate electrical safety requirements of UL 45, *Standard for Safety for Portable Electric Tools*.

4-1.1.14 All RT electrical connectors shall be rated to handle the electrical current realized when the system is operating at rated system input.

4-1.1.15 A switch or other control device shall be acceptable for the application, with voltage and amperage ratings not less than the corresponding values of the load that it controls.

4-1.1.16 Electrical parts of the RT shall be so located or enclosed that protection against unintentional contact with non-insulated live parts will be provided.

4-1.1.17 Strain relief shall be provided to prevent a mechanical stress on a flexible cord from being transmitted to terminals, splicing, or internal wiring.

4-1.1.18 Wiring shall be protected from sharp edges, burrs, moving parts, and other agencies that might cause abrasion of the insulation of conductors.

4-1.1.19 The electric motor of the RT shall drive the maximum intended load of the tool without introducing risk of fire, electric shock, or injury to persons.

4-1.1.20 An enclosure for a battery or battery cell shall be provided with ventilation openings located so as to permit the circulation of air for dispersion of gases that can be generated under abnormal battery or charging conditions.

4-1.1.21 An enclosure for a battery or battery cell shall be provided with heat transfer means, such as ventilation openings or heat sinks, located so as to prevent thermal runaway of the battery during normal charging at the maximum allowable ambient temperature as specified by the battery manufacturer.

4-1.1.22 An RT that uses self-contained batteries shall provide an indicator or other means to visually check the battery's state of charge (indicator).

4-1.1.23 All battery or battery pack exposed live terminals shall have protective covers in order to prevent accidental contact and arcing when not being used.

4-1.2 Additional Requirements for Spreaders.

4-1.2.1 The outside of the spreader arm ends or tips shall be provided with a gripping surface. The gripping surface shall extend the full width of the ends or tips and shall be at least 25 mm (1 in.) in length where measured inward from the ends or tips.

4-1.2.2 All double-acting spreaders that are designed for pulling as well as pushing shall have a fixed pulling attachment point(s) for the pulling accessories.

4-1.2.3 The opening and closing travel distance of the spreader shall be determined at 21°C, ±3°C (70°F, ±5°F). The spreader shall be opened to the fullest extent using the rated system input and no external load. The distance between the tips shall be measured. The spreaders shall then be closed to its full closure using the rated system input and no external load. The distance between the tips shall again be measured. The difference in measurements shall be the travel distance. The opening and closing times of the unloaded tool also shall be measured.

4-1.2.4 The opening and closing travel distance and times of the spreaders shall be recorded and verified with the data that are supplied by the manufacturer.

4-1.3 Additional Requirements for Rams.

4-1.3.1 The opening and closing travel distance of the ram shall be determined at 21°C, ±3°C (70°F, ±5°F). The ram shall be opened to the fullest extent using the rated system input and no external load. The distance from the base to the tip of the ram shall be measured. The ram shall then be closed to its full closure using the rated system input and no external load. The distance from the base to the tip of the ram shall again be measured. The difference in measurements shall be the travel distance. The opening and closing times of the unloaded tool also shall be measured.

4-1.3.2 The fully retracted and the fully extended lengths and times of the ram shall be recorded and verified with the data that are supplied by the manufacturer.

4-1.3.3 Rams shall be permitted to pull as well as push. Where rams are designed to pull as well as push, they shall be provided with a connection point to facilitate the use of pulling devices.

4-1.4 Additional Requirements for Combination Tools.

4-1.4.1 The outer edge of the combination tool arm ends or tips shall be provided with a gripping surface. The gripping surface shall extend the full width of the ends or tips and shall be at least 25 mm (1 in.) in length where measured inward from the ends or tips.

4-1.4.2 The opening distance of the cutter of the combination tool and opening and closing travel times of the cutter of the combination tool shall be determined at 21°C, ±3°C (70°F, ±5°F). The cutter shall be opened to the fullest extent using the rated system input and no external load. The opening distance of the cutter shall be measured in a straight line at the tips of the cutter, with the cutter in the fully open position. The opening and closing times of the unloaded tool shall also be measured.

4-1.4.3 The opening distance of the cutter of the combination tool shall be recorded and verified with the data that are supplied by the manufacturer. The opening and closing travel times of the cutter of the combination tool shall be recorded and verified with the data that are supplied by the manufacturer.

4-1.4.4 The cutter of the combination tool shall be rated for ability to cut specific material with an alphanumeric Level Rating System.

4-1.4.4.1 The numerical performance Levels and the material Categories of the rating system shall be as specified in the performance requirements of 5-1.3.4 and Section 6-13, Cutting Test.

4-1.4.4.2* The Level Rating shall be expressed as follows:

A#/B#/C#/D#/E#

The letters A, B, C, D, and E shall indicate the material Category, and the performance Level number for the specific material Category shall be inserted in place of the # sign.

4-1.4.5 The opening and closing travel distance of the spreader of the combination tool shall be determined at 21°C, ±3°C (70°F, ±5°F). The spreader shall be opened to the fullest extent using the rated system input and no external load. The opening shall be measured in a straight line on the outside surface of the arms at the farthest projection of the tips. The spreader shall then be closed to its full closure using the rated system input and no external load. The distance between the tips shall again be measured. The difference in measurements shall be the travel distance. The opening and closing times of the unloaded tool also shall be measured.

4-1.4.6 The opening and closing travel distance and times of the spreader of the combination tool shall be recorded and verified with the data that are supplied by the manufacturer.

4-1.5 Additional Requirements for Cutters.

4-1.5.1 The opening distance of the cutter and the opening and closing travel times of the cutter shall be determined at 21°C, ±3°C (70°F, ±5°F). The cutter shall be opened to the fullest extent using the rated system input and no external load. The opening distance of the cutter shall be measured in a straight line at the tips of the cutter, with the cutter in the fully open position. The opening and closing times of the unloaded tool also shall be measured.

4-1.5.2 The opening distance of the cutter shall be recorded and verified with the data that are supplied by the manufacturer. The opening and closing travel times of the cutter shall be recorded and verified with the data that are supplied by the manufacturer.

4-1.5.3 The cutter shall be rated for ability to cut specific material with an alphanumeric Level Rating System.

4-1.5.3.1 The numerical performance Levels and the material Categories of the rating system shall be as specified in the performance requirements of 5-1.4.2 and Section 6-13, Cutting Test.

4-1.5.3.2* The Level Rating shall be expressed as follows:

A#/B#/C#/D#/E#

The letters A, B, C, D, and E shall indicate the material Category, and the performance Level number for the specific material Category shall be inserted in place of the # sign.

