Designation: F2939 – 13

Standard Specification for High Voltage Phasing Testers[1]

This standard is issued under the fixed designation F2939; 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 portable, live-line tool-supported two-pole phasing testers to be used on AC electrical systems.

1.2 Two types of phasing testers are provided and are designated as Type I Resistive and Type II Capacitive.

1.3 Two styles of phasing testers are provided and are designated as Style A Numerical and Style B Audible/Visual.

1.4 The use and maintenance of these high voltage phasing testers and any necessary insulated tool handles are beyond the scope of this specification.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—Except where specified, all voltage defined in this specification refers to phase-to-phase voltage in a three-phase system. Phasing Testers covered by this specification may be used in other than three-phase systems, but the applicable phase-to-phase or phase-to-ground (earth) voltages shall be used to determine the operating voltage.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1796 Specification for High Voltage Detectors—Part 1 Capacitive Type to be Used for Voltages Exceeding 600 Volts AC

2.2 *Other Standards:*[3]

ANSI C84.1 Electric Power Systems and Equipment—Voltage Ranges

3. Terminology

3.1 *Definitions:*

3.1.1 *clear indication, n*—a specific condition that detects and indicates the presence or absence of the correct voltage, or phase relationship, or both, between two energized parts.

3.1.2 *contact electrode, n*—the bare conductive part of the conductive element that establishes the electrical connection to the component to be tested.

3.1.3 *indicator, n*—part of the phasing tester that indicates the presence or absence of the correct voltage, or phase relationship, or both, between two energized parts.

3.1.4 *indication, n*—visible, audible, or numeric indication of which clearly indicates the presence of nominal operating voltage within the specified voltage range.

3.1.4.1 *Discussion*—Noise and light indications shall be clearly detectable under the conditions outlined as follows: (See Specification F1796, sections 10.3.13 and 10.3.14). Acceptable Audible Indication – The audible test should be performed in an environment where background noise does not exceed 60 dBA. Acceptable Visual Indication – The Style B visual tests should be conducted in an environment with ambient light conditions ranging from 0 to 18 000 fc.

3.1.5 *insertion limit, n*—distinctive location to indicate to the user the physical limit to which the phasing device may be inserted between energized/grounded parts, as specified by the manufacturer.

3.1.6 *interference field, n*—electrical field capable of affecting the indication. It may result from the part to be tested or other adjacent parts.

3.1.7 *interference ground, n*—ground potential capable of affecting the indication. It may result from the part to be tested or other adjacent parts.

3.1.8 *phasing tester, n*—portable device used to detect and indicate the presence or absence of the correct voltage, or

[1] This test method is under the jurisdiction of ASTM Committee F18 on Electrical Protective Equipment for Workers and is the direct responsibility of Subcommittee F18.35 on Tools & Equipment.

Current edition approved Sept. 1, 2013. Published October 2013. DOI: 10.1520/F2939-13

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

phase relationship, or both, between two energized parts at the same nominal voltage and frequency.

3.1.9 *response time, n*—time delay between sudden change of the voltage state on the contact electrode and the associated clear indication.

3.1.10 *status indication, n*—the ability by the user to determine that the phasing tester is in its operating position.

3.1.11 *test:*

3.1.11.1 *acceptance test, n*—a test made at the option of the purchaser to verify that a product meets design criteria.

3.1.11.2 *design test, n*—a test made on a sample treated as representative of an industrial product. These tests will not generally be repeated in quantity production.

3.1.11.3 *routine test, n*—a test made regularly on production material.

3.1.12 *testing element, n*—built-in or external device, by means of which the functioning of the phasing tester can be checked by the user.

3.1.13 *threshold angle, n*—minimum phase angle between the two parts to be compared which gives a change of signal indicating the incorrect presence or absence of the correct voltage, or phase relationship, or both.

3.1.14 *threshold voltage, n*—minimum voltage between the two parts to be compared to give a change of signal indicating the presence or absence of the correct voltage, or phase relationship, or both (not applicable for capacitive phasing testers).

3.1.15 *voltage, nominal design, n*—a nominal value consistent with the latest revision of ANSI C84.1, 2001, assigned to the circuit or system for the purpose of conveniently designating its voltage class.

3.1.16 *voltage range, n*—values stated by the manufacturer indicating the minimum and maximum operating voltage in which the phasing tester will operate.

4. Significance and Use

4.1 This specification establishes requirements for the design and testing of high voltage phasing set, used in the electrical power industry, to determine the presence or absence of the correct voltage or phase relationships, or both, and approximate voltage line to line or line to ground.

5. Classification

5.1 *Type I Resistive*——Two-pole phasing device with interconnect cable(s) used to detect and indicate the correct phase relationship of conductors by measuring voltage difference whose operation is based on the current passing through a resistor or other impedance device.

