CAN/UL 2735C:2022

STANDARD FOR SAFETY

Electric Utility Meters for Canada

SCC FOREWORD

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UL Standard for Safety for Electric Utility Meters for Canada, CAN/UL 2735C

First Edition, Dated July 15, 2022

Summary of Topics

This is the First Edition of the Standard for Electric Utility Meters for Canada, CAN/UL 2735C dated July 15, 2022, which covers the electrical safety of electricity meters rated up to 600 VAC, which measure, monitor, record, transmit, or receive electrical energy generation or consumption information.

The requirements are substantially in accordance with Proposal(s) on this subject dated December 3, 2021 and March 3, 2022.

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CAN/UL 2735C:2022

Standard for Electric Utility Meters for Canada

First Edition

July 15, 2022

This CAN/UL Safety Standard consists of the First Edition.

This standard has been designated as a National Standard of Canada (NSC) on July 15, 2022.

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Preface

This is the First Edition of the Standard for Electric Utility Meters for Canada, CAN/UL 2735C.

UL is accredited by the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of SCC for accreditation of a Standards Development Organization.

Annexes A and B, identified as normative, form a mandatory part of this Standard.

This CAN/UL 2735C Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

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This Edition of the Standard has been formally approved by the STP on Electric Utility Meters for Canada, STP 2735C.

This list represents the STP 2735C membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

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This Standard is intended to be used for conformity assessment.

The intended primary application of this standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

INTRODUCTION

1 Scope

1.1 This Standard covers the electrical safety of electricity meters rated up to 600 VAC, which measure, monitor, record, transmit, or receive electrical energy generation or consumption information.

1.2 Meters covered by this Standard may be provided with one or two-way communication capabilities, by means of carrier signals, telephone, cable, wireless communication, or other methods.

1.3 Meters covered by this Standard may additionally provide signals, either by direct connection or wirelessly, for the control of electrical loads or electrical power generation equipment in response to signals received from the utility or local communication networks.

1.4 This Standard applies to detachable meters (Type “S” meters or “S-base” meters), and bottom-connected meters (Type “A” meters or “A-base” meters), intended for installation in ordinary (non-classified) locations. These may or may not be intended to be under the exclusive control of the serving utility.

1.5 This Standard does not apply to equipment intended as test equipment or equipment intended to make measurements for analysis in a laboratory or industrial setting.

2 Definitions

2.1 For the purpose of this Standard, the following definitions apply.

2.2 ACCESS PANEL – A panel or door that may be opened or removed to provide access to a portion of the meter interior.

2.3 ACCESSIBLE (part) – A meter part, conductive or non-conductive, which may be touched in normal use when the meter is installed as specified by the manufacturer, with the meter cover in place.

2.4 AUXILIARY (control) POWER SUPPLY – An electrical power supply of the meter, provided via dedicated terminal(s) in addition to the measurement terminals.

NOTE: The auxiliary power supply terminals of the meter are intended for connection to a power source separate from the measured circuit(s). For example, this type of power supply is used in applications where a meter is expected to operate when the measured circuits may be de-energized or function outside of the normal operating range of parameters (e.g. power quality monitoring).

2.5 AUXILIARY WIRING LEADS (of the meter) – Connections of meter communication ports, input/output ports, auxiliary power supply or other auxiliary ports provided on cables leaving the meter enclosure through an opening in the meter base.

2.6 BASE – The back portion of a meter that mates with the meter cover to form a complete enclosure, which supports the terminals, a hanger if provided, and provides support for sealing to the cover.

2.7 BOTTOM-CONNECTED METER (Type “A” meter or “A-BASE” meter) – A non-detachable meter that is connected using wiring terminals on the bottom of the meter.

2.8 CLEARANCE DISTANCE – The shortest distance in air between two conductive parts.

2.9 COVER – A lid or equipment covering used to protect the measurement components of a meter from external elements while allowing the viewing of the dials and nameplate information. A cover may contain other components which may be required for resetting demand and electronically reading the meter[§].

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NOTE: The use of the term "dials" throughout this Standard also includes electronic displays.

2.10 CREEPAGE DISTANCE – The shortest distance along the surface of a solid insulating material between two conductive parts.

2.11 DETACHABLE METER (Type “S” Meter) – A socket type meter, intended to plug into a meter socket or similar equipment.

2.12 ENCLOSURE – The exterior portion of a meter that prevents access to live parts when the meter is properly installed. For example, the enclosure of a typical Type S meter consists of the meter cover and the meter base.

2.13 GROUND TERMINAL (Functional Earth Terminal) – An equipment terminal connecting to earth ground. The ground terminal is not considered a mains terminal.

2.14 ISOLATED SECONDARY CIRCUIT – A circuit derived from an isolating source (such as a transformer, optical isolator, limiting impedance, electromechanical relay, or a battery) and having no other connection to the mains terminals. A ground terminal connection may be present.

2.15 MAINS – The electrical network supplying energy to the premises which consist of phase conductor(s) and neutral conductor(s). Neutral is considered a mains conductor.

2.16 MAINS CIRCUIT – Any circuit directly connected to the mains terminals. A circuit having direct connection to a neutral terminal is also considered a mains circuit.

2.17 MAINS TERMINALS – The equipment terminals used for connection to the mains which consist of potential (voltage) terminal(s), input current terminal(s), output current terminal(s) and neutral terminal(s). In some meter forms input current terminals also connect potential circuitry. Output current terminals may also connect to potential circuitry. Some meter forms do not have neutral terminals.

2.18 MATERIAL GROUPS – Related to the CTI performance level category values of insulating materials that are specified in Insulation coordination, CSA C22.2 No. 0.2, to be included in the group, as follows:

a) I – CTI ≥ 600 (PLC = 0)

b) II – 400 ≤ CTI < 600 (PLC = 1)

c) IIIa – 175 ≤ CTI < 400 (PLC = 2 or 3)

d) IIIb – 100 ≤ CTI < 175 (PLC = 4)

NOTE: PLC stands for Performance Level Category, and CTI stands for Comparative Tracking Index.

2.19 METER – A device intended to measure electrical energy usage for billing. It may include energy consumption of individual loads and appliances.

2.20 MICRO-ENVIRONMENT – The conditions that immediately surround the clearance or creepage distance under consideration. It includes all factors influencing the insulation, such as climatic, electromagnetic, and generation of pollution.

NOTE: The micro-environment of the creepage distance or clearance and not the general environment of the equipment determines the effect on the insulation. The micro-environment might be less severe or more severe than the general environment that the equipment is in.

2.21 NORMAL USE – Operation, including stand-by, according to the instructions for use or for the obvious intended purpose.

2.22 NOMINAL DISCHARGE CURRENT (I_n) – Peak value of the current, selected by the manufacturer, through the voltage-dependent resistor (VDR) having a current waveshape of 8/20 where the VDR remains functional after 15 surges. See also CSA C22.2 No. 269.5.

2.23 OPERATING TEMPERATURE RANGE – The temperature range specified by the manufacturer over which the meter will continue to function per the manufacturer's specifications.

2.24 POLLUTION DEGREES – Based on the presence of contaminants and possibility of condensation or moisture at the creepage distance and defined as follows:

a) POLLUTION DEGREE 1 – No pollution or only dry, nonconductive pollution. The pollution has no influence.

b) POLLUTION DEGREE 2 – Normally, only nonconductive pollution. However, a temporary conductivity caused by condensation may be expected.

c) POLLUTION DEGREE 3 – Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation that is expected.

d) POLLUTION DEGREE 4 – Pollution that generates persistent conductivity through conductive dust or rain and snow.

2.25 PRINTED WIRING BOARD – Printed Circuit Board.

2.26 RATED AMBIENT TEMPERATURE – The maximum temperature surrounding the meter at which the meter complies with all of the requirements of this Standard.