4-2 Hose and Electrical Cables.

4-2.1 The manufacturer of hose and couplers that will come into contact with tool or system hydraulic fluid shall supply the RTS or RT manufacturer with written documentation that such hose and couplers are compatible with the specified hydraulic fluid and that they will function properly at a maximum hydraulic fluid temperature of 71°C (160°F).

4-2.2 Hose for RTS shall be rated for use with hydraulic fluid that is nonflammable or noncombustible unless classified as a Class IIIB combustible liquid in accordance with NFPA 30, *Flammable and Combustible Liquids Code.*

4-2.3 Hose assemblies shall have a minimum safety factor against burst of 200 percent.

4-2.4* All hose hydraulic fittings and quick-connect couplers shall be rated for at least the rated system input and shall have a minimum safety factor of 200 percent.

4-2.5 All hose quick-connect couplers shall be equipped with a locking feature to prevent accidental uncoupling during operation.

4-2.6 Electrical cables and wires shall be rated to handle the electrical current realized when the system is operating at rated system input.

4-2.7 All quick-connect electrical cables shall be polarized.

4-2.8 All electrical cables and wires shall be properly insulated to prevent short circuits.

4-3 Power Units.

4-3.1 Where hydraulic fluid is used, the manufacturer of seals, valves, and fittings that will come into contact with hydraulic fluid in the RT shall supply the RT manufacturer with written documentation that such seals, valves, and fittings are compatible with the specified hydraulic fluid for the RT and that they will function properly at a maximum hydraulic fluid temperature of 71°C (160°F).

4-3.2 Where hydraulic fluid is used, the hydraulic fluid that is specified for use with the power unit shall not be classified as either a flammable liquid or a combustible liquid unless classified as a Class IIIB combustible liquid in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

4-3.3 All power unit hydraulic fittings and quick-connect couplers shall be rated for at least the rated system input and shall have a minimum safety factor of 200 percent.

4-3.4 All power unit quick-connect couplers shall be equipped with a locking feature to prevent accidental uncoupling during operation.

4-3.5 Handles and controls shall be located on the power unit to allow the power unit to be safely carried and operated by personnel wearing gloves that are certified as compliant with the glove requirements of NFPA 1971, *Standard on Protective Ensemble for Structural Fire Fighting*.

4-3.6 Each power unit with a continuously operating prime mover shall be equipped with a manually operated pressure dump valve to relieve hose line pressure in order to allow a tool to be removed or attached while the prime mover is operating at full speed.

4-3.7 All power units shall have all integral control parts properly labeled to ensure ease of identification by the user. The control parts shall include the following:

(1) Start switch or control
(2) Stop switch or control
(3) Choke location and position, if applicable
(4) Throttle, if applicable
(5) Fuel or power shutoff
(6) Open and closed position of any dump valve

4-3.8 All labeling of the prime mover, as specified by the prime mover manufacturer, shall be included.

4-3.9 Where the power unit includes an internal combustion prime mover, the appropriate engine fuel and engine oil reservoirs shall be indicated by a label.

4-3.10 Where the power unit includes an internal combustion prime mover, the manufacturer shall provide a label on the power unit that indicates the proper proportions for the fuel/oil mixture, if applicable.

4-3.11 Where the power unit includes an electric prime mover, the manufacturer shall provide a label on the power unit that indicates the rated horsepower, speed (rpm), amperage, and voltage.

4-3.12 Where the power unit includes a pneumatic prime mover, the manufacturer shall provide a label on the power unit that indicates the proper air pressure and cubic feet per minute necessary to maintain the specified rated power unit performance.

4-3.13 Where the power unit includes a hydraulic prime mover, the manufacturer shall provide a label on the power unit that indicates the proper hydraulic pressure and flow necessary to maintain the specified rated power unit performance.

4-3.14 The RTS or RT manufacturer shall provide the purchaser with any maintenance tools that are not commercially available and that are necessary to perform the expected service and maintenance of the power unit.

4-3.15 Where hydraulic fluid is used, a hydraulic fluid reservoir shall be provided and shall have an unobstructed port(s) for adding hydraulic fluid to the reservoir or for draining hydraulic fluid from the reservoir.

4-3.16 Where hydraulic fluid is used, a label shall be provided near the hydraulic fluid fill port that indicates the type of fluid that is specified by the manufacturer for use with the system.

4-3.17 The power unit manufacturer shall label the usable capacity of the hydraulic fluid reservoir.

4-3.18 All power units that weigh in excess of 22.5 kg (49 lb), including fluid, and all power units with an internal combustion engine shall be provided with an unobstructed port at the lowest point of the hydraulic fluid reservoir in order to allow the reservoir to be emptied when the power unit is in the upright position.

4-3.19 Where hydraulic fluid is used, the hydraulic fluid reservoir shall be provided with a means to visually determine the fluid level. Such means shall include, but not be limited to, dip stick–type indicators, sight gauges, or remote fluid level gauges.

4-3.20 Where hydraulic fluid is used, the power unit hydraulic pump intake shall be provided with a filter screen.

4-3.21 The hydraulic pump shall be equipped with a pressure relief device.

4-3.22 Any pressure relief automatic limiting device shall be designed to deter its adjustment by the user.

4-3.23 All power unit electrical connectors shall be rated to handle the electrical current realized when the system is operating at rated system input.

4-3.24 An enclosure for a battery or battery cell shall be provided with ventilation openings located so as to permit the circulation of air for dispersion of gases that can be generated under abnormal battery or charging conditions.

4-3.25 An enclosure for a battery or battery cell shall be provided with heat transfer means, such as ventilation openings or heat sinks, located so as to prevent thermal runaway of the battery during normal charging at the maximum allowable ambient temperature as specified by the battery manufacturer.

4-3.26 Power units that use batteries shall provide an indicator or other means to visually check the battery's state of charge.

4-3.27 All battery or battery pack exposed live terminals shall have protective covers to prevent accidental contact and arcing when not being used.

4-3.28 All electric components shall be listed and labeled for their intended application. Where labeled and listed electric components are not available for a specific application, the electric components that are used shall be suitable for the intended application.

4-3.29 All electric prime movers that are rated at greater than 100 V ac shall provide for an electric ground.

4-3.30 All portable internal combustion prime movers that are equipped with an electric starter shall also be equipped with a mechanical starter as a backup.

4-3.31 All portable internal combustion prime movers shall be equipped with a spark-arresting muffler that is listed by the U.S. Department of Agriculture Forest Service and shall also be equipped with a guard to prevent accidental contact with the muffler.