5.2 *Type II Capacitive*—Two-pole phasing device without interconnect cable(s) used to detect and indicate the correct phase relationship of conductors by measuring phase angle whose operation is based on the current passing through the stray capacitance to earth (ground).

5.3 *Style A, Numerical*—The presence of voltage or phase relationship is displayed numerically.

5.4 *Style B, Audible/Visual*—The presence of voltage or phase relationship is indicated by an audible sound and light, capable of being heard and seen as defined in Section 10.

6. Ordering Information

6.1 Orders for high voltage phasing testers under this specification shall include this ASTM designation and the following information:

6.1.1 Type,
6.1.2 Style,
6.1.3 Voltage range(s), and
6.1.4 Catalog number.

7. Marking and Instructions

7.1 Labeling:

7.1.1 Each phasing tester shall be marked clearly with the name of the manufacturer or supplier, operating voltage range, catalog number, and date code or serial number.

7.1.2 Instructions for operating the phasing tester shall be included with each unit.

8. Specifications

8.1 The manufacturer shall clearly specify the limits of performance of phasing tester within the instructions as follows:

8.1.1 Operating voltage range(s),
8.1.2 Operating temperature range,
8.1.3 Operating humidity range,
8.1.4 Storage temperature range,
8.1.5 Storage humidity range, and
8.1.6 Precautions or limitations in use.

9. Workmanship, Finish, and Appearance

9.1 Workmanship and finish shall be of such quality as to ensure safe operation of the unit. Appearance shall be the prerogative of the manufacturer.

10. Testing

10.1 *General*—Tests shall be performed using a minimum of two phasing testers that have been completely assembled. Tests shall be carried out under the following test conditions:

10.1.1 Ambient temperature 59 to 95°F (15 to 35°C).
10.1.2 Relative humidity 45 to 75 %.
10.1.3 Unless otherwise specified, tests shall be carried out using a 60 Hz AC power source.
10.1.4 An acceptable tolerance of ±10 % is allowed for all required values.

10.2 *Test Methods (Environmental):*

10.2.1 *Temperature Dependence of the Indication*—The phasing tester shall operate correctly in the temperature range of the climatic category according to 8.1.2. The numeric or threshold voltage shall not vary by more than ±10 %, with respect to the numeric or threshold voltage measured when tested at the minimum and maximum temperature. The phasing tester shall be subjected to the minimum and maximum temperature extremes for 24 h and immediately subjected to a numeric or threshold voltage test. The numeric or threshold voltage is not to deviate more than ±10 % from the previously

tested and recorded test report when conducted under the standard atmospheric conditions as stated in 10.1.1.

10.2.2 *Humidity*—The phasing tester shall operate correctly in the humidity range of the climatic category according to 8.1.3. The phasing tester is to be exposed to a minimum of 96 % humidity for 24 h. The phasing tester is considered to have passed if it meets the same criteria as outlined in 10.2.1.

10.3 *Test Methods (Mechanical):*

10.3.1 *Drop/Impact*—The test surface shall be concrete or steel and smooth, hard and unpliable. The height of the fall shall be 3 ft. The unit shall be dropped twice; once in the horizontal position and once in the vertical. The vertical drop shall be made on the contact electrode, if present. It is acceptable if the contact electrode bends, as long as the unit continues to operate. The unit shall be considered to have passed the test if there is no significant mechanical damage and the unit meets the requirements of 10.5.

10.3.2 *Durability of Labeling*—The labels on the detector shall be scrubbed for 1 min with a towelette soaked in water, then scrubbed for another minute with towelette soaked in ethyl alcohol. The test is considered passed if the marking remains legible, the printing does not smear, and the label remains attached.

10.4 *Test Methods (Electrical):*

10.4.1 *Battery Life Test*—The phasing tester shall be subjected to a voltage or phase angle test at a value that is ≥ threshold voltage and provides a continuous indication for a minimum of 10 min.

10.4.2 *Continuous Duty Rating*—The phasing tester shall be placed in contact with a high voltage supply lead and subjected to maximum rated voltage for 5 min. The phasing tester is considered to have passed the test if the indication doesn't deviate more than ±10 % of the initial indication.

10.4.3 *Response Time*—The test voltage applied shall be the minimum operating voltage of the phasing tester ±10 %. The test voltage shall remain ON and the phasing tester shall be applied and removed five times. The time sequence between these periods should vary and each shall be at least 3 s long in duration. The test is considered passed if all response times are shorter than 3 s.

10.4.4 *Self-Test Function*—The self-test function for a phasing tester equipped with this feature, shall be activated per the instructions, a minimum of three times. The test is considered passed if the proper indications appear each time.

10.5 *Test Methods (Audible/Visual Indication):*

10.5.1 *Acceptable Audible Indication*—The audible test should be performed in an environment where background noise does not exceed 60 dBA.

