



Designation: **F855—09 F855 – 14**

Standard Specifications for Temporary Protective Grounds to Be Used on De-energized Electric Power Lines and Equipment ¹

This standard is issued under the fixed designation F855; 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 These specifications cover the equipment making up the temporary grounding system used on de-energized electric power lines, electric supply stations, and equipment.

1.2 It is common practice for the users of protective grounding equipment to prepare complete instructions and regulations to govern in detail the correct use and maintenance of such equipment.

1.3 The uses and maintenance of this equipment are beyond the scope of these specifications.

1.4 These specifications for a system of protective grounding utilizing copper cables are covered in four parts, as follows:

| | Sections |
|---|----------|
| Clamps for Temporary Protective Grounds | 4 – 16 |
| Ferrules for Temporary Protective Grounds | 17 – 30 |
| Cables for Temporary Protective Grounds | 31 – 39 |
| Protective Grounds (Complete Assembly With Clamps, Ferrules, and Cable) | 40 – 52 |

1.5 Each of the four parts is an entity of itself, but is listed as a part of the system for completeness and clarification.

1.6 Currents presented in **Table 1** are based upon cable melting times, as determined from equations by I. M. Onderdonk and are to be used in situations involving an asymmetry value less than 20 % ($X/R \leq 1.8$). See **Appendix X3**.

1.6.1 Currents presented in **Table 2** are based upon the values from EPRI Project RP2446 Computer Program RTGC “A Desktop Computer Program for Calculating Rating of Temporary Grounding Cables” and are to be used in situations involving an asymmetry value greater than 20 % ($X/R \geq 1.8$), see **Appendix X4**.

NOTE 1—**Table 1** represents the clamp and assembly ratings that existed prior to this revision. **Table 2** represents new ratings now required for high X/R situations.

1.6.2 See **Appendix X3** and **Appendix X4** for a discussion of these topics.

1.7 The values stated in Newton-Meter units are to be regarded as the standard. The values in parentheses are the inch-pound units.

1.8 The following precautionary caveat pertains to the test method portions, Sections **12** and **25** of these specifications: *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.*

2. Referenced Documents

2.1 *ASTM Standards*:²

B172 Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors

B173 Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

¹ These specifications are under the jurisdiction of ASTM Committee **F18** on Electrical Protective Equipment for Workers and are the direct responsibility of Subcommittee **F18.45** on Mechanical Apparatus.

Current edition approved ~~May 1, 2009~~ Oct. 1, 2014. Published ~~July 2009~~ November 2014. Originally approved in 1983. Last previous edition approved in ~~2004~~ 2009 as **F855—04**; **F855—09**. DOI: ~~10.1520/F0855-09~~ 10.1520/F0855-14.

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.

TABLE 1 Protective Ground Cable, Ferrule, Clamp and Assembly Ratings for Symmetrical Current

| Grade | Grounding Clamp Torque Strength, min | | | | Short Circuit Properties ^A | | | | | | | Continuous Current Rating, A RMS, 60 Hz |
|-------|--------------------------------------|-----|----------|-----|---|--------------------|--------------------|--|--------------------|-----------------|--------------------------------|---|
| | Yield ^B | | Ultimate | | Withstand Rating, Symmetrical kA RMS, 60 Hz | | | Ultimate Rating Capacity ^{CD} , Symmetrical kA RMS, 60 Hz | | | | |
| | lbf-in. | n-m | lbf-in. | n-m | 15 cycles (250 ms) | 30 cycles (500 ms) | Copper Cable Size | 15 cycles (250 ms) | 30 cycles (500 ms) | 60 cycles (1 s) | Maximum Copper Test Cable Size | |
| | | | | | | | | | | | | |
| 1 | 280 | 32 | 330 | 37 | 14 | 10 | #2 | 18 | 13 | 9 | 2/0 | 200 |
| 2 | 280 | 32 | 330 | 37 | 21 | 15 | 1/0 | 29 | 21 | 14 | 4/0 | 250 |
| 3 | 280 | 32 | 330 | 37 | 27 | 20 | 2/0 | 37 | 26 | 18 | 4/0 | 300 |
| 4 | 330 | 37 | 400 | 45 | 34 | 25 | 3/0 | 47 | 33 | 23 | 250 kcmil | 350 |
| 5 | 330 | 37 | 400 | 45 | 43 | 30 | 4/0 | 59 | 42 | 29 | 250 kcmil | 400 |
| 6 | 330 | 37 | 400 | 45 | 54 | 39 | 250 kcmil or 2 2/0 | 70 | 49 | 35 | 350 kcmil | 450 |
| 7 | 330 | 37 | 400 | 45 | 74 | 54 | 350 kcmil or 2 4/0 | 98 | 69 | 48 | 550 kcmil | 550 |

^A Withstand and ultimate short circuit properties are based on performance with surges not exceeding 20 % asymmetry factor (see 9.1 and 12.3.4.2).