4-3.32 All internal combustion prime mover crankcases shall be equipped with an unobstructed port to allow oil to be drained without removing the internal combustion prime mover from the power unit.

4-3.33 All internal combustion prime movers shall have unobstructed access to the fuel tank fill cap and, where applicable, to the oil cap.

4-3.34 All pneumatic prime movers shall be equipped with an automatically resetting pressure relief device to prevent overpressurizing the pneumatic system.

4-3.35 The length, width, and height dimensions of the power unit, stated in the commercially printed matter as supplied by the RTS or RT manufacturer, shall be verified in order to establish the minimum storage dimensions.

4-3.36 The weight of the ready-to-use power unit, including any necessary attachments, shall be verified against the commercial printed matter that is supplied by the RTS or RT manufacturer. The weight of the pumps, hose, and hose reels shall be stated, including the weights of the hydraulic fluid, fuel, and maximum specified quantities of engine oil, if applicable.

4-4 Accessories.

4-4.1 Accessories including, but not limited to, chain, cable, hook-end connectors, U-end connectors, and wide-surface tip plates that are designed and intended for use with a compliant tool, or a compliant RTS, shall have a minimum safety factor of 1.5:1. The safety factor shall be determined by the forces that act on the accessory at the tool's tip separation that produces the HSF or HPF, as applicable.

4-4.2 Accessories shall be listed and labeled for use with a specific compliant RT or a specific compliant RTS.

4-4.3 Accessories shall not impair or degrade the design or performance of the compliant RT or compliant RTS below the applicable requirements of this standard.

4-4.4 Where hydraulic fluid is used, the manufacturer of seals, valves, and fittings used in accessories that will come into contact with hydraulic fluid in the RT shall supply the RT manufacturer with written documentation that such accessory seals, valves, and fittings are compatible with the specified hydraulic fluid for the RT and that they function properly at a maximum hydraulic fluid temperature of 71°C (160°F).

4-4.5 Where hydraulic fluid is used, the hydraulic fluid that is specified for use with the accessory shall not be classified as either a flammable liquid or a combustible liquid unless classified as a Class IIIB combustible liquid in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

4-4.6 All accessory hydraulic fittings and quick-connect couplers shall be rated for at least the rated system hydraulic pressure and shall have a minimum safety factor of 2:1.

4-4.7 All accessory quick-connect couplers shall be equipped with a locking feature to prevent accidental uncoupling during operation.

4-4.8 All electric components shall be listed and labeled for their intended application. Where labeled and listed electric components are not available for a specific application, the electric components that are used shall be suitable for the intended application.

Chapter 5 Performance Requirements

5-1 Rescue Tools.

5-1.1 Spreaders.

5-1.1.1 Spreaders shall be tested for operating temperature range as specified in Section 6-1, Tool Operating Temperature Test, and shall operate for five operational cycles, and shall perform without any defect or any leak.

5-1.1.2 Spreaders shall be tested for their ability to hold spreading force as specified in Section 6-6, Spreading Force Sudden Power Loss Test, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes.

5-1.1.3 Where spreaders are also rated for pulling, those spreaders shall be tested for its ability to hold the pulling force as specified in Section 6-7, Pulling Force Sudden Power Loss Test, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes.

5-1.1.4 Spreaders shall be tested for spreading forces generated as specified in Section 6-2, Spreading Force Test. The spreading force at each of the 10 test points shall be at least 8900 N (2000 lbf). The lowest calculated spreading force of all 10 test points shall be designated as the LSF for that specific tool. The highest calculated spreading force of all 10 test points shall be designated as the HSF for that specific tool.

5-1.1.5 Where spreaders are also rated for pulling, those spreaders shall be tested for pulling forces generated as specified in Section 6-4, Spreader Tool Pulling Force Test. The pulling force at each of the 10 test points shall be at least 7120 N (1600 lbf). The lowest recorded pulling force of all 10 test points shall be designated as the LPF for that specific tool. The highest recorded pulling force of all 10 test points shall be designated as the HPF for that specific tool.

5-1.1.6 Spreaders shall be tested for endurance as specified in Section 6-8, Dynamic Endurance Test, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes.

5-1.1.7 Spreaders shall be tested for hydrostatic and mechanical overload as specified in Section 6-9, Overload Test, and shall not exhibit any functional damage; shall generate the HSF, ±8 percent, for the tool as determined in 5-1.1.4; and the deadman control shall automatically return to the neutral position. Where spreaders are also rated for pulling, those spreaders shall also generate the HPF, ±8 percent, for the tool as determined in 5-1.1.5.

5-1.1.8 The deadman control of spreaders shall be tested for endurance as specified in Section 6-10, Deadman Control Device Endurance Test, and the spreader shall generate the HSF, ±8 percent, for the tool as determined in 5-1.1.4. The spreader shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes. Where a spreader is also rated for pulling, it shall also generate the HPF, ±8 percent, for the tool as determined in 5-1.1.5.

5-1.1.9 Where spreaders are equipped with a built-in automatic safety relief device in accordance with 4-1.1.4, spreaders shall be tested for proper functioning of the tool and the built-in safety relief device as specified in Section 6-11, Safety Relief Device Test, and the tool shall operate as specified in 5-1.1.2.

5-1.2 Rams.

5-1.2.1 Rams shall be tested for operating temperature range as specified in Section 6-1, Tool Operating Temperature Test, and shall operate for five operational cycles, and shall perform without any defect or any leak.

5-1.2.2 Rams shall be tested for ability to hold spreading force as specified in Section 6-6, Spreading Force Sudden Power Loss Test, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes.

5-1.2.3 Where rams are also rated for pulling, those rams shall be tested for ability to hold pulling force as specified in Section 6-7, Pulling Force Sudden Power Loss Test, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes.

5-1.2.4 Rams shall be tested for ability to hold spreading force during reconnection of the supply hose or electrical cables as specified in Section 6-6, Spreading Force Sudden Power Loss Test, and shall not have the creep value exceed 6 mm ($^1/_4$ in.) before spreading begins again.

5-1.2.5 Rams shall be tested for spreading forces generated as specified in Section 6-3, Ram Tool Spreading Force Test. The spreading force at each of the three test points shall be at least 8900 N (2000 lbf). The lowest recorded spreading force of all three test points shall be designated as the LSF for that specific tool. The highest recorded spreading force of all three test points shall be designated as the HSF for that specific tool.

5-1.2.6 Where rams are also rated for pulling, those rams shall be tested for pulling forces generated as specified in Section 6-5, Ram Tool Pulling Force Test. The pulling force at each of the three test points shall be at least 7120 N (1600 lbf). The lowest recorded pulling force of all three test points shall be designated as the LPF for that specific tool. The highest recorded pulling force of all three test points shall be designated as the HPF for that specific tool.