2.27 RATED VOLTAGE (of a meter) – The voltage provided by the manufacturer on the product nameplate excluding any additional tolerance.

2.28 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist at any accessible part if:

a) The potential between the part and earth ground or any other accessible part is more than 30 V rms (42.4 V peak) or 60 V dc; and

b) The continuous current flow through a 2000 Ω resistor connected across the potential exceeds 0.5 mA rms ac or 2 mA dc.

2.29 RISK OF FIRE – A risk of fire is considered to exist at any two points in a circuit where:

a) The open circuit voltage is more than 30 Vrms (42.4 V peak) and the energy available to the circuit under any condition of load including short circuit, results in a current of 8 A or more after 1 minute of operation; or

b) A power of more than 15 watts can be delivered into an external resistor connected between the two points.

2.30 SELF CONTAINED METER (directly connected meter) – A meter in which the terminals are arranged for connection to the circuit being measured without using external instrument transformers[§].

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2.31 SERVICE SWITCH – A device internal to the meter that is intended to energize or de-energize the load terminals of the meter.

2.32 SINGLE FAULT CONDITION – A condition in which one method for protection against a risk of fire or risk of electric shock is defective or one fault is present which could cause a risk of fire or risk of electric shock.

2.33 SOLID INSULATION – Solid non-conductive material interposed between two conductive parts.

NOTE: Solid insulation refers to many different types of construction, including monolithic blocks of insulating material and insulation subsystems composed of multiple insulating materials, organized in layers or otherwise.

2.34 TRANSFORMER RATED METER – A meter in which the terminals are arranged for connection to the circuit being measured using external instrument transformers. Instrument transformers may be required for the connection of meter's voltage measurement terminals, or current measurement terminals, or both[§].

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3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Components

4.1 A component of a product covered by this Standard shall:

a) Comply with the requirements for that component as specified in this Standard;

b) Be used in accordance with its rating(s) established for the intended conditions of use; and

c) Be used within its established use limitations or conditions of acceptability.

4.2 A component of a product covered by this Standard is not required to comply with a specific component requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product;

b) Is superseded by a requirement in this Standard; or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

4.3 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

4.4 Except as noted in 4.2(b), a component that is also intended to perform other functions such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable standard(s) that cover devices that provide those functions.

5 Normative References

5.1 Any undated reference to a code or standard appearing in the requirements of this Standard shall be interpreted as referring to the latest edition of that code or standard.

5.2 Products covered by this Standard shall comply with the referenced installation codes and standards noted in this Section as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product shall comply with the installation codes and standards for all countries where it is intended to be used.

ANSI C12.1, *Electric Meters Code for Electricity Metering*

ANSI C12.10, *Physical Aspects of Watthour Meters – Safety Standard*

ASTM D3195, *Standard Practice of Rotameter Calibration*

ASTM D5025, *Standard Specification for a Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials*

ASTM D5207, *Standard Practice for Confirmation of 20-mm (50-W) and 125-mm (500-W) Test Flames for Small-Scale Burning Tests on Plastic Materials*

CSA C22.1, *Canadian Electrical Code, Part I*

CAN/CSA-C22.2 No. 0, *General Requirements – Canadian Electrical Code, Part II*

CAN/CSA C22.2 No. 0.2, *Insulation Coordination*

CAN/CSA-C22.2 No. 0.17, *Evaluation of Properties of Polymeric Materials*

CSA C22.2 No. 14, *Industrial Control Equipment*

CAN/CSA C22.2 No. 94.1, *Enclosures for Electrical Equipment, Non-Environmental Considerations*

CAN/CSA C22.2 No. 94.2, *Enclosures for Electrical Equipment, Environmental Considerations*

CAN/CSA C22.2 No. 115, *Meter-Mounting Devices*

CSA C22.2 No. 269.5, *Surge protective devices – Type 5 – Components*

CAN/CSA E60384-14, *Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains*

CAN/CSA C22.2 No. 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

IEC 60529, *Degrees of Protection Provided by Enclosures (IP Code)*

UL 1577, *Optical Isolators*

CONSTRUCTION

6 General

6.1 Other than as noted in 6.2, a detachable meter or bottom-connected meter shall be of one of the form designations and current classes described in ANSI C12.10 and shall comply with all the requirements of ANSI C12.10.

6.2 When intended for installation by a specific utility and when agreeable to all parties concerned, special form designations and current classes not listed in ANSI C12.10 are allowed. When special forms are utilized the meter shall:

a) Be provided with a wiring diagram on a label affixed to the product;

b) Be evaluated in combination with an appropriately rated mounting socket (if socket mounted); and

c) Comply with all other requirements of ANSI C12.10.

6.3 Terminals shall be arranged to reduce the possibility of short circuits during meter connection, adjustment of the meter, or removal or replacement of the cover. The blades or terminals of a meter having a standard configuration as described in ANSI C12.10 are considered to meet this requirement.

6.4 Terminals for connection to isolated secondary circuits shall be located such that the wiring connected to these terminals may be reliably routed away from live parts of the mains circuit, such that the creepage distance and clearance distance requirements between mains and isolated secondary circuits are maintained.

6.5 Meters provided with auxiliary wiring leads for connection of isolated secondary circuits or auxiliary power supply shall comply with the following:

a) Auxiliary wiring leads shall be insulated for the highest rated voltage of the meter, or shall be routed and secured away from live parts of the mains circuit internal to the meter, such that the creepage distance and clearance distance requirements between mains and isolated secondary circuits are maintained. When the insulation voltage rating of the auxiliary wiring leads is lower than the highest rated voltage of the meter, the creepage distance and clearance distance requirements shall be evaluated as if there were no insulation on the auxiliary wiring leads;

b) Auxiliary wiring leads shall be protected against abrasion and sharp bends at the point where the conductors enter the meter and the meter-mounting equipment, by an inlet or bushing with a smoothly rounded opening;

c) Auxiliary wiring leads shall be protected against being pushed into the meter enclosure through the auxiliary wiring leads opening when such displacement results in any of the following:

1) Mechanical damage to the auxiliary wiring leads;

2) Exposure of the auxiliary wiring leads to a temperature higher than that for which they are rated;

3) Reduction of creepage or clearance distance (such as to a metal strain-relief clamp) below the minimum required values; or

4) Damage to internal meter connections or components.

Compliance shall be determined by the Push Back Relief Test, Section 24.

6.6 Auxiliary wiring leads shall be secured to relieve the conductors from strain, including twisting, where they are connected within the meter. Knots in conductors shall not be used as strain relief. Compliance shall be determined by the Strain Relief Test, Section 23.

6.7 A meter may have provision for adjustments during use. Such adjustments shall be accessible without disassembly of the meter or removal of the cover.

6.8 Polymeric materials in contact with uninsulated live parts shall comply with Annex B.

7 Enclosure

7.1 Meters shall comply with the performance requirements of IEC 60529 for the IP Codes designated in Table 7.1 as demonstrated by the tests in enclosure tests, Section 21.

Table 7.1
IP Code Requirements

	Indoor only[a]	Outdoors[b]
IP Code	51	55

[a] Protected against dust infiltration and dripping water.

[b] Protected against moderate volume hose directed water and dust infiltration.

7.2 Meter enclosures incorporating polymeric materials shall comply with the requirements for polymeric materials in CAN/CSA-C22.2 No. 94.1. Additionally, if the meter is intended for outdoor use, polymeric materials used for the enclosure shall comply with the Weatherometer Test of CAN/CSA C22.2 No. 0.17.

7.3 A meter marked with additional enclosure type designations that are in addition to those in Table 7.1 shall also comply with the performance requirements for those enclosure type designations.

7.4 If an enclosure has a door or access panel, a means for firmly securing it in place shall be provided.

7.5 If a protective ground terminal is provided, it shall comply with the requirements for grounding terminals in ANSI C12.10.