^B Yield shall mean no permanent deformation such that the clamp cannot be reused throughout its entire range of application.

^C Ultimate rating represents a symmetrical current which the assembly or individual components shall carry for the specified time.

^D Ultimate values are based upon application of Onderdonk's equation to 98 % of nominal circular mil area allowed by Specifications B172 and B173.

[D470 Test Methods for Crosslinked Insulations and Jackets for Wire and Cable](#)

[D753 Specification for General Purpose Polychloroprene Jacket for Wire and Cable \(Withdrawn 1984\)³](#)

[D2219 Specification for Poly\(Vinyl Chloride\) Insulation for Wire and Cable, 60°C Operation](#)

[D2633 Test Methods for Thermoplastic Insulations and Jackets for Wire and Cable](#)

[D2768 Specification for General-Purpose Ethylene-Propylene Rubber Jacket for Wire and Cable \(Withdrawn 2007\)³](#)

[D2770 Specification for Ozone-Resisting Ethylene-Propylene Rubber Integral Insulation and Jacket for Wire and Cable \(Withdrawn 2007\)³](#)

[E8/E8M Test Methods for Tension Testing of Metallic Materials](#)

2.2 [ANSI Standard:⁴](#)

[C 37.09 Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Basis](#)

2.3 [ICEA/NEMA Standard:⁵](#)

[ICEA S-19-81/NEMA WC 3-80 \(R 1986\) Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy](#)

2.4 [IEC Standard:⁶](#)

[IEC 61230 Ed. 2, 2008, Portable Equipment for Earthing or Earthing and Short-Circuiting](#)

2.5 [IEEE Standard:⁷](#)

[IEEE 386 Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V](#)

[IEEE 1048 Guide for Protective Grounding of Power Lines](#)

[IEEE 1246 Guide for Temporary Protective Grounding Systems Used in Substations](#)

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *continuous current rating*—designated RMS current which can be carried continuously under specified conditions.

3.1.2 *protective ground assembly*—a temporary electrical connection between a source of potential energization and the earth, rated for the maximum anticipated fault current or continuous induced current, or both.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

⁵ Available from Insulated Cable Engineers Assoc., P.O. Box P, South Yarmouth, MA 02664.

⁶ Available from International Electrotechnical Commission (IEC), 3 rue de Varembe, Case postale 131, CH-1211, Geneva 20, Switzerland, <http://www.iec.ch>.

⁷ Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., P.O. Box 1331, Piscataway, NJ 08854-1331, <http://www.ieee.org>.

3.1.2.1 Discussion—

Throughout this specification, kc mil = 1000 circular mils.

3.1.3 *protective grounding equipment*—devices installed temporarily on de-energized electric power circuits for the purposes of potential equalization and to conduct a short circuit current for a specified duration (time).

TABLE 2 Ultimate Assembly Rating for High X/R Ratio Applications

| Grade | Size | High Asymmetrical Test Requirements | | | |
|-------|---------|-------------------------------------|--|------------------------------|------------------------|
| | | Rating Rated Current (kA) | X/R = 30 1st-Cycle Current Peak (kA) X 2.69 | Last Cycle Current Peak (kA) | Test Duration (cycles) |
| 1H | No.-2 | 15 | 41 | 23 | 15 |
| 2H | 1/0 | 25 | 65 | 37 | 15 |
| 3H | 2/0 | 31 | 84 | 46 | 15 |
| 4H | 3/0 | 39 | 105 | 58 | 15 |
| 5H | 4/0 | 47 | 126 | 70 | 15 |
| 6H | 250-MCM | 55 | 148 | 82 | 15 |
| 7H | 350-MCM | 68 | 183 | 101 | 15 |