5-1.2.7 Rams shall be tested for endurance as specified in Section 6-8, Dynamic Endurance Test, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes.

5-1.2.8 Rams shall be tested for hydrostatic and mechanical overload as specified in Section 6-9, Overload Test, and shall not show any functional damage; shall generate the HSF, ±8 percent, for the tool as determined in 5-1.2.5; and the deadman control shall automatically return to the neutral position. Where rams are also rated for pulling, those rams shall also generate the HPF, ±8 percent, for the tool as determined in 5-1.2.6.

5-1.2.9 The deadman control of rams shall be tested for endurance as specified in Section 6-10, Deadman Control Device Endurance Test, and the spreader shall generate the HSF, ±8 percent, for the tool as determined in 5-1.2.5. The ram shall not have a creep value greater 5 mm ($^3/_{16}$ in.) at 9 minutes. Where rams are also rated for pulling, those rams shall also generate the HPF, ±8 percent, for the tool as determined in 5-1.2.6.

5-1.2.10 Rams shall be tested for bending resistance as specified in Section 6-12, Ram Bend Test, and shall not exhibit any sign of external leakage or functional damage, and shall generate the HSF, ±8 percent, for the tool as determined in 5-1.2.5. Where rams are also rated for pulling, those rams shall also generate the HPF, ±8 percent, for the tool as determined in 5-1.2.6.

5-1.2.11 Where rams are equipped with a built-in automatic safety relief device in accordance with 4-1.1.4, rams shall be tested for proper functioning of the tool and the safety relief device as specified in Section 6-11, Safety Relief Device Test, and the tool shall operate as specified in 5-1.2.2.

5-1.3 Combination Tools.

5-1.3.1 Combination tools shall be tested for operating temperature range as specified in Section 6-1, Tool Operating Temperature Test, and shall operate for five operational cycles, and shall perform without any defect or leak.

5-1.3.2 Combination tools shall be tested for their ability to hold spreading force as specified in Section 6-6, Spreading Force Sudden Power Loss Test, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes.

5-1.3.3 Where combination tools are also rated for pulling, those combination tools shall be tested for ability to hold pulling force as specified in Section 6-7, Pulling Force Sudden Power Loss Test, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes.

5-1.3.4 Combination tools shall be tested for their ability to cut through the materials as specified in Section 6-13, Cutting Test, and shall cut the material in each material Category at a minimum of Level 1 performance.

5-1.3.4.1 The combination tool cutter shall receive a separate Level Rating for each material Category as determined by 12 pieces of the largest size material, indicated by the highest numerical performance Level, that the cutter is able to cut consecutively.

5-1.3.4.2* The minimum total number of qualified cuts that are required for certification shall be 60.

5-1.3.4.3 For each cut, the cutter shall completely sever the material in a single continuous motion.

5-1.3.4.4* The Level Rating for the cutter shall be expressed as specified in 4-1.4.4.2.

5-1.3.4.5 It shall be assumed that the cutter is capable of cutting all performance Levels *below* its rated level in any specific materials Category.

5-1.3.5 All mechanical parts of the combination tool cutter shall be tested for product integrity as specified in Section 6-14, Cutter Integrity Test, and shall sustain the maximum load that can be imparted from the force generated by the tool without damage, and the combination tool cutter shall operate and cut. For each cut, the cutter shall completely sever the material in a single continuous motion.

5-1.3.6 Combination tools shall be tested for spreading forces generated as specified in Section 6-2, Spreading Force Test. The spreading force at each of the 10 test points shall be at least 8900 N (2000 lbf). The lowest recorded spreading force of all 10 test points shall be designated as the LSF for that specific tool. The highest recorded spreading force of all 10 test points shall be designated as the HSF for that specific tool.

5-1.3.7 Combination tools shall be tested for pulling forces generated as specified in Section 6-4, Spreader Tool Pulling Force Test. The pulling force at each of the 10 test points shall be at least 7120 N (1600 lbf). The lowest recorded pulling force of all 10 test points shall be designated as the LPF for that specific tool. The highest recorded pulling force of all 10 test points shall be designated as the HPF for that specific tool.

5-1.3.8 Combination tools shall be tested for endurance as specified in Section 6-8, Dynamic Endurance Test, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes.

5-1.3.9 Combination tools shall be tested for overload as specified in Section 6-9, Overload Test, and shall not fail, and shall generate the HSF, ±8 percent, for the tool as determined in 5-1.3.6. Where combination tools are also rated for pulling, those combination tools shall also generate the HPF, ±8 percent, for the tool as determined in 5-1.3.7.

5-1.3.10 The deadman control of combination tools shall be tested for endurance as specified in Section 6-10, Deadman Control Device Endurance Test, and the combination tool shall generate the HSF, ±8 percent, for the tool as determined in 5-1.3.6, and shall not have a creep value greater than 5 mm ($^3/_{16}$ in.) at 9 minutes. Where combination tools are also rated for pulling, those combination tools shall also generate the HPF, ±8 percent, for the tool as determined in 5-1.3.7.

5-1.3.11 Where combination tools are equipped with a built-in automatic safety relief device in accordance with 4-1.1.4, combination tools shall be tested for proper functioning of the tool and the safety relief device as specified in Section 6-11, Safety Relief Device Test, and shall operate as specified in 5-1.3.2.

5-1.4 Cutters.

5-1.4.1 Cutters shall be tested for operating temperature range as specified in Section 6-1, Tool Operating Temperature Test, and shall operate for five operational cycles, and shall perform without any defect or any leak.

5-1.4.2 Cutters shall be tested for their ability to cut through the materials as specified in Section 6-13, Cutting Test, and shall cut the material in each material Category at a minimum of Level 1 performance.

5-1.4.2.1 The cutter shall receive a separate Level Rating for each material Category as determined by 12 pieces of the largest size material, indicated by the highest numerical performance Level, that the cutter is able to cut consecutively.

5-1.4.2.2* The minimum total number of qualified cuts that are required for certification shall be 60.

5-1.4.2.3 For each cut, the cutter shall completely sever the material in a single continuous motion.

5-1.4.2.4* The Level Rating for the cutter shall be expressed as specified in 4-1.5.3.2.

5-1.4.2.5 It shall be assumed that the cutter is capable of cutting all performance Levels *below* its rated level in any specific materials Category.

5-1.4.3 All mechanical parts of the cutter shall be tested for product integrity as specified in Section 6-14, Cutter Integrity Test, and shall sustain the maximum load that can be imparted from the force generated by the tool without damage, and the cutter shall operate and cut. For each cut, the cutter shall completely sever the material in a single continuous motion.

5-1.4.4 The deadman control of cutters shall be tested for endurance as specified in Section 6-10, Deadman Control Device Endurance Test, and the deadman control shall automatically return to neutral, and the cutter shall develop the rated system input.

5-1.4.5 Where cutters are equipped with a built-in automatic safety relief device in accordance with 4-1.1.4, cutters shall be tested for proper functioning of the tool and the safety relief device as specified in Section 6-11, Safety Relief Device Test, and the tool shall operate properly without any sign of permanent damage, defect, or leaks. The safety relief device shall automatically reset.

5-2 Hose Assemblies.

5-2.1 Hose assemblies shall be proof pressure tested as specified in Section 6-25, Hose Assembly Proof Pressure Test, and shall not leak or rupture.

5-3 Power Units.

5-3.1 The power unit shall be tested for impact resistance as specified in Section 6-15, Impact Resistance Test, and shall develop the rated system input of an RT during each of five operational cycles.

5-3.2 The power unit shall be tested for noise production as specified in Section 6-16, Noise Test, and shall not exceed 83 dBA at 4 m (13 ft).

5-3.3 The power unit shall be tested for operation on an incline as specified in Section 6-17, Incline Operational Test, and shall power an RT through a complete operational cycle to the rated system input of the RT.

5-3.4 The power unit hydraulic pump shall be tested for its ability to maintain rated system input as specified in Section 6-18, Power Unit Pressure Test, and shall maintain the rated system input for at least 1 minute. Pressure fluctuation during the 1 minute test, if any, shall not be more than ±5 percent of the rated system input.

5-3.5 The power unit output pressure relief or automatic limiting device shall be tested for proper operation as specified in Section 6-19, Power Unit Pressure Relief and Automatic Limiting Device Test, and shall prevent the power unit output from achieving greater than 105 percent of the rated system input.

5-3.6 The manually operated dump valve of power units shall be tested for proper operation as specified in Section 6-20, Power Unit Dump Valve Test, and shall allow hose to be disconnected from and reconnected to the power unit.

5-3.7 Power units shall be tested for endurance as specified in Section 6-21, Power Unit Endurance Test, and shall operate normally, and shall not leak.

5-3.8 Directional valves on power units, where provided, shall be tested for endurance as specified in Section 6-22, Directional Valve Endurance Test, and shall operate normally, and shall not leak.

5-4 Accessories.

5-4.1 Remote valve blocks on accessories shall be tested for endurance as specified in Section 6-23, Remote Valve Block Endurance Test, and shall operate normally, and shall not leak.

5-4.2 Hose reels shall be tested for endurance as specified in Section 6-24, Hose Reel Endurance Test, and hose reel rotary seals shall not leak.

Chapter 6 Testing

6-1 Tool Operating Temperature Test.

6-1.1 The tool test specimen, including the power unit designed to be used in conjunction with the specific tool and all hose and cables necessary to connect the power unit to the tool, shall be placed in a temperature-conditioning chamber at –20°C, ±1°C (–4°F, ±2°F) for a minimum of 5 hours. The 5-hour storage time shall begin when the temperature-conditioning chamber has stabilized at –20°C, ±1°C (–4°F, ±2°F) after the tool test specimen has been placed in the chamber.

6-1.2 The tool test specimen shall be removed from the temperature-conditioning chamber after being subjected to at least 5 hours at the conditioning temperature. The tool test specimen shall then be started within 2 minutes of removal from the temperature-conditioning chamber and shall be operated for five full cycles from the fully open to the fully closed position at rated system input.

6-1.3 The tool test specimen, power unit, hose, and cables shall be observed for defects and leaks while the tool test specimen is in operation.

6-1.4 After a 12-hour minimum dwell time, the same tool test specimen, including the power unit designed to be used in conjunction with the specific tool and all hose and cables necessary to connect the power unit to the tool, shall then be stored in a temperature-conditioning chamber at 49°C (120°F) for a minimum of 5 hours. The 5-hour storage time shall begin when the temperature-conditioning chamber has stabilized at 49°C, ±1°C (120°F, ±2°F) after the tool test specimen has been placed in the chamber.

6-1.5 The tool test specimen shall be removed from the temperature-conditioning chamber after being subjected to at least 5 hours at the conditioning temperature. The tool test specimen shall then be started within 2 minutes of removal from the temperature-conditioning chamber and shall be operated for five full cycles from the fully open to the fully closed position at rated system input.

6-1.6 The tool test specimen, power unit, hose, and cables shall be observed for defects and leaks while the tool test specimen is in operation.

6-1.7 The results of observation of all test cycles shall be used to determine pass/fail. During any of the test cycles, any operational abnormalities, defects, or leaks in the tool, power unit, hose, or cables shall constitute failure.

6-2 Spreading Force Test.

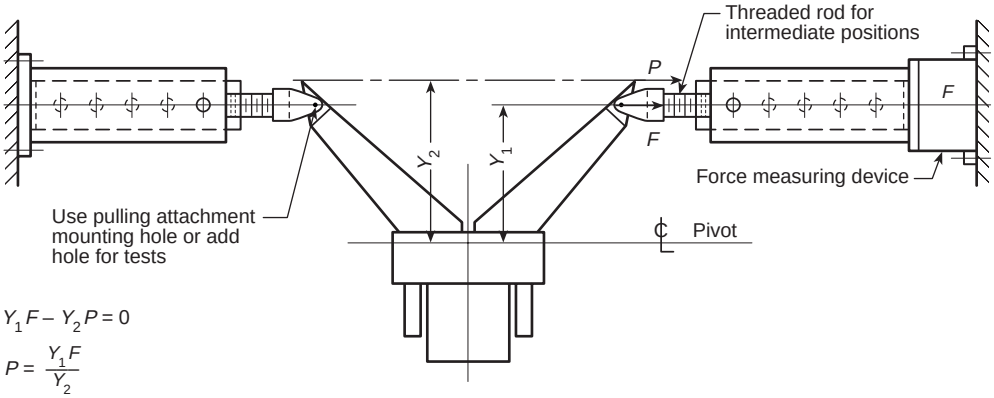
6-2.1 The spreading forces of tool test specimens shall be measured using the tips normally supplied to the purchaser or user.

6-2.2 A test fixture shall be provided that allows the tool test specimen to move through its full operational cycle.

6-2.3 The test fixture shall be equipped with a calibrated force-measuring device, with a minimum accuracy of ±0.5 percent of the total scale reading, to record the forces developed.

6-2.4 The general test setup shall be as shown in Figure 6-2.4(a) or Figure 6-2.4(b), as applicable. Equivalent test setups that use the same concept shall be permitted.

Figure 6-2.4(a) Test fixture to determine spreading and retracting forces of spreaders.

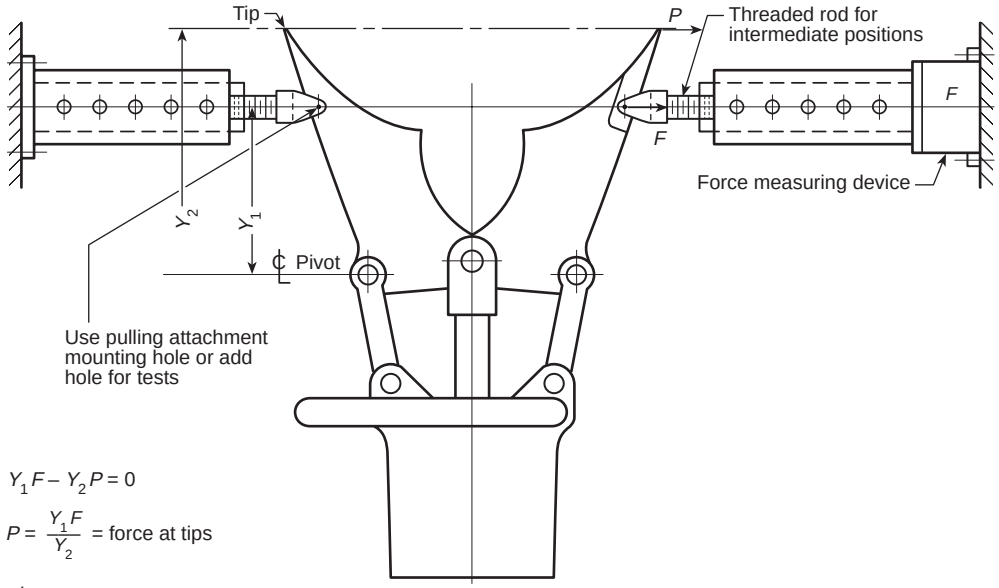


$$Y_1 F - Y_2 P = 0$$

$$P = \frac{Y_1 F}{Y_2}$$

where:
Y_1 = moment arm length of the measured force F
F = measured force at the attachment points (N)
Y_2 = moment arm length of the calculated force P
P = calculated force at the tips

Figure 6-2.4(b) Test fixture to determine spreading and retracting forces of combination tools.



$Y_1F - Y_2P = 0$

$P = \frac{Y_1F}{Y_2}$ = force at tips

where:
Y_1 = moment arm length of the measured force F
F = measured force at the attachment points (N)
Y_2 = moment arm length of the calculated force P
P = calculated force at the tips

6-2.4.1 The test points shall be the existing holes in the tool for pulling attachments.

6-2.4.2 Where there are no pulling attachment holes in the tool, holes shall be made for the purposes of conducting this test.

6-2.5 The tool test specimen shall be operated at the rated system input of the tool.

6-2.6 The spreading force exerted by the tool test specimen shall be measured and recorded at 10 uniformly spaced intervals that range from the fully closed position to 95 percent of the fully open position.

6-2.7 The recorded spreading forces shall be used to calculate the spreading force at the tool tip using the following formula:

$$P = \frac{Y_1F}{Y_2}$$

where:
P = calculated force at the tips
Y_1 = moment arm length of the measured force F
F = measured force at the attachment points
Y_2 = moment arm length of the calculated force P

Any calculated spreading force at the tool tips less than 8900 N (2000 lbf) shall constitute failure.

6-2.8 The calculated spreading forces at the tool tips shall be reviewed to determine the LSF and the HSF designations, respectively.

6-2.9 The calculated spreading forces at the tool tips shall be the reported forces that are required by 3-2.5.

6-3 Ram Tool Spreading Force Test.

6-3.1 The spreading forces of the tool test specimens shall be measured using the tips normally supplied to the purchaser or user.

6-3.2 A test fixture shall be provided. The test fixture shall be equipped with a force-measuring device and shall allow the tool test specimen to move through its full operational cycle.

6-3.3 The test fixture shall be equipped with a calibrated force-measuring device, with a minimum accuracy of ±0.5 percent of the total scale reading, to record the forces developed.

6-3.4 The general test setup shall be as shown in Figure 6-3.4, as applicable. Equivalent test setups that use the same concept shall be permitted.

6-3.4.1 The test points shall be the existing holes in the tool for pulling attachments.

6-3.4.2 Where there are no pulling attachment holes in the tool, holes shall be made for the purposes of conducting this test.

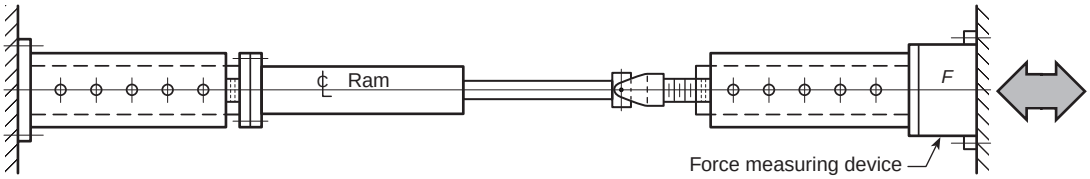
6-3.5 The ram tool test specimen shall be operated at the rated system input of the tool.

6-3.6 The spreading force exerted by the ram shall be measured and recorded at three uniformly spaced intervals that range from the fully closed position to 95 percent of fully open position.

6-3.7 The recorded spreading forces shall be reviewed to determine pass/fail. Any recorded spreading force less than 8900 N (2000 lbf) shall constitute failure.

6-3.8 The recorded spreading forces shall be reviewed to determine the LSF and the HSF designations, respectively.

Figure 6-3.4 Test fixture to determine extension and retraction forces of rams.



F = measured force at attachment points (N)

6-3.9 The recorded pulling forces at the tool tips shall be the reported forces required by 3-2.5.

6-4 Spreader Tool Pulling Force Test.

6-4.1 The pulling forces of tool test specimens shall be measured using the tips normally supplied to the purchaser or user.

6-4.2 A test fixture shall be provided that allows the tool test specimen to move through its full operational cycle.

6-4.3 The test fixture shall be equipped with a calibrated force-measuring device, with a minimum accuracy of ±0.5 percent of the total scale reading, to record the forces developed.

