b) The measured ratio V_3/I_1 with sinusoidal voltages is to be as close as feasible to the ratio V_3/I_1 calculated with the resistance and capacitance values of the measurement instrument shown in Figure 8.6. V_3 is to be measured by the meter M in the measuring instrument. The reading of meter M in RMS volts can be converted to MIU by dividing the reading by 500 ohm and then multiplying the quotient by 1,000. The mathematic equivalent is to simply multiply the RMS voltage reading by 2.

Figure 8.5

Circuit for leakage current test

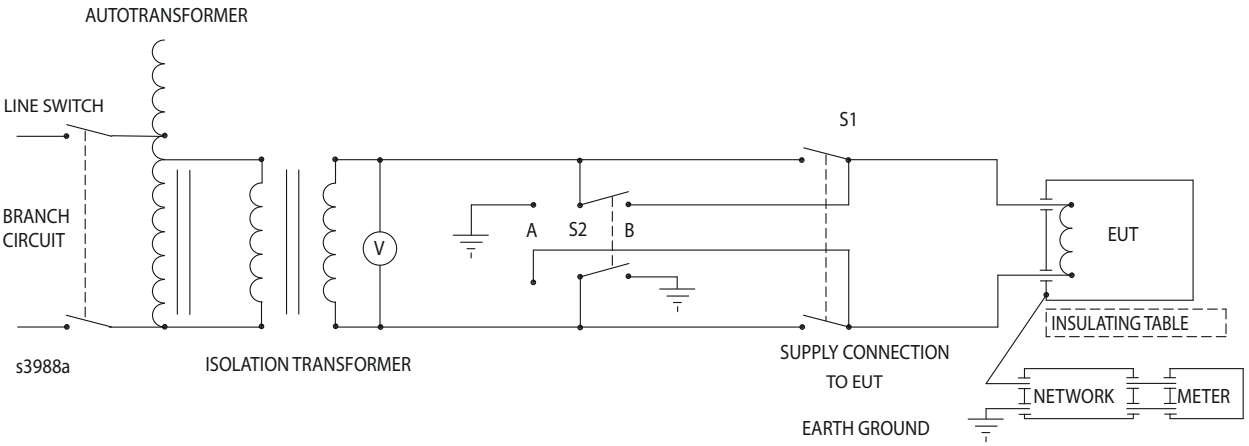
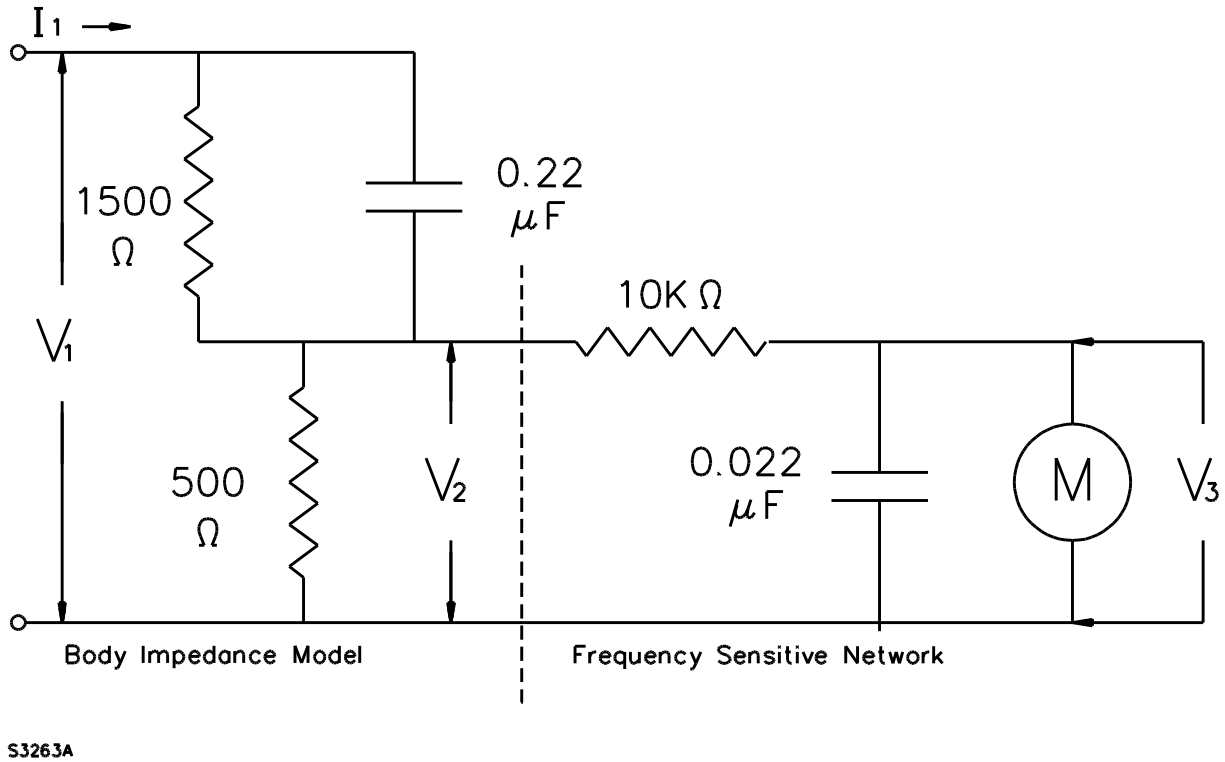