TABLE 2 Ultimate Assembly Rating for High X/R Ratio Applications

| Grade Size | Rating Rated Current (kA) | High Asymmetrical Test Requirements | | | | | | | | | | | | | | | Test Duration (cycles) | 1 ^{2t} (Mega amps ² -s) |
|------------|---------------------------|--|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------------------------|---|
| | | X/R = 30 Cycle Current Peak Values (kA) Rating X 2.69 | | | | | | | | | | | | | | | | |
| | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | 11th | 12th | 13th | 14th | 15th | | |
| 1H | 15 | 41 | 37 | 34 | 32 | 30 | 28 | 27 | 26 | 25 | 25 | 24 | 24 | 23 | 23 | 23 | 15 | 74 |
| 2H | 25 | 68 | 62 | 57 | 53 | 50 | 47 | 45 | 43 | 42 | 41 | 40 | 39 | 38 | 38 | 38 | 15 | 208 |
| 3H | 31 | 84 | 76 | 70 | 65 | 61 | 58 | 56 | 53 | 52 | 50 | 49 | 48 | 47 | 47 | 46 | 15 | 312 |
| 4H | 39 | 105 | 96 | 88 | 82 | 77 | 73 | 70 | 67 | 65 | 63 | 62 | 61 | 60 | 59 | 58 | 15 | 501 |
| 5H | 47 | 127 | 116 | 106 | 99 | 93 | 88 | 84 | 81 | 78 | 76 | 74 | 73 | 72 | 71 | 70 | 15 | 728 |
| 6H | 55 | 148 | 135 | 124 | 116 | 109 | 103 | 98 | 94 | 91 | 89 | 87 | 85 | 84 | 83 | 82 | 15 | 997 |
| 7H | 68 | 183 | 167 | 154 | 143 | 134 | 127 | 121 | 117 | 113 | 110 | 107 | 105 | 104 | 102 | 101 | 15 | 1523 |

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NOTE 1—The above current values are based on electromechanical test values.

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NOTE 2—Assemblies that have been subjected to these shall not be re-used.

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NOTE 3—For use with currents exceeding 20 % asymmetry factor.

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NOTE 4—See X4.7.2 for additional information.

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NOTE 5—Alternate testing circuits are available for laboratories that cannot achieve the above requirements. See Appendix X4 for details.

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3.1.4 *time to failure*—failure time of the cable is the time between the initiation of current flow and the instant at which arcing begins.

3.1.5 *ultimate capacity*—this represents a current which it is calculated the component is capable of conducting for the specified time. It is expected that component damage may result. The component shall not be reused, except in test situations.

3.1.6 *withstand rating*—this represents a near symmetrical current which shall be conducted without any component being damaged sufficiently to prevent being operable and reusable. The protective ground shall be capable of passing a second test at this current after being cooled to ambient temperature.

CLAMPS FOR TEMPORARY PROTECTIVE GROUNDS

4. Scope

4.1 This specification covers clamps used with ferrules and elastomer or thermoplastic covered flexible cable in the manufacture of protective grounds installed temporarily for protective grounding of de-energized circuits.

5. Classification

5.1 Clamps are furnished in, but not limited to, three types according to their function and method of installation, as follows:

5.1.1 *Type I*—Clamps for installation on de-energized conductors equipped with eyes for installation with removable hot sticks.

5.1.2 *Type II*—Clamps for installation on de-energized conductors having permanently mounted hot sticks.

5.1.3 *Type III*—Clamps for installation on permanently grounded conductors or metal structures with tee handles, and eyes or square or hexagon head screw(s), or both.

5.1.4 Other types of special clamps, such as those for cluster grounds or for underground equipment grounding, may be made, tested, and certified by the manufacturer as meeting the requirements of this specification.

5.1.5 Separable insulated connectors used in manufacturing underground equipment grounding assemblies shall meet the requirements of IEEE 386.

5.2 Clamps are furnished in grades according to mechanical strengths, short circuit capabilities, and duration of faults, as indicated in [Table 1](#).

5.3 Clamps are furnished in two classes according to the characteristics of the main contact jaws:

5.3.1 *Class A*—Clamp jaws with smooth contact surfaces.

5.3.2 *Class B*—Clamp jaws with serrations, or cross hatching, or other means intended to abrade or bite through corrosion products on the surfaces of the conductor being clamped.

6. Sizes

6.1 Clamp size is the combination of the main contact and cable size ranges as listed by the manufacturers. It should be noted that the main contact may connect to a cable or bus bar or be used at the “ground end” to connect to a variety of conductive grounded objects.

7. Ordering Information

7.1 Orders for clamps under this specification shall include this ASTM designation and the following information:

7.1.1 Quantity,

7.1.2 Name (grounding clamp),

7.1.3 Main contact size ranges, conductor descriptions, and materials which are to be clamped by main contact,

7.1.4 Cable size, material, and description by which clamps are to be assembled,

7.1.5 Type (see [5.1](#)),

7.1.6 Grade (see [5.2](#) and [Table 1](#) or [Table 2](#)),

7.1.7 Class (see [5.3](#)),

7.1.8 Asymmetrical current or other supplementary requirements, if applicable. (See Supplementary Requirements S1 to S10 for styles and designs.)