6-4.4 The general test setup shall be as shown in Figure 6-2.4(a) or Figure 6-2.4(b), as applicable. Equivalent test setups that use the same concept shall be permitted.

6-4.5 The test points shall be the standard production pulling attachment points on the RT.

6-4.6 The tool test specimen shall be operated at the rated system input of the tool.

6-4.7 The pulling force exerted by the tool test specimen shall be measured and recorded at 10 uniformly spaced intervals that range from the fully open position to 95 percent of the fully closed position.

6-4.8 The reported pulling forces at the tool tips shall be reviewed to determine pass/fail and to determine the LPF and the HPF designations, respectively.

6-4.9 The recorded pulling forces shall be the reported forces required by 3-2.5.

6-5 Ram Tool Pulling Force Test.

6-5.1 The pulling forces of tool test specimens shall be measured using the tips normally supplied to the purchaser or user.

6-5.2 A test fixture shall be provided. The test fixture shall be equipped with a force-measuring device and shall allow the tool test specimen to move through its full operational cycle.

6-5.3 The test fixture shall be equipped with a calibrated force-measuring device, with a minimum accuracy of ±0.5 percent of the total scale reading, to record the forces developed.

6-5.4 The general test setup shall be as shown in Figure 6-3.4, as applicable. Equivalent test setups of the same concept shall be permitted.

6-5.5 The test points shall be the standard production pulling attachment points on the RT.

6-5.6 The ram tool test specimen shall be operated at the rated system input of the tool.

6-5.7 The pulling force exerted by the ram shall be measured and recorded at three uniformly spaced intervals that range from the fully open position to 95 percent of the fully closed position.

6-5.8 The recorded pulling forces shall be reviewed to determine pass/fail and the LPF and the HPF designations, respectively.

6-5.9 The recorded pulling forces at the tool tips shall be the reported forces required by 3-2.5.

6-6 Spreading Force Sudden Power Loss Test.

6-6.1 Tool test specimens shall be placed in the test fixture exactly as for the spreading force test specified in Section 6-2 or Section 6-3, as applicable for the specific tool test specimen. Tool test specimens shall be set at the HSF position and shall be subjected to an external load equal to the greatest spreading force measured in the respective spreading force test ±2 percent.

6-6.2 The pressure supply hose or electric cable that supplies the tool test specimen shall then be disconnected from the tool to simulate a sudden power loss, and any creep of the tool test specimen shall be measured.

6-6.2.1 Where the tool test specimen is not equipped with a control, the creep shall be measured at 9 minutes.

6-6.2.2 Where the tool test specimen is equipped with a control, the control shall be set at each setting during the test. The control setting shall be set for 3 minutes at fully open, 3 minutes at fully closed, and 3 minutes at neutral. The creep shall be measured at 9 minutes.

6-6.3 The measured creep shall be evaluated to determine pass/fail. Any creep that exceeds the requirement shall constitute failure.

6-7 Pulling Force Sudden Power Loss Test.

6-7.1 Tool test specimens shall be placed in the test fixture exactly as for the pulling force test specified in Section 6-4 or Section 6-5, as applicable for the specific tool test specimen. Tool test specimens shall be set at the HPF position and shall be subjected to an external load equal to the greatest pulling force measured in the respective pulling force test ±2 percent.

6-7.2 The pressure supply hose or electric cable that supplies the tool test specimen shall then be disconnected from the tool to simulate a sudden power loss, and any creep of the tool test specimen shall be measured.

6-7.3 The tool test specimen control shall be set at each setting during the test. The control setting shall be set for 3 minutes at fully open, 3 minutes at fully closed, and 3 minutes at neutral. The creep shall be measured at 9 minutes.

6-7.4 The measured creep shall be evaluated to determine pass/fail. Any creep that exceeds the requirement at 9 minutes shall constitute failure.

6-8 Dynamic Endurance Test.

6-8.1 A test fixture shall be provided that allows the tool test specimen to move through its full operational cycle.

6-8.2 The test fixture shall be equipped with a calibrated force-measuring device, with a minimum accuracy of ±0.5 percent of the total scale reading, to record the forces developed.

6-8.3 The general test setup shall be as shown in Figure 6-2.4(a) or Figure 6-2.4(b), as applicable. Equivalent test setups that use the same concept shall be permitted.

6-8.4 Cooling of the hydraulic fluid, electric motor, and electric switches shall be permitted during this test.

6-8.5 The tool test specimens for spreading and pulling shall undergo 1000 continuous operational cycles while under a spreading load equal to 80 percent of the LSF and while under a pulling load equal to 80 percent of the LPF, as defined in 5-1.1.4, 5-1.1.5, 5-1.2.5, 5-1.2.6, 5-1.3.6, or 5-1.3.7, as applicable for the specific tool test specimen.

6-8.5.1 A pause in the continuous operational cycles for lubrication shall be permitted.

6-8.5.2 The continuous operational cycles shall not be interrupted for maintenance other than as allowed by 6-8.5.1.

6-8.6 The tool test specimens shall then be placed in the same test fixture exactly as for the load test specified in Section 6-2 or Section 6-3, as applicable for the specific tool test specimen. Tool test specimens shall be subjected to a test load equal to 110 percent of the HSF of the specific tool. Where tools also are rated for pulling, those tool test specimens shall also be subjected to a test load equal to 110 percent of the HPF of the specific tool.

6-8.7 The pressure supply hose or electrical cables supplying the tool test specimen shall then be disconnected from the tool to simulate a sudden power loss, and any creep of the tool test specimen shall be measured.

6-8.7.1 Where the tool test specimen is not equipped with a control, the creep shall be measured at 9 minutes.

6-8.7.2 Where the tool test specimen is equipped with a control, the control shall be set at each setting during the test. The control setting shall be set for 3 minutes at fully open, 3 minutes at fully closed, and 3 minutes at neutral. The creep shall be measured at 9 minutes.

6-8.8 The measured creep shall be evaluated to determine pass/fail. Any creep that exceeds the requirement at 9 minutes shall constitute failure.

6-9 Overload Test.

6-9.1 While the tool test specimen is in the test fixture used for the test specified in Section 6-2 or Section 6-3, as applicable for the specific tool test specimen, a test load equal to 150 percent of the HSF and HPF, as applicable, shall be applied as follows for 1 minute.

6-9.1.1 For RTs with pressure vessels having external pressure supply and return ports, the test load shall be achieved by applying 150 percent of the rated system input.

6-9.1.2 For nonpressure vessel RTs, the test load shall be applied externally.

6-9.1.3 RTs with pressure vessels having self-contained internal pressure supply and return ports (closed-loop systems) shall be permitted to be tested in accordance with the procedures specified in either 6-14.2 or 6-14.3.

6-9.2 For spreader tool or combination tool test specimens, the test load shall be applied to the tool at the tip separation producing the HSF as determined in 5-1.1.4 or 5-1.3.6. Where the tool is also rated for pulling, the test load shall be applied to the tool at the tip separation producing the HPF as determined in 5-1.1.5 or 5-1.3.7.

6-9.3 For ram tool test specimens, the test load shall be applied to the tool at the tip separation producing the HSF as determined in 5-1.2.5. Where the ram tool is also rated for pulling, the test load shall be applied to the tool at the tip separation producing the HPF as determined in 5-1.2.6.

6-9.4 The test results shall be evaluated and the tool test specimen shall be examined and operated to determine pass/fail. The inability of a tool to produce the HSF or HPF, or both, as applicable, shall constitute failure. The inability of a tool to be fully operational from the fully open position to the fully closed position back to the fully open position shall constitute failure.

6-10 Deadman Control Device Endurance Test.

6-10.1 The deadman control on the tool test specimen shall be subjected to a 5000-cycle endurance test at no load.

6-10.2 A cycle for this test shall be defined as the activation of the control for opening and closing the tool test specimen and its release, allowing the control to return to neutral.

6-10.3 Where all deadman controls on the tool test specimen are identical, a single test with one tool shall be conducted. However, each different type of deadman control shall be tested separately.

6-10.4 Following the 5000 cycles, the deadman control shall be evaluated to determine that it has automatically returned to the neutral position.

6-10.5 For spreaders, rams, and combination tools, the tool test specimen shall then be evaluated in accordance with Section 6-6, Spreading Force Sudden Power Loss Test.

6-10.5.1 The measured creep shall be evaluated to determine pass/fail. Any creep that exceeds the requirement at 9 minutes shall constitute failure.

6-10.5.2 The tool test specimen shall be examined and operated to determine pass/fail. The inability of a tool to produce the HSF or HPF, or both, as applicable, shall constitute failure.

6-10.6 For cutters, the tool test specimen shall then be evaluated in accordance with Section 6-14, Cutter Integrity Test.

6-11 Safety Relief Device Test.

6-11.1 The pressure and return lines shall be connected to the tool, and the return line from the tool shall be blocked.

6-11.2 The power unit shall be activated and the tool shall be operated with the piston rod extending for 15 seconds to the rated system input.

6-11.3 For spreaders, rams, and combination tools, the return line shall then be unblocked and the tool shall be tested as specified in Section 6-6, Spreading Force Sudden Power Loss Test. Testing in accordance with Section 6-8, Dynamic Endurance Test, shall be permitted to be performed only once to evaluate both Sections 6-6 and 6-11.

6-11.4 For spreaders, rams, and combination tools, pass/fail shall be determined as specified in 5-1.1.2, 5-1.2.2, and 5-1.3.2, respectively.

6-11.5 For cutters, the return line shall then be unblocked, and the cutter shall be operated for five complete operational cycles to the rated system input.

6-11.6 For cutters, pass/fail shall be determined in accordance with 5-1.4.5.

6-12 Ram Bend Test.

6-12.1 The ram tool test specimen shall be tested at 95 percent of the full extension as shown in Figure 6-12.1.

6-12.2 An external off-center load equal to 125 percent of the spreading force measured at 95 percent of its full extension in 6-3.6 shall be applied to the ram while the ram is extended to 95 percent of its stroke. The load shall be applied at a point not more than 13 mm ($^1/_2$ in.) from the farthest edge of the gripping surfaces of the feet and in the same radial plane.

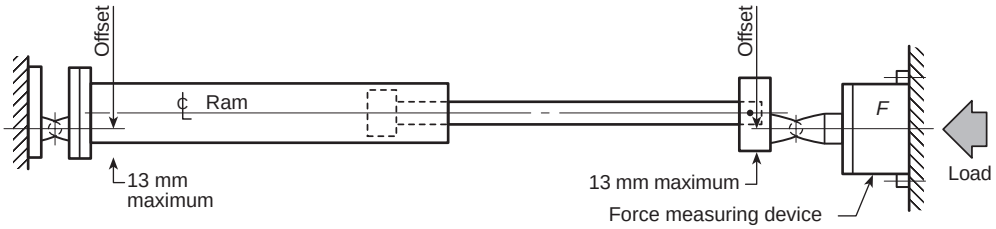
6-12.3 The tool test specimen shall be examined for leakage to determine pass/fail. Any leakage shall constitute failure.

6-12.4 The tool test specimen shall be operated to determine pass/fail. The inability of a tool to produce the HSF or HPF, or both, as applicable, shall constitute failure.

6-13 Cutting Test.

6-13.1 The tool test specimen shall be operated to cut 12 pieces of the largest size material, indicated by the highest numerical performance Level, that it is capable of cutting for each material Category specified in Figure 6-13.1.

Figure 6-12.1 Fixture for ram bend test.



For SI units 1in. = 25.4 mm.

F = measured force at the attachment points (N)

Figure 6-13.1 Cut testing and level performance rating.

Material Category	A Round Bar	B Flat Bar	C Round Pipe		D Square Tube	E Angle Iron
						
Material	A-36 Hot-Rolled	A-36	Schedule 40 A-53 Grade B		A-500 Grade B	A-36
Performance Level	Diameter (in.)	Thickness × Width (in. × in.)	Nominal size (in.)	OD × Wall Thickness (in. × in.)	Dimension × Wall Thickness (in. × in.)	Square Dimension × Thickness (in. × in.)
1	⅜	¼ × ½	⅜	0.68 × 0.09	½ × 0.06	½ × ⅛
2	½	¼ × 1	¾	1.05 × 0.11	1¾ × 0.06	1 × ⅛
3	⅝	¼ × 2	1	1.32 × 0.13	1 × 0.08	1¼ × 3⁄16
4	¾	¼ × 3	1¼	1.66 × 0.14	1¼ × 0.12	1½ × 3⁄16
5	⅞	¼ × 4	1½	1.90 × 0.15	1½ × 0.12	1½ × ¼
6	1	⅜ × 3	2	2.38 × 0.15	1¾ × 0.12	1¾ × ¼
7	1¼	⅜ × 4	2½	2.88 × 0.20	2 × 0.15	1½ × ⅜
8	1½	⅜ × 5	3	3.50 × 0.22	2½ × 0.19	2 × ⅜
9	1¾	⅜ × 6	3½	4.00 × 0.23	3 × 0.19	2½ × ⅜

For SI units 1 in. = 25.4 mm.