Figure 8.6

Measurement instrument for reaction (leakage) current



8.9.5 Unless the measurement instrument is being used to measure leakage current from one part of a unit to another, it is to be connected between accessible parts and the grounded supply conductor.

8.9.6 The sample unit is to be tested for leakage current without prior energization, except as may occur as part of the production-line testing. The supply voltage is to be adjusted to rated voltage. The test sequence is to be as follows, with reference to the Figure 8.5 measurement circuit:

a) With switch S1 open, the unit is to be connected to the measurement circuit. Leakage current is to be measured using both positions of switch S2, and with the unit switching devices in all their normal operating positions.

b) Switch S1 is then to be closed, energizing the unit. Within 5 seconds, the leakage current is to be measured using both positions of switch S2 and with the unit switching devices in all their normal operating positions.

c) Leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation as in the normal temperature test.

8.9.7 Using a commercially available meter having the network shown in Figure 8.6 or built to conform to the Standard for Leakage Current for Appliances, ANSI C101, meets the intent of these requirements. The meter is to be set to “reaction” curve.

8.10 Cord strain and pushback relief test

8.10.1 A supply cord shall be subject to a pulling force of 156 N (35 lbf) applied for 1 min in a direction perpendicular to the plane of entrance into the unit.

8.10.2 Following the test of 8.10.1, the supply cord is to be gripped 25.4 mm (1 in) from the point where it emerges from the product. When a removable bushing that extends further than 25.4 mm (1 in) is present, it is to be removed prior to the test. When the bushing is an integral part of the cord, the test is to be carried out by holding the bushing. The cord is to be pushed back into the product in 25.4-mm (1-in) increments until the cord buckles, or the force applied exceeds 26.7 N (6 lbf).

8.10.3 A field wiring lead wire shall be subject to an applied force as follows:

a) For a unit with leads extending from the enclosure – 89 N (20 lbf) or four times the weight of the unit, whichever is less but not less than 22 N (5 lbf), for a period of 1 minute.

b) For a unit with leads located within a wiring compartment – 44.5 N (10 lbf) or four times the weight of the unit, whichever is less but not less than 22 N (5 lbf) (per lead) for a period of 1 minute.

8.10.4 The results of 8.10.1 – 8.10.3 shall exhibit no:

a) Movement of the flexible cord more than 1.6 mm (0.063 in),

b) Movement of a lead wire that indicates stress was applied to internal connections,

c) Damage to conductors, connectors, or other components, or loosening of connections inside the enclosure of the unit, or

d) Exposure of the supply cord or lead wire to temperatures higher than for what they are rated.