NOTE 2—A typical ordering description is as follows: 100 Grounding Clamps, Main contact range #2 to 350 kcmil for 2/0 Copper flexible grounding cable, ASTM F855, Type 1, Grade 3, Class A, Design C, Style 7.

NOTE 3—It is expected that manufacturers will publish catalog data conforming to this specification that will combine the requirements of [7.1.1 – 7.1.8](#) in a single product number. With that system, a typical order description is: 100 (Smith Manufacturing Co. Product No. XXXX) grounding clamps ASTM F855, Grade 2 or 2H.

8. Materials

8.1 Current carrying parts made of copper base or aluminum base alloy shall have the following material properties in accordance with Test Methods [E8/E8M](#):

Tensile strength, min
Yield strength, min
Elongation, min

Copper Base Alloy
207 MPa (30 000 psi)
90 MPa (13 000 psi)
6 %

Aluminum Base Alloy
207 MPa (30 000 psi)
138 MPa (20 000 psi)
3 %

8.2 Type II clamps shall be equipped with an insulating handle (hot stick) appropriate for the nominal voltage of the circuit to be grounded.

9. Electrical and Mechanical Properties

9.1 Electrical and mechanical properties shall conform to the requirements prescribed in **Table 1** or **Table 2**, as appropriate, and the following paragraphs. See **Appendix X3** for a discussion and derivation of the current levels in **Table 1**. See **Appendix X4** for a discussion of the effects of asymmetrical current and the derivation of the currents in **Table 2**.

9.1.1 Types I and II stick installed clamps shall be designed such that a failure does not increase the risk of injury to the user or have excess mechanical strength to prevent failure, defined as follows:

9.1.1.1 In the event the clamp is over-torqued during installation, normal fracture shall be such that the attached cable remains under control by being retained with the stick.

9.1.1.2 Clamps with an ultimate torque strength exceeding 45 N·m (400 lbf·in.) are exempt from the provisions of **9.1.1.1**.

9.1.2 Resistance from the main contact to the attached cable contact shall be less than that for an equal length of maximum size cable(s) for which the clamp is rated.

9.1.3 Main contacts shall accept and clamp all conductors or structural members in accordance with the manufacturer's rating.

9.1.4 Clamp shall accept hand assembly of all cables fitted with compatible ferrules as rated per **Table 3**.

9.1.5 Cable termination shall include a cable support or shall be made to accept a cable supporting ferrule. This support shall secure the entire cable over the jacket and is provided in addition to the electrical connection to the strand.

9.1.6 Type I clamps shall be operable with clamp sticks and shall fit securely inside a nominal 13 mm (½ in.) wide slot in the head of the stick.

10. Workmanship, Finish, and Appearance

10.1 Components shall be free of structural porosity, fins, sharp edges, splits, cracks, and other defects that affect handling or performance.

TABLE 3 Cable Terminations and Compatible Ferrules for Protective Ground Clamps

| Grounding Clamp | | Matching Cable Ferrule | | | Essential Data ^A |
|------------------------------|---|--|-------------------|---|--|
| ASTM Cable Termination Style | Cable Termination Description | Essential Size Data | ASTM Ferrule Type | Ferrule Description | Size |
| 1 | Cable retaining eyebolt | ferrule OD accepted Stud and shroud OD accepted | I III | compression plain stud shrouded compression | compressed OD stud dia and compressed shroud dia |
| 2 | eyebolt and cable support | ferrule or stud dia accepted | I | compression | compressed OD |
| 3 | plain bore bolted clamp and cable support | | III | plain stud shrouded compression | stud dia and compressed shroud dia |
| 4 | plain bore tubular with screws and cable support | | | | |
| 5 | plain bore boss | nominal ID ½ in. (12.7 mm), ⅝ in. (16 mm), or ¾ in. (20 mm) and included angle of cone contact | IV | threaded stud shrouded | stud or bolt dia ^A ½ in.–13NC, ⅝ in.–11 NC, or ¾ in.–10 NC and included angle of cone contact |
| 6 | plain bore boss and cable support | | V IV V | compression bolted shrouded compression threaded stud shrouded compression bolted shrouded compression threaded stud compression | |
| 7 | | thread size ^B ½ in.–13 NC, ⅝ in.–11 NC, or ¾ in.–10 NC | VI | | |
| 8 | threaded bore boss | | IV | threaded stud shrouded compression | stud size ^A ½ in.–13 NC, ⅝ in.–11 NC, or ¾ in.–10 NC |
| 9 | threaded bore boss and cable support threaded bore clamp and cable support | | VI | threaded stud compression ferrule | |

^A The material shall be copper or aluminum base. The cable size and material description shall include overall outside diameter.