10.5.1.1 The phasing set shall be mounted so that the sound axis is parallel to the ground at least 3 ft off any sound reflecting surface. The test shall be performed by applying a voltage of 10 % over the threshold voltage to the contact electrode.

10.5.1.2 The sound intensity shall be measured at 2 ft intervals at ±15° off centerline while moving away from the phasing tester until the following audible thresholds are determined: *(1)* 77 dBA for detectors with intermittent signals, and *(2)* 80 dBA for detectors with continuous signals.

10.5.1.3 The phasing tester is considered passed if the audible thresholds are met at distances consistent with the maximum voltage rating of the phasing tester and OSHA minimum approach distances. These audible thresholds may be reduced by 10 dBA if the phasing set is equipped with a visual indication also.

10.5.2 *Acceptable Visual Indication*—The Style A visual tests should be conducted in an environment with ambient light conditions ranging from 0 to 18 000 fc.

10.5.2.1 The test shall be performed by applying a minimum voltage of 10 % over the threshold voltage to the contact electrode.

10.5.2.2 Three observers shall determine that visual detection can be made throughout angles of ±15° off the detect centerline at distances up to and including 10 ft from the phasing tester under test.

10.5.3 *Visual Inspection*—The phasing tester shall be reviewed for any defects apparent in its enclosure, contact electrode, or visual and audible indicating systems. Labeling shall be inspected and any accessories shall also be visually inspected. If any defects are found, the phasing tester is to be rejected.

10.6 *Test Methods (Operating for Type I, Resistive, only):*

10.6.1 *Method of Testing:*

10.6.1.1 The phasing tester shall be supported in a nonconductive fixture in a horizontal position. A phasing tester with a maximum rated voltage of 69 kV and below, it will be positioned a minimum of 3 ft above a conductive floor. No foreign objects shall be located between the test fixture and the floor. For phasing testers rated above 69 kV, the height from floor dimension will be a minimum of 6 ft.

10.6.1.2 The high voltage input cable connected to the electrodes A and B shall be free and clear of all surrounding objects connecting to the detector on an even axis. The interconnect cable of the phasing set shall also be free and clear of surrounding objects and ground. (See Fig. 1).

10.6.2 *Operating Voltage Range Test*—Each unit shall be subjected to the minimum and maximum operating voltage in which the phasing tester is rated for direct contact. The unit should indicate the correct voltage relationship ±10 % when the minimum and maximum voltages are applied.

10.6.3 *In-Phase Voltage Test*—Each pole of the phasing tester should be attached to one (the same) energized part. The part should be energized to the minimum and maximum operating voltage range. The unit should not indicate more than 5 % of the line to ground voltage.

10.6.4 *Out-of-Phase Voltage Test*—Each pole of the phasing tester should be attached to a separate phase conductor separated by 20° at the respective minimum and maximum operating voltage range of the unit. The unit should indicate an out-of-phase condition or 50 % of the phase-to-ground voltage. The unit should indicate the actual phase-to-phase voltage difference between the two parts, ±10 %.

10.6.5 *Alternate Out-of-Phase Voltage Test*—One phasing tester should be grounded and the second phasing tester installed on a conductor energized at 50 % of the minimum and

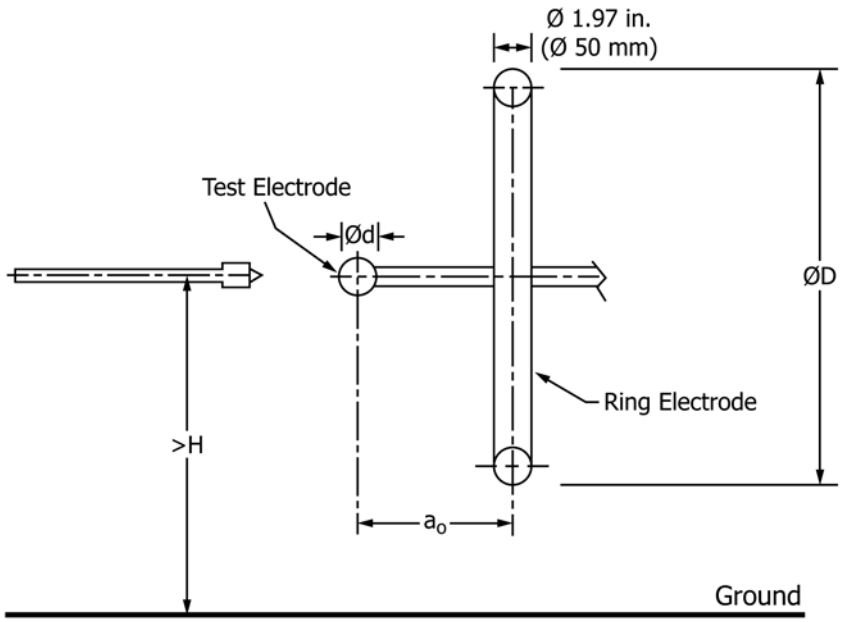

FIG. 1 Example of the Test Method

maximum rated voltages. The phasing tester should then indicate out-of-phase of 50 % or the phase-to-ground voltage.

10.7 *Test Methods (Operating for Type II, Capacitive, only):*

10.7.1 *Method of Testing:*

10.7.1.1 The phasing tester shall be supported in a non-conductive fixture in a horizontal position. For a phasing tester with a maximum rated voltage of 69 kV and below, it will be positioned 3 ft minimum above a conductive floor. No foreign objects shall be located between the test fixture and the floor. For phasing testers rated above 69 kV, the height from floor dimension will be 6 ft minimum.

10.7.1.2 The high voltage input cable connected to the electrodes A and B shall be free and clear of all surrounding objects connecting to the detector on an even axis. (See Fig. 1).

10.7.2 *Operating Voltage Range Test*—Each unit shall be subjected to the minimum and maximum operating voltage in which the phasing tester is rated for direct contact. The unit should indicate the correct phase angle relationship when the minimum and maximum voltages are applied per 10.7.3 and 10.7.4.

10.7.3 *In-Phase Angle Test*—Each pole of the phasing tester should be attached to separate conductors with the same voltage and separated by 10° degrees of phase angle ±1°. The part should be energized to the minimum and maximum operating voltage range. The unit should indicate an in-phase condition.

10.7.4 *Out-of-Phase Angle Test*—Each pole of the phasing tester should be attached to separate conductors with the same voltage and separated by 20 ± 1°. The part should be energized to the minimum and maximum operating voltage range. The unit should indicate an out-of-phase condition.

10.8 *Interference Voltage Testing*—Refer to Fig. 2. All Interference Testing applied to both types and styles of units below 50 kV only.

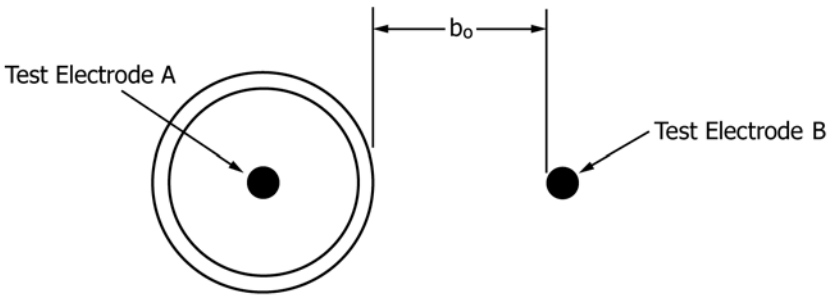

FIG. 2 Interference Voltage Testing

Nominal Voltage (kV)	Electrode Separation a_o (in.)	H (in.)	D Ring Diameter (in.)	d Sphere Diameter (in.)	b_o Conductor Separation
≤69 kV	12	>36	24	2	24
>69 kV	39	>72	43	4	43

10.8.1 *Same Phase Interference (up to 50 kV)*—When the ball and ring are energized to the same potential the unit should meet the requirements of 10.6.2.

10.8.2 *Out-of-Phase Interference (up to 50 kV)*—When the ball is energized and the ring is grounded the unit should meet the requirements of 10.6.2.

10.9 *Routine Performance Requirement:* A routine voltage test shall be performed on each completed unit of a production run to ensure that each unit is performing according to the following operational specifications:

10.9.1 Voltage test as referenced in 10.6.2, 10.7.2 or equivalent.

10.9.2 Testing the self-test function as referenced in 10.4.4.

10.9.3 Visual inspection as referenced in 10.5.3.

10.10 *Acceptance Test*—As defined, an acceptance test is only performed at the request of the customer in compliance with specific requirements.

10.11 *Performance:*

10.11.1 *Low Battery*—Low battery conditions shall be clearly indicated as described in the instructions.

10.12 *Phasing Tester Check*—If a self-checking system can be incorporated into the overall design of the phasing tester to allow internal functions to operate before and after each use, it will test all visual, audible and numeric indications and all normal operating functions. This test does not test for line functions.

11. Rejection and Rehearing

11.1 Devices that fail to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the rejection, the producer or supplier may make a claim for another approval.

12. Certification

12.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been tested and inspected as directed in this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

13. Precision and Bias

13.1 Each testing agency has the responsibility of judging the acceptability of its own results. The precision of the results is a function of the procedures and facilities utilized, as well as compliance to the recommended industry state-of-the-art practices. Reproducible analysis determinations by different users can be achieved only with identical facilities and trained, conscientious personnel.

14. Keywords

14.1 high voltage; live-line tools; phasing testers