8.11 Security of output terminals

8.11.1 A wire-binding screw terminal having fewer threads or lesser thickness than required by 7.4.2.3.5, or that relies upon a lockwasher to prevent turning per 7.4.2.3.7, shall be subject to 100 cycles of conductor connection and disconnection as described in 8.11.2.

8.11.2 The appropriate wires are to be inserted, and the tightening torque specified in Table 8.4 is to be applied for 10 seconds to the terminals. The screw terminals are then to be loosened fully. Following 100 cycles, the screw terminals shall not turn or exhibit any signs of damage.

Table 8.4
Tightening torque for wire-binding screws

Size of terminal screw		Wire sizes to be tested		Tightening torque	
mm	No.	AWG	(mm^2)	N·m	(lbf·in)
3.5	6	16 – 22	(1.3 – 0.32)[a]	1.4	(12)
4.0	8	14	(2.1)[b]	1.8	(16)
		16 – 22	(1.3 – 0.32)[a]		
5.0	10	10 – 14	(5.3 – 2.1)[b]	2.3	(20)
		16 – 22	(1.3 – 0.32)[a]		

[a] Stranded
[b] Solid wire

8.12 Insulation-piercing connection thermal cycling test

8.12.1 Six units shall be assembled to conductors of the size and type for which they are intended. The temperature of the insulation-piercing terminal connections shall be monitored continuously for seven hours while carrying the maximum rated load. The units shall then be subject to 180 cycles at a rate of 3-1/2 hours on and 1/2 hour off (the off-cycle time may be extended for the convenience of measurement), while continuing to monitor the temperatures of the insulation-piercing terminal connections. After the last cycle, the units shall be energized for a period of seven hours, while still monitoring temperatures.

8.12.2 Temperatures of the insulation-piercing terminal connections on each LED unit at the end of the test shall not be more than 30°C (54°F) higher than the temperatures measured on the same unit after the initial seven hours of operation. At no point during the testing shall the temperature of any insulation-piercing terminal connection exceed 90°C (194°F).

8.13 Adhesive support test

8.13.1 An adhesive relied upon to secure a part to another part shall have sufficient strength to withstand a pulling force equal to five times the weight of the supported part after the conditioning described in 8.13.2.

8.13.2 The adhesive secured parts shall be conditioned at 23°C (73.4°F) for 48 hours. They shall then be placed in an air-circulating oven at the temperature and for the time specified by Table 8.5. The adhesive rating temperature shall be based on results from the temperature test of 8.3; the associated conditioning time shall be by mutual agreement of the parties.

Table 8.5
Adhesive support oven temperature and time

Adhesive rating, °C	Oven temperature, °C			
	300 h (12.5 d)	720 h (30 d)	1000 h (42 d)	1440 h (60 d)
60	125	115	110	100
75	145	135	125	110
90	160	150	140	130
105	180	170	160	145
130	200	190	180	170
155	220	215	205	195
180	245	235	230	220
200	280	265	255	245
220	295	285	275	265
240	N/A	300	290	280

8.13.3 After conditioning, the sample is to be removed from the oven and allowed to cool to room temperature. A separating force shall then be evenly applied for one minute, perpendicular to the primary axis of the adhesive joint. The parts shall remain secured together.

8.14 Environmental tests

8.14.1 Humidity exposure

8.14.1.1 A unit intended for use in damp or wet locations shall be exposed for 168 hours to moist air having a relative humidity of 88 ±2 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F) to be followed by the dielectric voltage withstand test of 8.6.

8.14.1.2 A unit intended for wet locations is to be tested for water exposure in accordance with 8.14.2.

8.14.2 Water exposure

8.14.2.1 A unit intended for use in wet locations shall be subjected to a simulated rain produced in accordance with 8.14.2.4 – 8.14.2.6.