^B Bolt stud and thread sizes metric conversion is as follows: ½ in. – 13 NC ≈ M12 × 1.75, ⅝ in. – 11 NC ≈ M16 × 2.00, ¾ in. – 10 NC ≈ M20 × 2.50.

10.2 All parts shall be formed, machined, and assembled with sufficient accuracy for smooth operation by hand, and shall be free of excessive looseness to the extent detrimental to repeated applications at the recommended installing torque.

10.3 Class A (smooth jaw) clamps shall have smooth contact surfaces free of burrs, fins, or other protuberances that would impair performance.

10.4 Class B (serrated jaw) clamps shall have longitudinally level surfaces that, with clamp movement as specified by the manufacturer, will provide a cleaning effect on the surface of the conductor from the serrations or crosshatching present.

10.5 Snag grinding marks, depressions, and other surface irregularities which do not affect strength, performance, or handling are not cause for rejection.

11. Sampling

11.1 A product model represents a manufacturer's design specification standard according to which the production lot is manufactured.

11.2 A production lot shall consist of all clamps of one product model produced at one time.

11.3 A test sample shall consist of two specimens for each different test specified. Specimens are selected at random and shall pass the inspection requirements of Section 13. When a failure occurs in one specimen from the first sample, a second sample from the same lot shall be selected and tested. If the second sample (two specimens) passes, the lot shall be accepted. If one specimen from the second sample fails, the lot shall be rejected.

12. Design Tests

12.1 The design tests that follow shall be made on test samples of each product model to verify that the requirements of this specification are met.

12.2 *Mechanical Torque Strength :*

12.2.1 Install the clamp on the main conductor of the minimum and maximum size for which the clamp is rated and apply torsional force to the main screw. Force may be applied to other devices designed to secure the clamp on the conductor.

12.2.2 Measure torque by a torque wrench that indicates torque directly or by another manner easily convertible.

12.2.3 The main conductor is defined as the material(s) for which the clamp is rated to be used.

12.2.4 Yield and ultimate strength shall equal or exceed the values shown in [Table 1](#).

12.3 *Electrical Short Circuit Capacity:*

12.3.1 Assemble the clamp with ferrules and cable in accordance with the manufacturer's specifications. The current is to be determined by the method described in ANSI C37.09-1979 (R-1989, Section 7). Cables shall have a minimum length of 3 m (10 ft.).

12.3.2 Electrode spacing shall be as specified in [Fig. 1](#), with the clamps in a vertical position, in order that the slack cable length stresses the clamps with electromagnetic tensile impact during test surge.

12.3.3 Test the clamp on the main conductor within the rated range established by manufacturer.

12.3.4 Short circuit values and time durations specified by the customer shall be as specified in [Table 1](#) or [Table 2](#), as appropriate. [Table 2](#) shall be used if no asymmetrical currents have been specified.

12.3.4.1 The withstand rating of [Table 1](#) represents a near symmetrical current which the clamp shall conduct without being damaged sufficiently to prevent being operable and reusable.

12.3.4.2 The ultimate rating of [Table 1](#) represents a current which the clamp shall carry for the specified time. The clamp thus tested might be damaged and shall not be reused.

12.3.4.3 The ultimate rating of [Table 2](#) represents an asymmetrical current at an X/R ratio of 30 which the clamp shall carry for the specified time. The clamp thus tested might be damaged and shall not be reused.

12.4 Grounding, clamps and ferrules tested at their continuous current rating shall have a lower maximum temperature than that of the maximum size copper main or tap cable for which rated. Temperature shall be measured at the warmest spot on the clamp, midpoint on the ferrule and on the metal strand at the midpoint of the main and top conductors, each a minimum of 1.5 m (5 ft).

13. Inspection and Product Testing

13.1 The clamps shall be inspected and tested as follows:

13.1.1 Verification of the main contact and cable capacities shall be in accordance with [9.1.2](#) and [9.1.3](#).

13.1.2 Visual inspection and hand operation to verify workmanship, finish, and appearance shall be in accordance with Section [10](#).

13.1.3 Torque test on a test sample shall be in accordance with [12.2](#).

14. Acceptance, Rejection, and Rehearing

14.1 At the option of the purchaser, a production lot may be subjected to the following: