Designation: F2973 – 21

Standard Specification for Insulating Lifting Links for Load Lifting Equipment Working Near Energized Power Lines[1]

This standard is issued under the fixed designation F2973; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers insulating lifting links used for protection of workers positioning a load from accidental contact of the load lifting equipment with live electrical conductors, apparatus, and circuits.

1.2 This specification includes design, material, and testing requirements for the manufacturer and in-service inspection, testing and care requirements for the user or the agent of the user.

1.3 Insulating links whose primary application does not pertain to power line electrical safety are not within the scope of this specification.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E4 Practices for Force Verification of Testing Machines

F819 Terminology Relating to Electrical Protective Equipment for Workers

2.2 *IEEE Standard:*[3]

IEEE 4 Standard Techniques for High-Voltage Testing

2.3 *ISO Standard:*[4]

ISO 7500–1 Metallic Materials—Verification of Static Uniaxial Testing Machines—Part 1: Tensile Testing Machines—Corrigendum

3. Terminology

3.1 *Definitions*—Terminology used in this specification is in accordance with Terminology F819.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *design verification test, n*—test made on a sample treated as representative of an industrial product.

3.2.2 *electrical test, n*—a test ensuring that a product meets the minimum electrical requirements of the standard.

3.2.3 *flashover, n*—a disruptive discharge over the surface of the insulating link.

3.2.4 *mechanical test, n*—a test confirming that a product meets the minimum mechanical requirements of a standard.

3.2.5 *proof load, n*—specific mechanical load applied in the performance of the proof load test.

3.2.6 *proof test, n*—mechanical and electrical tests performed by the manufacturer on all production units.

3.2.7 *puncture, n*—disruptive discharge through an insulator.

3.2.8 *qualified personnel, n*—personnel who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, have demonstrated the ability to deal with problems relating to the subject matter, the work, or the project.

3.2.9 *rated load, n*—the maximum working load.

3.2.10 *visual inspection, n*—visual check made to detect defects that impede the performance of a product(s).

[1] This specification is under the jurisdiction of ASTM Committee F18 on Electrical Protective Equipment for Workers and is the direct responsibility of Subcommittee F18.55 on Inspection and Non-Destructive Test Methods for Aerial Devices.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854, http://www.ieee.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

4. Materials and Manufacture

4.1 The mechanical design factor shall not be less than 5.0 times its rated load for ratings up to 100 tons and 4.0 times rated load for ratings 100 tons and up.

4.2 The electrical design factor of the link shall not be less than 2 times it rated use voltage.

4.3 The insulation system shall not absorb water and shall have a water repellent surface.

4.4 Weather shields shall be made of impact resistant nonconductive material.

4.5 UV resistant polymers should be employed by the manufacturer if, without them, electrical performance may be affected.

4.6 Steel used shall meet ASTM or AISI standards.

5. Workmanship and Finish

5.1 The insulating surface of the links shall be free of cracks, nicks, gouges, damage to the insulating surface that would affect its insulating properties in both dry and wet conditions.

5.2 *Markings*—Each link should bear permanent, accessible, and readily visible markings that include, at a minimum, the manufacturer's mark, ASTM XXX, unit serial number, rated voltage, and rated load.

5.3 *Manuals*—The manufacturer shall provide a manual with each link. The manual shall contain:

5.3.1 Descriptions, specifications, and ratings of the link.

5.3.2 Ambient temperature range for which the link is designed.

5.3.3 Precautions concerning weather.

5.3.4 Instructions regarding routine and frequency of inspections and maintenance.

6. General Test Requirements

6.1 Personnel responsible for the tests outlined in this document shall be qualified individuals in accordance with 3.2.8, knowledgeable in the use of the test equipment used for tensile loading and high-voltage testing.

6.2 The electrical test equipment shall meet the requirements of IEEE 4-1995. The metering systems including measurement cable used to measure AC current shall have a system error of 5 % or less.

6.3 The electrical test set up shall provide the operator protection in the performance of his duties and isolate the specimen to guard against accidental contact by persons in the vicinity.

6.4 The ambient temperature for the test location shall not be lower than 15.5 °C.

6.5 Electrical discharge characteristics and measured current of a test object can be affected by its general arrangement, such as the clearance from other energized or grounded structures, the height above ground level, or the arrangement of the high-voltage lead that may affect flashover voltages. For that reason, the general arrangement should be as shown in Fig. 1 for testing links that are not installed on load lifting equipment.

6.6 Clearance to nearby structures that are equal to or greater than two times the length of the shortest possible electrical discharge path on the test object should make any proximity effects negligible.

7. Design Verification Tests

7.1 Design verification tests are to be performed on at least one representative unit from each class of insulating link, and this will qualify that class of link models of variable rated loads for a given rated voltage. A test unit is considered to be representative of its group if it meets the following requirements:

7.1.1 The same structural and dielectric materials, structural designs, manufacturing, and assembly methods apply to all links in the group,

7.1.2 The same structural stress and loading analysis can be applied to all the links in the group,

7.1.3 The test unit has the same or smaller electrical creepage and arcing distances per kV of rating.

7.2 *Mechanical Design Verification Test Procedure:*

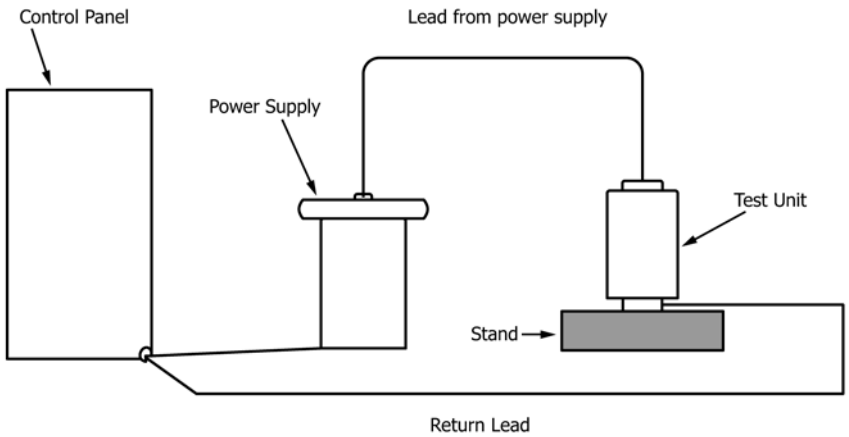

FIG. 1 Suggested Test Set Up for Insulated Links

7.2.1 The insulating link shall withstand a tensile load test of 5.0 times its rated load for rating up to 100 tons and 4.0 times rated load for ratings 100 tons and up for 60 s without separation. The tensile load test is to be performed on a test bed or hydraulic pulling machine calibrated to the latest revision of either ASTM E4 or ISO 7500–1.

7.3 *Electrical Design Verification Test Procedure:*

7.3.1 Three electrical tests to verify design voltage rating shall be peformed.

7.3.2 The insulating link will withstand an applied AC voltage while dry of twice the link-rated AC voltage for 5 min without dielectric puncture or flashover and leakage of no more than 3 mA.

7.3.3 The link shall be tested to verify that it does not absorb water with time.

7.3.3.1 Install the link in a humidity chamber for 48 h at a temperature between 65 and 100 °F with a minimum of 93 % relative humidity.

7.3.3.2 Within a time frame of 5 min after removal from humidity chamber in the vertical use position, apply test voltage in accordance with Table 1. Increase voltage at approximately 3 kV per second and hold for 3 min.

7.3.3.3 Measure and record the leakage current. A leakage current in excess of the values in Table 1 signifies a failure.

7.3.4 The link shall be tested to verify that it has a water repellent surface.

7.3.4.1 Immerse the entire link completely in a tank under tap water at room temperature for a minimum of 1 min.

7.3.4.2 In the vertical use position allow to set for 2 min to allow water to run off.

7.3.4.3 Apply test voltage in accordance with Table 1 within a time frame of 5 min after wetting. Increase voltage at approximately 3 kV per second and hold for 3 min.

7.3.4.4 Measure and record the leakage current. A leakage current in excess of the values in Table 1 signifies a failure.

8. Manufacturer Proof Tests

8.1 *Mechanical Proof Test Procedure:*

8.1.1 Each unit manufactured shall be subjected to an appropriate tensile proof load based on its rated load (see Table 2) for 60 s without permanent deformation. The load will be increased gradually in not less than 1 min. When requested, the manufacturer shall supply certification of compliance by unit serial number to the purchaser.

8.2 *Electrical Proof Test Procedure:*

8.2.1 General test requirements are given in 6.2 – 6.6.

8.2.2 An electrical proof test will be performed by the manufacturer on each insulating link before purchase. A copy of the proof test report will be kept on file by the manufacturer and made available to the customer upon request.

8.2.3 Electrically test the insulating link under dry conditions, applying two times the rated link voltage. Test voltages for typical voltage ratings are listed in Table 1.

8.2.4 Test current shall be no more than 3 mA and there shall be no sign of flashover or tracking.

TABLE 1 Test Voltages for Insulating Lifting Links

NOTE 1—Insulating links manufactured with rated voltages other than listed can have their test voltages calculated by using the formulas contained in the tables. Acceptance currents are 3 mA maximum.

Rated Link Voltage AC (RLV), kV	Line to Ground Equivalent RLV/square root of 3 (1.732), kV	Test Voltage (AC) Line to Ground Equivalent × 2	AC Maximum Leakage in milliamps not to exceed 3 mA	Test Voltage DC kV AC × 1.4	DC Maximum Leakage, in microamps
25	15	30	3 mA	42	84
35	20	40	3 mA	56	112
50	29	58	3 mA	81	162
69	40	80	3 mA	112	224
75	43	86	3 mA	120	240
125	72	144	3 mA	202	404
175	101	202	3 mA	283	566

9. Field Care, Inspection and Maintenance

9.1 *Frequent Inspections:*

9.1.1 Insulating lifting links shall be inspected at frequent intervals.

(a) Installation on lifting device when installed.

(b) Daily before first use.

9.1.2 *Frequent Inspection*—Visual inspections by the operator or other designated personnel.

(a) Frequent inspections shall include observations during operation.

(b) Links shall be inspected for distortion, cracks, nicks, gouges in the metal ends and damage to the insulating surface such as cracks, nicks, or punctures. A designated person shall determine whether conditions found during the inspection constitute a hazard and whether more detailed inspections are required. Cracks and other visible surface damage whose depths reach the link core will be cause for rejection and the link shall be removed from service and returned to the manufacturer for repair or replacement.

(c) In any condition that would moisten or wet the surface (dew, mist, rain, and so forth) links should be inspected for contamination that absorbs water over 20 % of the length of the link. Clean with a nonabrasive cleaner before returning to service.

(d) In any condition that would moisten or wet the surface (dew, mist, rain, and so forth) links should be inspected for water repelling surface. Apply water by spraying or pouring to ensure it beads up as in HC1–HC2 of Fig. 2. If the surface wets or shows poor beading pattern as in HC5 and HC6 of Fig. 2, the link surface should be cleaned and waxed with a water repelling nonconductive coating such as carnuba wax.

9.2 *Periodic Inspections:*

TABLE 2 Tensile Proof Load Based on Its Rated Load for Manufactured Unit in Tons

Rated Load	Proof Test Load as % of Rated Load
Below 54 tons	200
67 tons	193
90 tons	183
112 tons	166
135 tons	150
136 tons and above	133

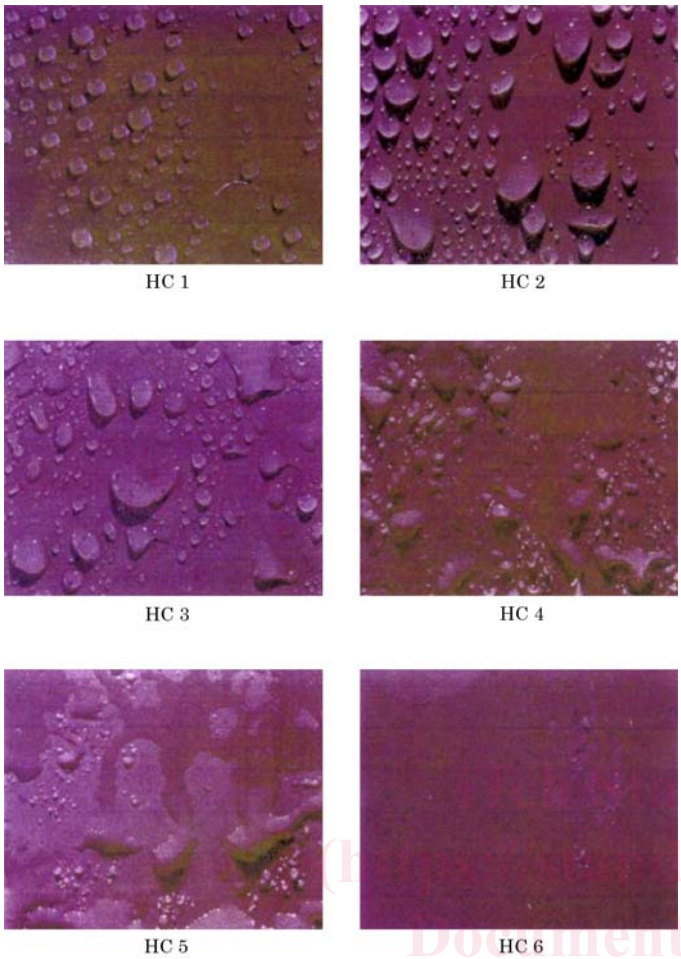

FIG. 2 HC1, HC2, HC3, HC4, HC5, HC6

9.2.1 Insulating lifting links shall be inspected at periodic intervals.

(a) A periodic inspection shall be performed annually.

(b) A periodic inspection shall be performed when an extraordinary event occurs, such as a sudden release of load, abnormal impact, lightning strike, vandalism, or any suspected occurrence of possible damage to the insulating link. The manufacturer should be consulted to aid in evaluation and determination if suitable for continued use.

9.2.2 Periodic inspections are visual inspections of apparent external conditions by a designated person.

9.2.2.1 The periodic inspection shall include a detailed inspection of items listed in 9.1.2, Frequent Inspection. When the inspection indicates there may be reason to suspect the electrical or mechanical integrity of the link it shall be mechanically and electrically tested in accordance with Section 10 before return to service.

9.3 *Care and Maintenance:*

9.3.1 The link surface should be cleaned to remove any accumulations of dirt or contamination such as salt and dust particles.

9.3.2 Links should be waxed on an annual basis or as needed to ensure water beading with a carnauba wax to maintain its water shedding capability. Water should bead up on the link surface. See representative photos. Fig. 2 (HC1–HC2) show good beading pattern. HC3 and HC4 show poor beading pattern with continuous rivulets that could cause electrical failure.

9.3.3 Nicks and gouges to the surface may be repaired following the link manufacturer's recommendations.

9.3.4 When not in use, insulating links should be stored out of the elements following the link manufacturer's recommendations.

9.3.5 Any alteration of the insulating link from the original manufacturer's design or repair without accompanying written approval from the manufacturer is prohibited and will be cause for the link being removed from service.

10. In-Service Tests for Insulating Link

10.1 *Mechanical In-Service Test Procedure:*

10.1.1 When the frequent or periodic inspection indicates that there may be reason to suspect mechanical integrity, the link shall be removed from service and a mechanical proof load test shall be performed before continued use.

10.1.2 The insulating link shall withstand a tensile load of 1.25 times the rate load of the link as measured by a calibrated dynamometer or load cell, with the link in place on the load line as in field use, and the load will be applied gradually over a period of 1 min. Hold the load for 1 min and release slowly. Any evidence of tearing of the glass, or any evidence of the separation of metal parts will be cause for rejection and failure of the test.

10.2 *Electrical In-Service Test Procedure:*

10.2.1 When the frequent or periodic inspection indicate that there may be reason to suspect the electrical integrity of the link, it shall be removed from service and an electrical test shall be performed.

10.2.1.1 General test requirements are given in 6.2 – 6.6 and Fig. 3.

10.2.2 The insulating link shall be clean, dry, and free from contamination (see 9.2).

10.2.3 Test the link using DC to 2.8 times or AC to 2 times the line to ground voltage for 3 min. See Table 1.

10.2.4 Wax insulating surfaces using a water repelling nonconductive coating such as carnuba wax.

10.2.5 Completely wet all surfaces of the link or immerse it in a tank under tap water for a minimum of 1 min at room temperature.

10.2.6 In the vertical use position allow to set for 2 min to allow water to run off. Test the link using DC or AC at Table 1 voltage for 3 min without flashover or tracking.

11. Record-Keeping

11.1 No records are required for frequent inspections.

11.2 A record of the periodic inspection shall include, as a minimum, the test date and location, the link manufacturer, link serial number, link model number, rated load and rated voltage, and results of visual inspection. If in-service mechanical testing is done, include the test load. If in-service electrical testing is done, record test voltage dry and wet, and test leakage results. If in-service tests are performed as the result of an