8.14.2.2 After the exposure, outer surfaces shall be dried and the dielectric voltage withstand test of 8.6 shall be repeated. There shall be no breakdown as a result of the dielectric voltage withstand test.

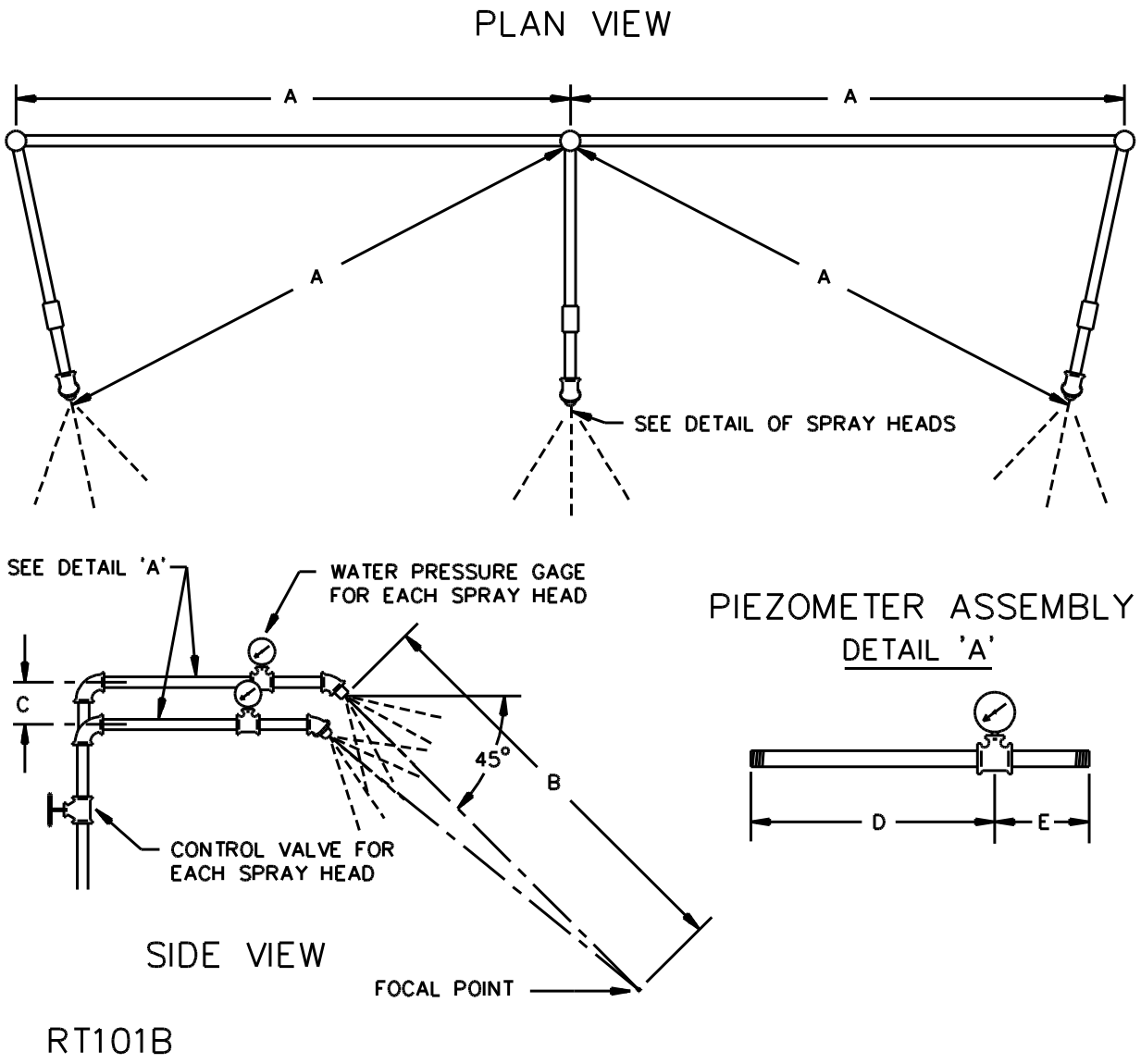
8.14.2.3 After the dielectric voltage withstand test of 8.6, the unit shall be carefully opened to determine if water entered. There shall be no water in contact with electrical parts, except for components suitable for the condition.

8.14.2.4 During the test the unit is to be oriented in the position that is most likely to result in the wetting of live parts, or in accordance with orientation markings specifically provided for the purpose.

8.14.2.5 The rain test apparatus shall consist of three spray heads mounted in a water supply pipe rack as shown in Figure 8.7. Spray heads are to be constructed in accordance with the details shown in Figure 8.8. The assembly is to be positioned in the focal area of the spray heads so that the greatest quantity of water is likely to enter the component. The water pressure is to be maintained at 34.5 kPa (5 psi) at each spray head.

Figure 8.7

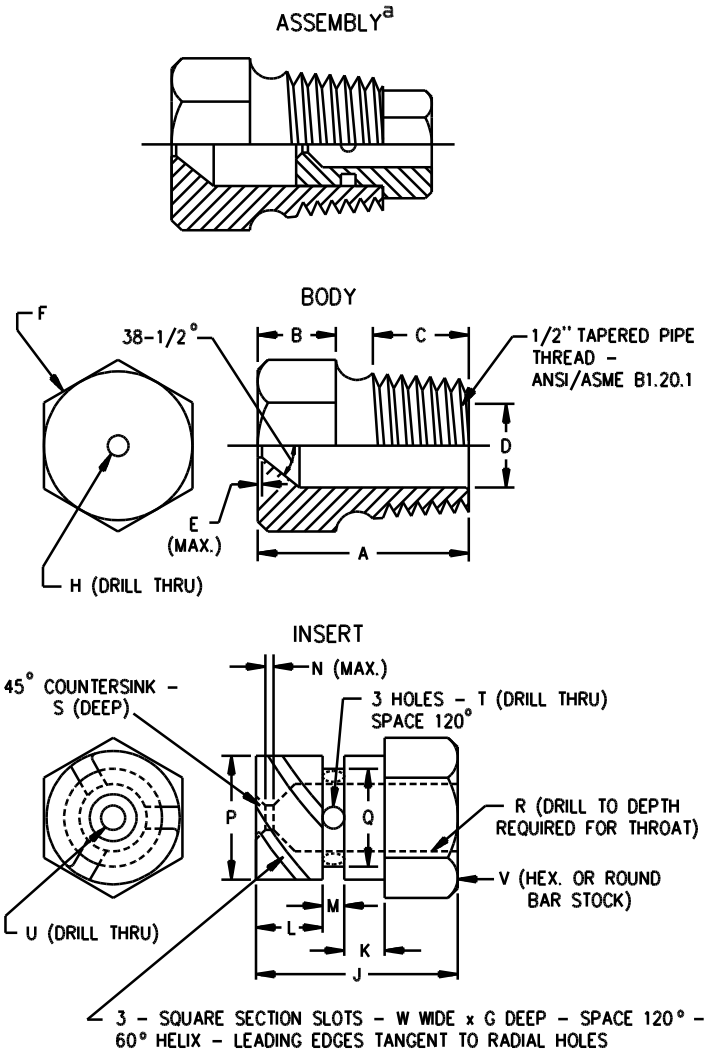
Spray head piping



Item	mm	(in)
A	710	(28)
B	1400	(55)
C	55	(2.25)
D	230	(9)
E	75	(3)

Figure 8.8

Spray head assembly



Item	mm	(in)	Item	mm	(in)
A	31.00	(1.219)	M	2.38	(0.094)
B	11.00	(0.438)	N	0.80	(0.031)
C	14.00	(0.563)	P	14.61 – 14.63	(0.575 – 0.576)
D	14.68 – 14.73	(0.578 – 0.580)	Q	11.51 – 11.53	(0.453 – 0.454)
E	0.40	(0.016)	R	6.35	(0.250)
F	Optional	Optional	S	0.80	(0.031)
G	1.52	(0.060)	T	2.80	(0.110)
H	5.00	(0.196)	U	2.50	(0.980)
J	18.30	(0.719)	V	16.00	(0.625)
K	3.97	(0.156)	W	1.52	(0.060)
L	6.35	(0.250)			

8.14.2.6 The assembly shall be subjected to the water spray for a total of 4 hours. During the 4 hours the assembly is to be energized and de-energized in the following sequence:

Test duration, h	Test period, h	Operational	Water
0 – 1.0	1.0	On	Off
1.0 – 1.5	0.5	Off	On
1.5 – 3.5	2.0	On	On
3.5 – 4.0	0.5	Off	On

8.15 Mechanical strength tests for metal enclosures

8.15.1 An enclosure part that is required by other parts of this standard to comply with this section shall withstand the two tests, in sequence, described in 8.15.2 and 8.15.3:

a) Without permanent distortion to the extent that spacings are reduced below the values specified in 7.8,

b) Without transient distortion that results in contact with live parts other than those connected in a Class 2 or LVLE circuit, and

c) Without development of openings that expose parts that involve a risk of electric shock or injury. Any openings resulting from the test are to be judged under the requirements for accessibility of 7.2.

8.15.2 The enclosure part is to be subjected to a 111 N (25 lbf) for 1 minute. The force is to be applied by means of a steel hemisphere 12.7 mm (1/2 in) in diameter.

8.15.3 The enclosure part is to be subjected to an impact of 6.8 J (5 ft-lb). The impact is to be applied by means of a smooth, solid, steel sphere 50.8 mm (2 in) in diameter and having 535 g (1.18 lb) mass. The sphere is to fall freely from rest through a vertical distance of 1.29 m (51 in).

8.16 Determination of low-voltage, limited-energy circuit status

8.16.1 LVLE circuits shall be limited in available current and voltage values as noted below, when tested according to other requirements of 8.16:

a) 8 amps for a voltage up to 42.4 V peak ac or 30 V dc, or

b) 150/V amps for a voltage between 30 – 60 V dc.

8.16.2 The input to the source under evaluation shall be connected as intended in the end product. The output to the circuit under evaluation shall be connected to a variable resistance load. If the source under evaluation has multiple outputs, all other outputs shall be open-circuited. The output voltage to the circuit under evaluation shall first be measured under open circuit conditions. The variable resistance load on the output under test shall then be adjusted from open circuit to short circuit until an available current of 8 A can be obtained and sustained for one minute of operation. If 8 A cannot be sustained for one minute under any condition of load, the test shall be discontinued.

8.16.3 When a secondary fuse or similar device is used to limit the output current to the circuit under evaluation, it shall be rated as indicated in Table 8.6. Any value may be used for a primary fuse; however, the maximum available output current levels shall be maintained. A fuse replacement marking (voltage and current rating) shall be provided adjacent to any fuse relied upon to limit the output current level, per 9.3.2.

Table 8.6
Output limiting secondary fuse

Open circuit potential, V_{peak} or DC	Maximum fuse rating, amps
0 – 20	5.0
> 20 – 60	100 / V_{peak} or DC

8.16.4 When a fixed impedance or regulating network is used to limit the voltage and/or current, it shall limit the voltage and current accordingly under any single component fault condition.

8.17 Knockout secureness test

8.17.1 A force of 44 N (10 lbf) shall be applied to a knockout for 1 min by means of a 6.4 mm (0.25 in) diameter mandrel with a flat end. The force shall be applied to the exterior surface of the knockout, in a direction perpendicular to the plane of the knockout, and at the point most likely to result in movement.

8.17.2 The knockout shall remain in place, and the clearance between the knockout and the opening shall be no more than 1.6 mm (0.063 in) when measured after the force has been removed.

8.18 Abnormal switching test

8.18.1 Two test samples are prepared and connected as follows:

a) The trigger circuit of the electromechanical relay is to be removed or modified to allow random switching.

b) The general abnormal test procedures described in 8.7.1.1 are followed as applicable.

8.18.2 The prepared test samples shall be operated in accordance with the applicable endurance test requirements in the Standard for Industrial Control Equipment, UL 508, based on the load types noted in 7.9.3 using random switching. The test samples shall be operated until either the required number of endurance test cycles is achieved or until ultimate results are demonstrated for 1 hour stabilized duration.

8.18.3 Immediately after each abnormal switching test, each control shall be subjected to the dielectric voltage withstand test of 8.6.

8.18.4 The control shall either operate as intended in accordance with the endurance test requirements, or demonstrate an end-of-life fail safe condition with no evidence of an imminent electrical shock, fire or injury to persons. There shall be:

a) No opening of the ground arc detection fuse.

b) No emission of the flame or molten metal, or ignition of the cheesecloth.

c) No opening of the branch circuit protection device.

d) No breakdown during the post-dielectric withstand testing.

8.19 Metal enclosure for conduit connection – rigidity

8.19.1 The enclosure shall be secured on a 12.7-mm (0.5-in) thick wood panel so that it is rigidly affixed to the wood panel. The panel dimensions shall extend beyond the junction box.

8.19.2 All enclosure covers shall be removed.

8.19.3 The weight specified in Table 8.7 shall be attached to a conduit fitting that has been installed to the enclosure so the force is applied from inside the enclosure at the point most likely to result in deformation. The weight is attached by a wire or cord so that it does not contact any surface of the enclosure.

8.19.4 After 2 min, the weight shall be removed and any permanent deformation from the original shall be measured.

Table 8.7
Deformation forces

Number of conductors in or out	Force (lb)	
	12 AWG	14 AWG
1 or 2	15	14
More than 2	30	16

8.19.5 Permanent deformation of the enclosure, its hardware, or its attachment to the luminaire shall not exceed 3.2 mm (0.125 in).

8.20 Metal enclosure for conduit connection – snap-in or tab-mounted parts pull test

8.20.1 A length of rigid conduit shall be connected to the opening in the enclosure part to be tested. The total length of exposed conduit shall be 305 mm (12 in).

8.20.2 When the enclosure is intended for conduit connection, a 133-N (30-lb) force shall be applied for 1 min at the end of the conduit in a direction perpendicular to the plane of the enclosure part being tested.

8.20.3 A 45-N (10-lb) force shall be applied for 1 min at the end of the conduit in a direction parallel to the plane of the enclosure part being tested and in the direction most likely to dislodge the enclosure part.

8.20.4 Before and after each test, the enclosure shall comply with the bonding circuit impedance test of 8.21.

8.20.5 After each test, the enclosure part shall remain attached to the enclosure, and permanent deformation of the enclosure or its parts shall not exceed 3.2 mm (0.125 in).

8.21 Bonding circuit impedance test

8.21.1 The test apparatus shall be an ohmmeter or similar indicating instrument capable of measuring 0.10 Ω. The measured resistance between the point of connection of the branch circuit equipment grounding conductor and any non-current carrying metal parts of the enclosure shall not exceed 0.10 Ω.

8.21.2 If the resistance measured in 8.21.1 exceeds 0.10 Ω, the test of 8.21.3 shall be conducted.

8.21.3 The test apparatus shall consist of an indicating instrument and an ac or dc power supply of approximately 12 V providing a current of 30 A through the bonding means being evaluated. The measured voltage between the point of connection of the branch circuit equipment grounding conductor and any non-current carrying metal parts of the enclosure shall comply with 8.21.4.

8.21.4 The test of impedance shall be performed by passing a 30 A current from a part to be grounded to the grounding terminal means for a period of 2 min and measuring the potential drop between them at the end of the period.

8.21.5 When tested in accordance with 8.21.4:

a) The resulting voltage drop shall not exceed 4.0 V,

b) There shall be no melting of any conductor or metal in the bonding circuit, and

c) There shall be no heating or burning that is likely to create a fire hazard.

8.22 Ground-screw assembly strength test

8.22.1 A 12 AWG (3.31 mm^2) solid-copper, insulated conductor shall be stripped to a length of 2.5 cm (1 in) minimum. The wire shall be wrapped around the screw under the screw head so that it makes a minimum 180-degree turn. The conductor shall be seated to follow any wire guides or dimples provided to align the conductor with the mating surface. The ground screw shall be tightened with a calibrated torque screwdriver to 1.6 N·m (14 lb-in).

8.22.2 When tested as described in this section, there shall not be:

a) Damage to the head of the ground screw which would prevent the 1.6 N·m (14 lb-in) of tightening torque to be achieved, or

b) Stripping of the ground screw assembly.

8.23 Bonding conductor tests

8.23.1 The bonding conductor path described in 7.2A.2.7 shall be subjected to the following tests.

a) A test current of 40 amperes for 2 minutes. Results are acceptable if the bonding conductor can carry this current for this duration. Also see 8.23.5 for additional acceptable results criteria; and

b) A limited-short-circuit test according to 8.23.2 – 8.23.4. Results are acceptable if the bonding conductor can carry the current until the fuse described in 8.23.3 opens. Also see 8.23.5 for additional acceptable results criteria.

Separate samples are to be used for each test, unless use of the same sample is acceptable to all parties involved.

8.23.2 The unit shall be prepared per 8.7.1.1 items (b) to (d) and (g).

8.23.3 The bonding conductor path shall be subjected to this test using the test current tabulated in Table 8.8 while connected in series with a 20A fuse as described in 8.7.1.1(f).

8.23.4 The test circuit is to have a power factor of 0.9 – 1.0 and a closed-circuit-test voltage equal to the maximum rated input voltage of the unit. The open-circuit voltage is to be 100 – 105 percent of the closed-circuit voltage.

8.23.5 During and following the test, the test shall not result in:

a) Emission of flame, molten metal, glowing or flaming particles through any openings;

b) Charring, glowing, or flaming of the supporting surface, tissue paper, or cheesecloth;

c) Ignition of the enclosure;

d) Creation of any openings in the enclosure that results in accessibility of live parts;

e) Evidence of degradation or separation of the trace from the printed-wiring board (when provided); or

f) Opening of the bonding conductor path or its solder connection.

Table 8.8
Circuit capacity for bonding conductor limited short-circuit test

Rating of unit, volt-amperes	Volts	Capacity of test circuit, amperes
0 – 1176	0 – 250	200
0 – 1176	251 – 600	1000
1177 – 1920	0 – 600	1000

9 Markings

9.1 General

9.1.1 A unit intended to be used in an application identified by one of the standards specified in 1.3 shall comply with the marking requirements of that standard. If an end-use application is not specified or identified, or if a construction or performance related marking of the unit is not covered by the identified standard, the unit shall comply with the marking requirements of this section.

9.1.2 A marking shall be legible, with minimum 1.6 mm (0.062 in) lettering and use one or more of the following methods:

a) Lettering on a pressure-sensitive label,

b) Paint stenciled lettering,

c) Ink-stamped machine lettering,

d) Ink-hand-stamped lettering,

e) Indelibly printed lettering,

f) Die-stamped lettering,

g) Embossed, molded, or cast lettering, raised or recessed a minimum of 0.010 in (0.25 mm) in depth,

h) Etched lettering,

i) Ink-jet lettering,

j) Laser engraving, or

k) Silk screening and transfer printing.

Exception: Identification and ratings markings in 9.2 are not subject to the minimum letter height requirement.

9.1.3 Pressure-sensitive labels and nameplates of the permanent type that are secured by adhesive shall comply with the Standard for Marking and Labeling Systems, UL 969, and be suitable for the mounting surface material and temperature involved, and the environment to which it will be subjected.