8 Clearance and Creepage Distances

8.1 A risk of electric shock shall not exist on any accessible parts of the meter both in normal use and in single fault conditions.

8.2 Data communication terminals such as KYZ, data I/O, terminals of serial communication ports, and ethernet ports, operating at voltages less than or equal to those given in 2.28(a), shall be considered accessible parts for the purpose of determining the clearance and creepage distances.

8.3 Clearance and creepage distances may be made up of composite spacings that add up to meet the required dimensions. Conformity is checked by inspection and measurement or, in the case of clearance distances, by the requirements of CAN/CSA C22.2 No. 0.2.

8.4 Clearance and creepage distances in Table 8.1 shall apply between (reference Safety Insulation 'SI' in Figure 8.1 – Figure 8.4):

a) Mains circuits and accessible parts – For non-conductive accessible parts, the clearance and creepage distances shall apply to any accessible surface of the part;

b) Mains circuits and isolated secondary circuits;

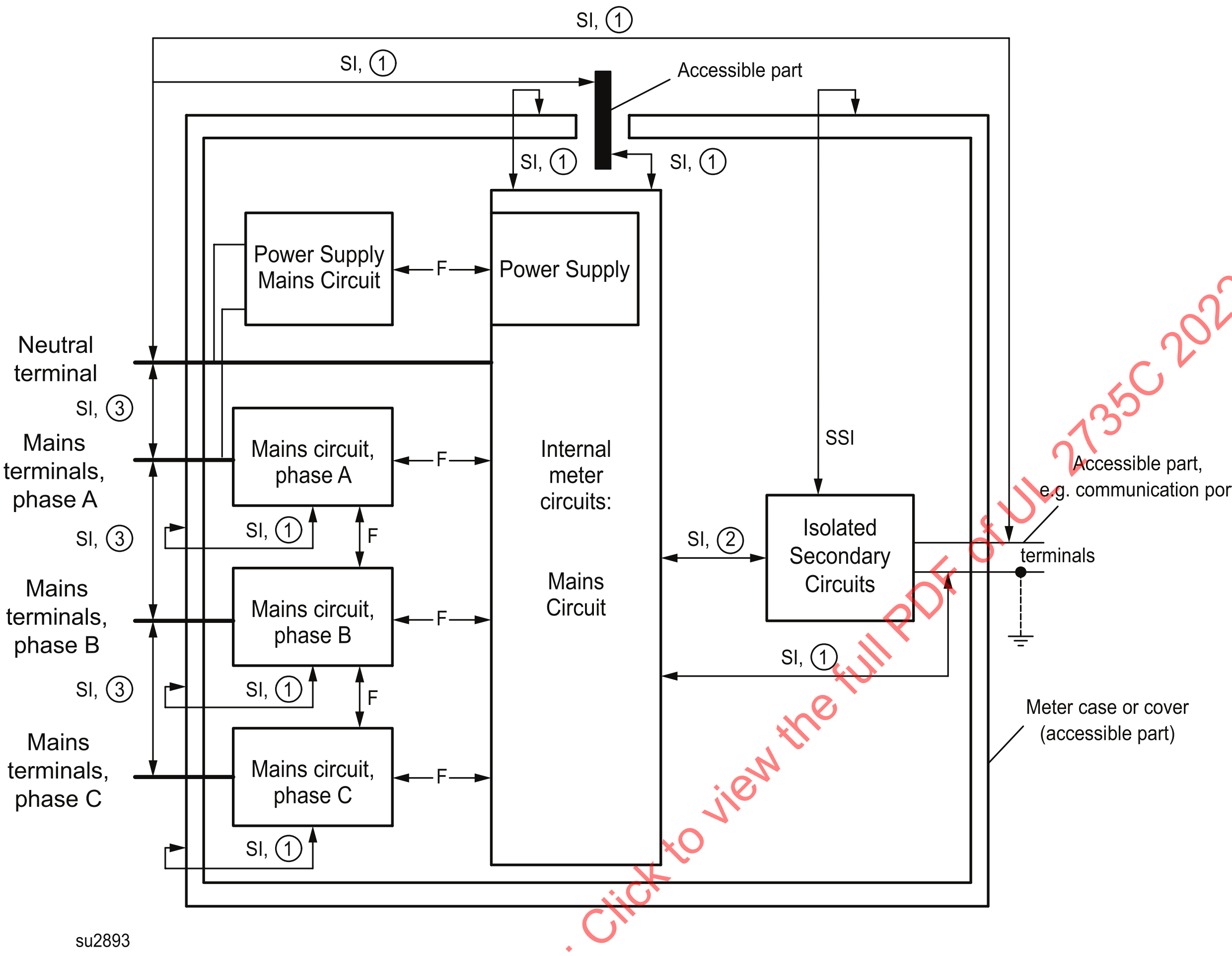
c) Different phases of the mains, including neutral; and

d) Voltage and current terminals for meters where current terminals and voltage terminals are isolated, such as for transformer rated meters.

NOTE: Internal meter circuits are either mains circuits or isolated secondary circuits as described in the meter construction examples illustrated in Figure 8.1 – Figure 8.4.

Figure 8.1

Meter Construction Example, Non-Isolated Neutral



NOTES:

1. See 8.4(a)

2. See 8.4(b)

3. See 8.4 (c) and(d)

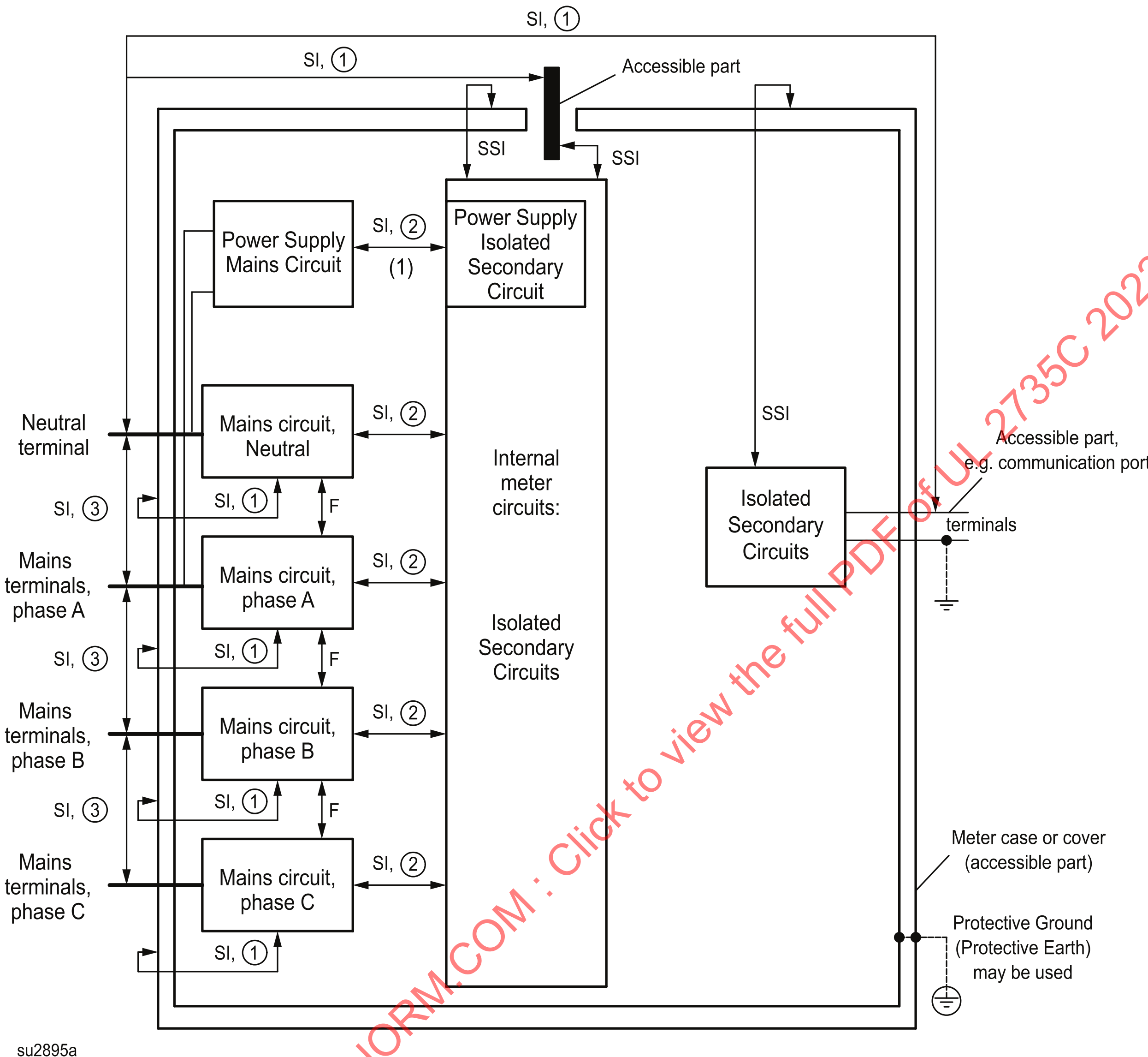
SI – Safety Insulation (for protection against electric shock, or protection against spread of fire) – distances from Table 8.1 shall be used.

SSI – Safety Insulation in Secondary circuits (for protection against electric shock, or protection against spread of fire) – distances from Table 8.3 and Table 8.4 shall be used.

F – Insulation within the mains circuit

Figure 8.2

Meter Construction Example, Isolated Neutral



NOTES:

1. See 8.4(a)
2. See 8.4(b)
3. See 8.4 (c) and(d)

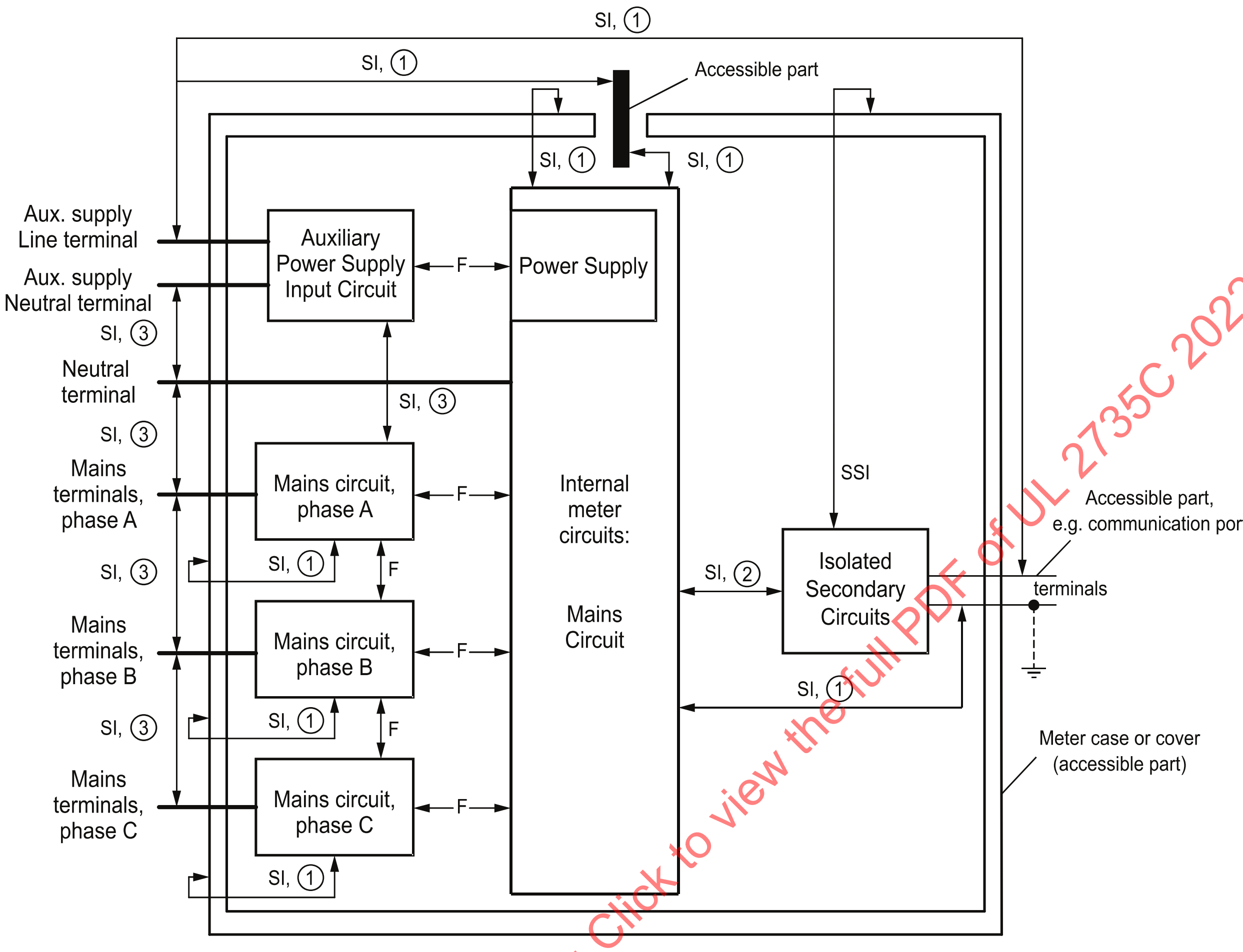
SI – Safety Insulation (for protection against electric shock, or protection against spread of fire) – distances from Table 8.1 shall be used.

SSI – Safety Insulation in Secondary circuits (for protection against electric shock, or protection against spread of fire) – distances from Table 8.3 and Table 8.4 shall be used.

F – Insulation within the mains circuit

Figure 8.3

Meter Construction Example, Non-Isolated Neutral and Auxiliary Power Supply



NOTES:

1. See 8.4(a)
2. See 8.4(b)
3. See 8.4 (c) and(d)

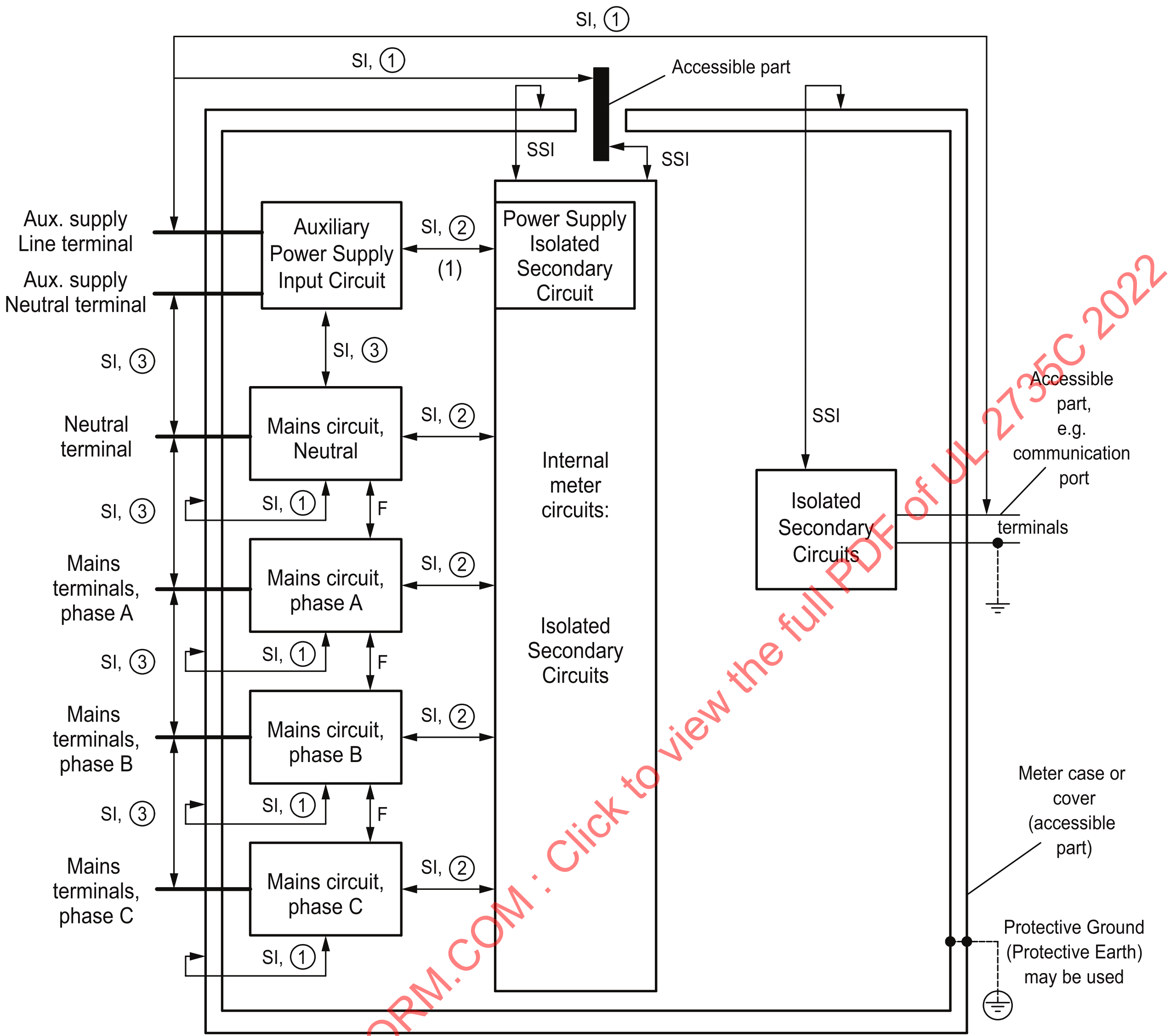
SI – Safety Insulation (for protection against electric shock, or protection against spread of fire) – distances from Table 8.1 shall be used.

SSI – Safety Insulation in Secondary circuits (for protection against electric shock, or protection against spread of fire) – distances from Table 8.3 and Table 8.4 shall be used.

F – Insulation within the mains circuit

Figure 8.4

Meter Construction Example, Isolated Neutral and Auxiliary Power Supply



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NOTES:

1. See 8.4(a)

2. See 8.4(b)

3. See 8.4 (c) and(d)

SI – Safety Insulation (for protection against electric shock, or protection against spread of fire) – distances from Table 8.1 shall be used.

SSI – Safety Insulation in Secondary circuits (for protection against electric shock, or protection against spread of fire) – distances from Table 8.3 and Table 8.4 shall be used.

F – Insulation within the mains circuit

Table 8.1
Clearances and Creepage Distances for Mains Circuits

Phase to ground[a] a.c. r.m.s. or d.c.	Values for clearance	Values for creepage distance		
V	mm	mm		
		Printed wiring board[b]	Other insulating materials	
			Pollution degree 2	Pollution degree 3
≤ 150	5.5	2.5	3.0	3.0
> 150 ≤ 300	5.5	5.5	5.5	5.5
> 300 ≤ 600	8.0[c]	8.0	8.0	9.4

[a] Phase-to-ground voltages refer to the nominal rated voltage of the supply system. For ungrounded systems or systems with one phase grounded, the phase-to-ground voltage is considered to be the same as the phase-to-phase voltage for the purposes of using this table.

[b] Creepage distances on printed wiring boards located in other than pollution degree 1 or 2 environment shall be determined using the creepages for other insulating materials.

[c] This clearance distance is with respect to accessible surfaces and accessible circuitry. Clearance distance with respect to non-accessible surfaces and non-accessible circuitry may use 5.5 mm clearance.

NOTE: Linear interpolation is not allowed.

8.5 Clearance distances of equipment rated to operate at altitudes above 2000 m above sea level shall be multiplied by the correction factors given in Table 8.2; the creepage distance does not require an altitude correction, however it shall not be smaller than the associated clearance distance.

Table 8.2
Multiplication Factors for Clearance Distance

Rated operating altitude M	Multiplication factor
≤ 2000	1.0
2001 to 3000	1.14
3001 to 4000	1.29
4001 to 5000	1.48

8.6 Clearance and creepage distances within the mains circuit (Reference 'F' in Figure 8.1 – Figure 8.4) shall meet condition (a) or (b) below. Clearance and creepage distances between a mains terminal and a location within a mains circuit are considered distances within the mains circuit. Clearance and creepage distances for insulation within the mains circuits (reference “F” in Figure 8.1 – Figure 8.4) are applied based on the calculated or measured voltage stressing the insulation between each pair of electrical nodes.

a) Clearance distance in 8.7 and creepage distance in 8.8, or

b) It can be demonstrated that clearance and creepage distances pass single-fault testing as described in Section 16 with fault-condition of 16.2.5.

8.7 Clearance for insulation within the mains circuit (reference “F” in Figure 8.1 – Figure 8.4) and for insulation for Secondary Circuits (Reference “SSI” in Figure 8.1 – Figure 8.4) is defined by the repetitive peak working voltage and the maximum transient overvoltage. The repetitive peak working voltage (U_w) may be determined by circuit analysis or by measuring the repetitive peak value of the voltage at the relevant circuit locations when the maximum nominal rated voltage is applied at the mains terminals. The maximum transient overvoltage (U_t) may be determined by circuit analysis or by measuring the peak value of transient overvoltage at the relevant circuit locations while performing the Effect of High Voltage Line

Surges test, 17.4, at the mains terminals. The determination of the relevant circuit locations should be based on circuit analysis, construction analysis, or both.

Clearances are determined from the following formula:

$$Clearance = D_1 + F \times (D_2 - D_1)$$

Where

F is a factor, determined from one of the equations:

$$F = (1.25 \times U_w / U_m) - 0.25 \quad \text{if } U_w / U_m > 0.2$$

$$F = 0 \qquad \text{if } U_w / U_m \leq 0.2$$

Where $U_m = U_w + U_t$;

U_w = the maximum repetitive peak value of the working voltage

U_t = the maximum additional transient overvoltage

D_1 and D_2 are values taken from Table 8.3 for U_m

Where

D_1 represents the clearance that would be applicable to a transient overvoltage with the shape of a 1.2 μs x 50 μs impulse.

D_2 represents the clearance that would be applicable to the repetitive peak working voltage without any transient overvoltage.

Table 8.3
Clearance Values for the Calculation of 8.7

Maximum voltage	Clearance		Maximum voltage	Clearance	
U_m V	D_1 mm	D_2 mm	U_m V	D_1 mm	D_2 mm
14.1 to 266	0.010	0.010	4000	2.93	6.05
283	0.010	0.013	4530	3.53	7.29
330	0.010	0.020	5660	4.92	10.1
354	0.013	0.025	6000	5.37	10.8
453	0.027	0.052	7070	6.86	13.1
500	0.036	0.071	8000	8.25	15.2
566	0.052	0.10	8910	9.69	17.2
707	0.081	0.20	11300	12.9	22.8
800	0.099	0.29	14100	16.7	29.5
891	0.12	0.41	17700	21.8	38.5
1130	0.19	0.83	22600	29.0	51.2
1410	0.38	1.27	28300	37.8	66.7
1500	0.45	1.40	35400	49.1	86.7

Table 8.3 Continued on Next Page

Table 8.3 Continued

Maximum voltage U_m V	Clearance D_1 mm	Clearance D_2 mm	Maximum voltage U_m V	Clearance D_1 mm	Clearance D_2 mm
1770	0.75	1.79	45300	65.5	116
2260	1.25	2.58	56600	85.0	150
2500	1.45	3.00	70700	110	195
2830	1.74	3.61	89100	145	255
3540	2.44	5.04	100000	165	290

NOTES:

1) Linear interpolation is allowed.

2) For voltages below the minimum level listed, clearance requirements do not apply.

8.8 Creepage distance for insulation within the mains circuit (Reference "F" in Figure 8.1 – Figure 8.4) and for Insulation of Secondary Circuits (Reference "SSI" in Figure 8.1 – Figure 8.4) shall meet the applicable values of Table 8.4, based on the rms working voltage which stresses the insulation.

Table 8.4
Creepage Distances within the Mains Circuit

Working voltage a.c. r.m.s. or d.c.	Printed wiring board material[z]		Other insulating material						
	Pollution degree 1	Pollution degree 2	Pollution degree 1	Pollution degree 2			Pollution degree 3		
	All material groups	Material group I, II or IIIa	All material groups	Material group I	Material group II	Material group IIIa.b	Material group I	Material group II	Material group IIIa.b[y]
V	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	0.025	0.04	0.08	0.40	0.40	0.40	1.00	1.00	1.00
12.5	0.025	0.04	0.09	0.42	0.42	0.42	1.05	1.05	1.05
16	0.025	0.04	0.10	0.45	0.45	0.45	1.10	1.10	1.10
20	0.025	0.04	0.11	0.48	0.48	0.48	1.20	1.20	1.20
25	0.025	0.04	0.125	0.50	0.50	0.50	1.25	1.25	1.25
32	0.025	0.04	0.14	0.53	0.53	0.53	1.3	1.3	1.3
40	0.025	0.04	0.16	0.56	0.80	1.10	1.4	1.6	1.8
50	0.025	0.04	0.18	0.60	0.85	1.20	1.5	1.7	1.9
63	0.040	0.063	0.20	0.63	0.90	1.25	1.6	1.8	2.0
80	0.063	0.10	0.22	0.67	0.95	1.3	1.7	1.9	2.1
100	0.10	0.16	0.25	0.71	1.00	1.4	1.8	2.0	2.2
125	0.16	0.25	0.28	0.75	1.05	1.5	1.9	2.1	2.4
160	0.25	0.40	0.32	0.80	1.1	1.6	2.0	2.2	2.5
200	0.40	0.63	0.42	1.00	1.4	2.0	2.5	2.8	3.2
250	0.56	1.0	0.56	1.25	1.8	2.5	3.2	3.6	4.0
320	0.75	1.6	0.75	1.60	2.2	3.2	4.0	4.5	5.0
400	1.0	2.0	1.0	2.0	2.8	4.0	5.0	5.6	6.3
500	1.3	2.5	1.3	2.5	3.6	5.0	6.3	7.1	8.0
630	1.8	3.2	1.8	3.2	4.5	6.3	8.0	9.0	10.0
800	2.4	4.0	2.4	4.0	5.6	8.0	10.0	11	12.5[y]
1 000	3.2[x]	5.0[x]	3.2	5.0	7.1	10.0	12.5	14	16[y]
1 250			4.2	6.3	9.0	12.5	16	18	20[y]

[x] For voltages above 1000 V, creepage distances on printed wiring board material are the same as for other insulators of the same material group.

[y] Material group IIIb is not recommended for application in pollution degree 3 above 630 V.

[z] Inner layers of multi-layer printed wiring boards are considered pollution degree 1.

Table 8.4 Continued on Next Page

Table 8.4 Continued

Working voltage a.c. r.m.s. or d.c.	Printed wiring board material[z]		Other insulating material						
	Pollution degree 1	Pollution degree 2	Pollution degree 1	Pollution degree 2			Pollution degree 3		
	All material groups	Material group I, II or IIIa	All material groups	Material group I	Material group II	Material group IIIa.b	Material group I	Material group II	Material group IIIa.b[y]
V	mm	mm	mm	mm	mm	mm	mm	mm	mm

NOTES:

1) Linear interpolation is allowed.

2) Creepage distances on printed wiring boards located in other than pollution degree 1 or 2 environment shall be determined using the creepages for other insulating materials.

3) Creepage distances cannot be smaller than the associated clearance distance.

4) For voltages below the minimum level listed, creepage distance requirements do not apply.

8.9 Clearances between isolated secondary circuits and accessible parts shall comply with 8.7 (Reference Safety Insulation in Secondary Circuits 'SSI' in Figure 8.1 – Figure 8.4).

8.10 Creepage distance between isolated secondary circuits and accessible parts shall comply with 8.8 (Reference Safety Insulation in Secondary Circuits 'SSI' in Figure 8.1 – Figure 8.4).

8.11 Clearances and creepage distances within isolated secondary circuits are not specified in this Standard.

8.12 For glass and ceramics, there are no requirements for creepage distances.

8.13 As an alternative to Table 8.1 – Table 8.4, lesser values may be acceptable when investigated in accordance with CAN/CSA C22.2 No. 0.2, with the considerations described in (a) through (e):

a) For equipment rated to operate at altitudes above 2000 m above sea level, the requirements of 8.5 shall apply.

b) Meters shall be evaluated as Overvoltage Category IV;

c) A printed wiring board is assumed to have a Comparative Tracking Index (CTI) of 100 unless investigated and shown to have a higher CTI;

d) The pollution degree on the external surfaces of a meter shall be considered to be pollution degree 3;

e) The pollution degree for microenvironment areas within a meter shall be considered to be pollution degree 3 based on the expected conditions for the microenvironment area, except as noted in (1) – (3);

1) A coating that complies with the requirements for Conformal Coatings in Insulation Coordination – General Instruction No. 1, C22.2 No. 0.2-16, may be used to create a microenvironment of pollution degree 1 for creepage distances under the coating;

2) Any coating suitable for use with the specific printed wiring board material, for example solder resist, may be used to create a microenvironment of pollution degree 2 for creepage distances between printed wiring board traces when adjacent conductive material is covered by the coating which provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material;

3) The pollution degree inside the meter is considered pollution degree 3. However, this may be reduced to pollution degree 2 for the microenvironment immediately surrounding the creepage distance by reducing the possibility of condensation or high humidity when no water or other contaminant is present on the surfaces of the microenvironment as a result of performing the applicable test specified in 7.1.

NOTE: Meters are considered to be continuously energized which reduces the possibility of condensation.

8.14 Where multiple pieces of insulation are reliably cemented together with insulating compound, clearances and creepage distances do not exist through the insulation. Clearances and creepage distances shall be measured around the insulation and over the surface of the insulation, respectively. The pieces of insulation and cemented joint are considered solid insulation and shall comply with the requirements of Section 9 for solid insulation.

8.15 Cemented joints referenced in 8.14, that are relied upon to eliminate clearances and creepage distances through the joint, shall be subjected to the Tests for Cemented Joints, Section 20.

9 Solid Insulation

9.1 Solid insulation shall meet the requirements of this Section when applied between (reference Safety Insulation 'SI' in Figure 8.1 – Figure 8.4) :

a) Mains circuits and accessible parts;

b) Mains circuits and isolated secondary circuits;

c) Different phases of the mains, including neutral;

d) Voltage and current terminals of meters where current terminals and voltage terminals are isolated, such as for transformer rated meters.

NOTE: Internal meter circuits are either mains circuits or isolated secondary circuits as described in Figure 8.1 – Figure 8.4.

9.2 Components bridging the insulation to be tested, such as discharge resistors for filter capacitors, voltage limiting devices or surge protective devices, shall be disconnected. For a self-contained meter, any potential circuit burden that cannot be isolated by means of test links shall be isolated by disconnection.

9.3 Solid insulation shall withstand the a.c. voltage test with duration of at least 5 s or the peak impulse voltage test using the applicable test voltage values given in Table 9.1.

Table 9.1
Test Voltages for Solid Insulation in Mains-Circuits

Phase-to-ground[a] a.c. r.m.s. or d.c.	Test voltage	
	5 s a.c. voltage test V r.m.s.	Impulse test[b] V peak
≤ 150	2500	6000
> 150 ≤ 300	3310	6000
> 300 ≤ 600	4260	6000

[a] Phase-to-ground voltages refer to the nominal rated voltage of the supply system. For ungrounded systems or systems with one phase grounded, the phase-to-ground voltage is considered to be the same as the phase-to-phase voltage for the purposes of using this Table.

[b] Impulse test shall be as specified in 17.4 (ANSI C12.1, Test No. 17) except peak voltage magnitudes shall be as specified in this table and only the combination wave is to be applied.

9.4 Solid insulation shall withstand the a.c. voltage test as defined in 17.3 (ANSI C12.1 Test No. 15).

9.5 The insulating layers of printed wiring boards shall have adequate electric strength through the thickness of insulation between copper layers. One of the following methods shall be used:

a) The thickness through the insulation is at least the value of Table 9.2; or

b) The insulation is assembled from at least two separate layers of printed wiring board material, where each of the layers separately, or the combination of layers is rated by the manufacturer of the material for an electric strength of at least the value of the test voltage of Table 9.1[§].

9.6 Conductors located on the same inner copper layer of a multilayer printed wiring board shall be separated by at least the applicable minimum distance of Table 9.2.

Table 9.2
Minimum Values for Isolation Distances within a Multilayer Printed Wiring Board

Phase-to-ground[a] a.c. r.m.s. or d.c. V r.m.s. or d.c.	Minimum thickness of insulation between copper layers[b] mm	Minimum distance between conductors on the same inner copper layer[b] mm
≤ 300	0.3	0.75
> 300 ≤ 600	0.6	1.8

[a] Phase-to-ground voltages refer to the nominal rated voltage of the supply system. For ungrounded systems or systems with one phase grounded, the phase-to-ground voltage is considered to be the same as the phase-to-phase voltage for the purposes of using this table.

[b] These values are independent of the overvoltage category.

NOTES:

1. This table applies only to the circuits identified in 9.1.

2. The minimum thickness values are consistent with IPC-2221B, Generic Standard on Printed Board Design.

10 Single Components Bridging Insulation

10.1 Capacitors

10.1.1 Capacitors bridging insulation (or forming limiting impedance) shall comply with the requirements of CAN/CSA-E60384-14, and shall be used in accordance with their ratings. Such capacitors shall not be subjected to the testing in single fault conditions in 16.1.

10.1.2 A capacitor connected between line conductors (L-L) or between line and neutral conductors (L-N) in a mains circuit shall comply with subclass X1 or X2. Y1, Y2 or Y4 may also be used.

10.1.3 A capacitor connected between line and protective earth conductors (L-PE) or between neutral and protective earth conductors (N-PE) in a mains circuit shall comply with subclass Y1, Y2 or Y4.

10.1.4 A capacitor bridging insulation relied upon to isolate secondary circuitry from mains circuitry shall comply with subclass Y1.

10.1.5 Multiple capacitors in series bridging insulation relied upon to isolate secondary circuitry from mains circuitry shall each comply with subclass Y1.

10.2 Surge protective devices

10.2.1 A surge protective device shall not bridge insulation relied upon to isolate secondary circuitry from mains circuitry.

10.2.2 A surge protective device may bridge the insulation between line conductors and the protective earth conductor or between neutral conductors and the protective earth conductor only if the meter is equipped with a protective earth terminal intended for permanent connection.

10.2.3 A voltage-dependent resistor (VDR) [varistor] shall comply with the CSA C22.2 No. 269 series of standards. A Type 1 VDR may be connected directly to mains. No additional conditions or tests are required for the VDR.

10.2.4 A VDR other than a Type 1 VDR, which is connected directly to the mains with no component in series with the VDR shall meet the following conditions:

a) Have a voltage rating (MCOV) of at least 200 % of the nominal working voltage between circuits;

b) Have a nominal discharge current rating (peak rating) no lower than the RMS maximum short circuit withstand rating of the meter (10 kA minimum); and

c) Pass artificial aging at 105 °C, as follows:

1) Find positive and negative Nominal Varistor Voltage (V_n) in accordance with the CSA C22.2 No. 269 series of standards at room temperature;

2) Apply rated A/C voltage, for 1000 hours, with EUT in a chamber held at 105 ±3 °C;

3) Find positive and negative Nominal Varistor Voltage (V_n) in accordance with the CSA C22.2 No. 269 series of standards, after allowing the VDR to cool to room temperature; and

4) The change in the Nominal Varistor Voltages (V_n) taken before and after aging must be less than 10 %.

10.2.5 A VDR conforming to the requirements of 10.2.4 (a) through (c) is not required to be subjected to the testing in single fault conditions as required in 16.1.

10.2.6 A VDR other than a Type 1 VDR, which is connected to the MAINS with an additional current limiting component in series with the VDR shall meet the following conditions:

NOTE: An additional current limiting component in series with the VDR may be connected to either series lead of the VDR. A component that limits current to a VDR and to circuitry in parallel with the VDR is considered a component in series with the VDR, reference Figure 10.1, Figure 10.2, and Figure 10.3.

a) Have a nominal discharge current rating at least equal to the maximum current calculated by dividing 6 kV by the impedance of the component(s) in series with the VDR.

b) Have an operating temperature rating above 85 °C or pass the artificial aging as described in 10.2.4(c).

NOTE: This is a component only test.

10.2.7 A meter incorporating a VDR in accordance with 10.2.6 shall be subjected to the following:

a) Single fault conditions as required in 16.1.

b) The Thermal Fault Test as required in Section 25, unless the resultant initial current is less than 2 amperes when the VDR is replaced with a short circuit.

Figure 10.1

Current Limiting Component in Series with VDR – Location 1

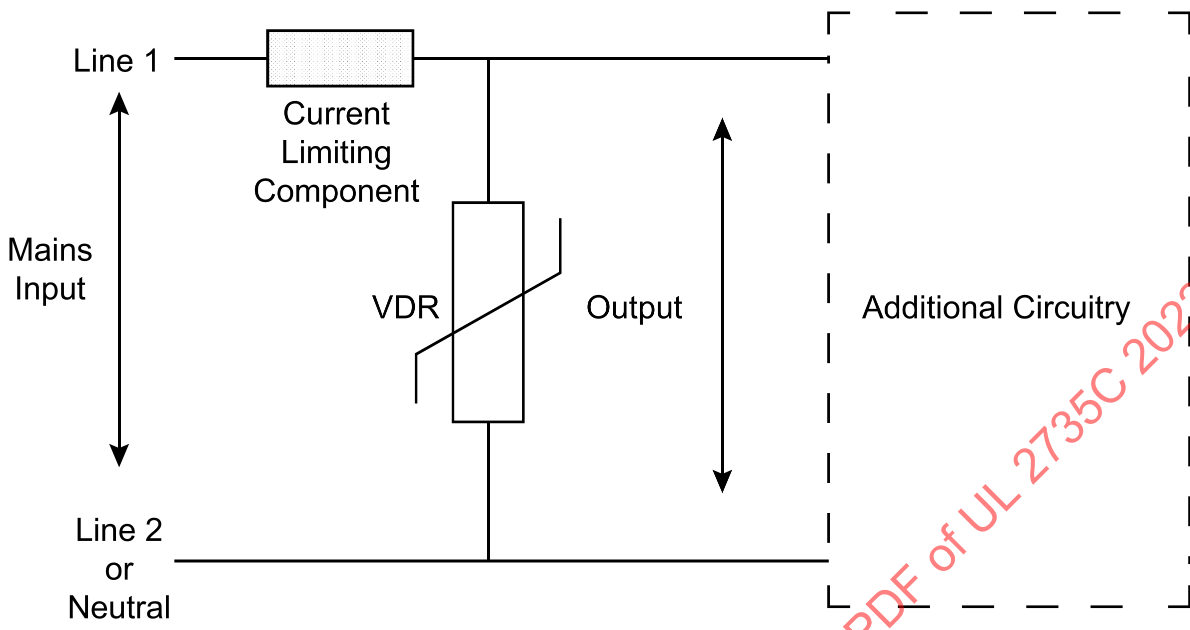

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Figure 10.2

Current Limiting Component in Series with VDR – Location 2

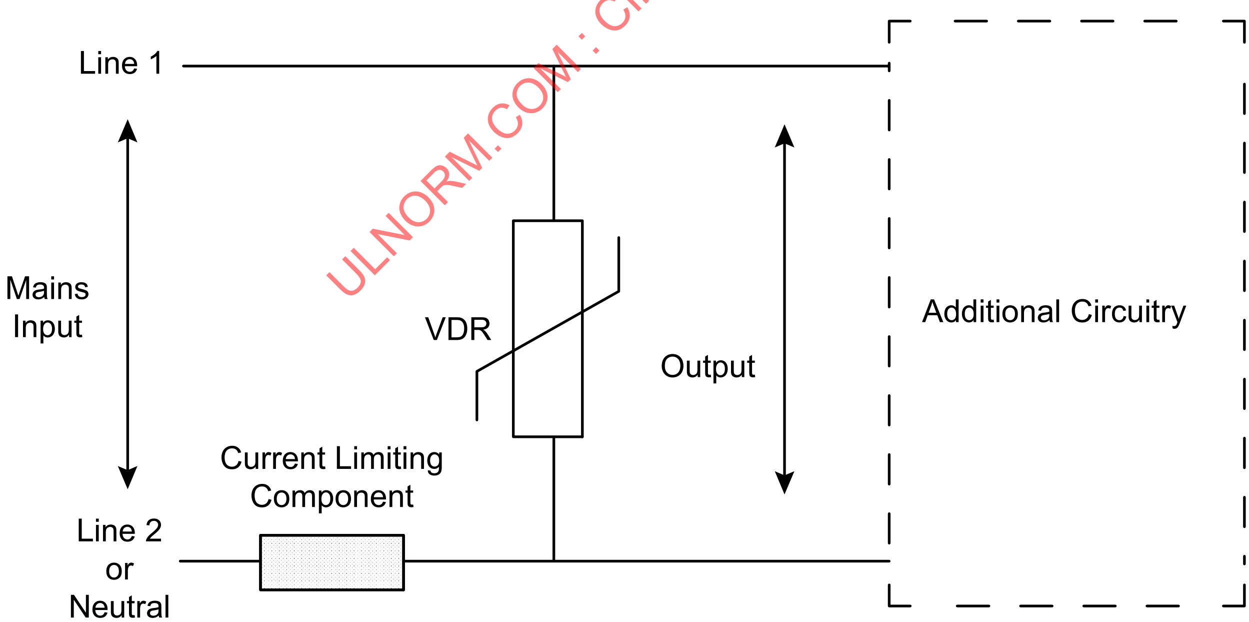

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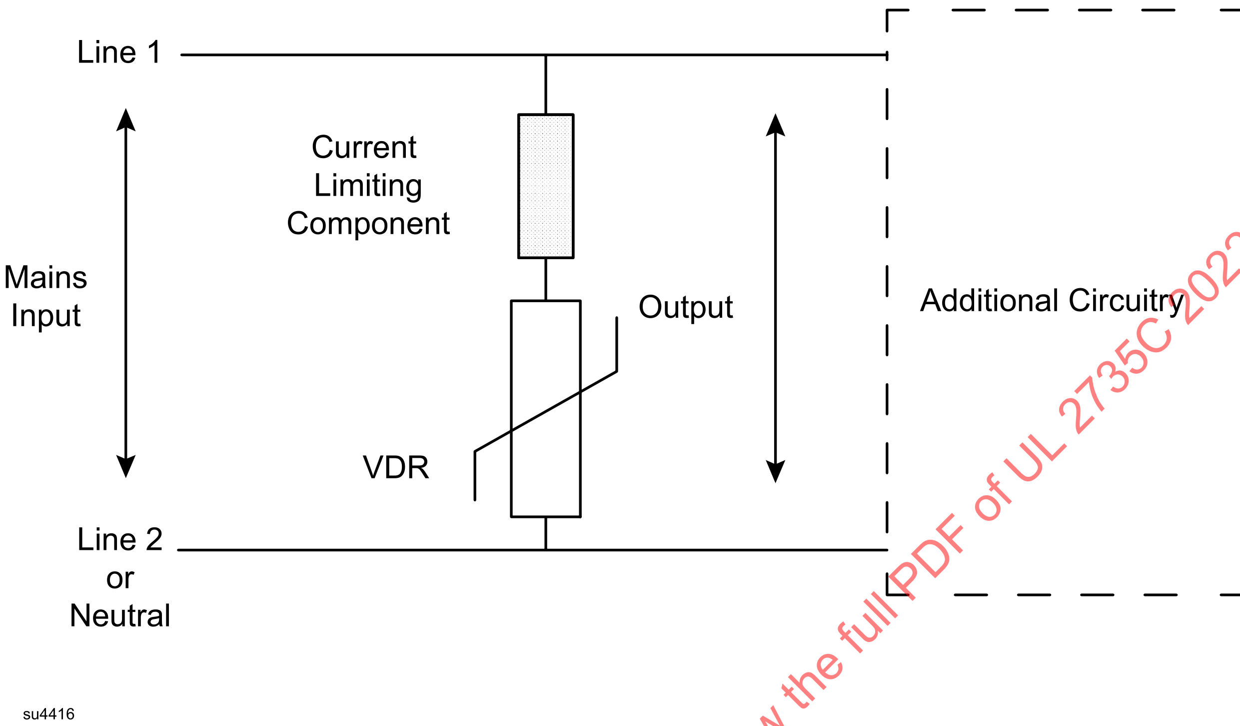
Figure 10.3

Current Limiting Component in Series with VDR – Location 3



10.2.8 If a meter is specified by the manufacturer for installation with external current limiting devices in series with the meter terminals, such devices may be considered as the additional current limiting components in series with the internal VDR (see 10.2.6), provided that the manufacturer's installation instructions comply with 27.4.

10.3 Opto-Isolator

10.3.1 An optical isolator (also known as photo coupler, or optical coupler) bridging insulation relied upon to isolate secondary circuits from mains circuits shall comply with UL 1577, and shall have a voltage isolation rating to comply with the rms test voltages in Table 9.1 for solid insulation. Such components shall not be subjected to the testing in single fault conditions in 16.1.

11 Limiting Impedance

11.1 A component or group of components forming the limiting impedance relied upon to isolate secondary circuits from mains circuits shall comply with 11.2 – 11.9.

11.2 If the circuit on the load side of the limiting impedance is accessible during normal use or if there are provisions for extending the circuit outside the meter installation enclosure (cabinet), a risk of electric shock shall not exist on the load side of the impedance under normal use and in single fault conditions.

11.3 If the circuit on the load side of the limiting impedance is completely enclosed and not accessible under normal use, and there are no provisions for extending the circuit outside the meter installation enclosure (cabinet), the limiting impedance is not required to be functional under single fault conditions.

11.4 Creepage and clearance distances between the terminations of the limiting impedance shall comply with Table 8.1.

11.5 A single component relied upon to limit voltage, current or both to the values specified in 2.28 shall be rated for twice the maximum working voltage; if this component is a resistor, it shall be rated for twice the power dissipation for the maximum working voltage.

11.6 The calculated power dissipation of the impedance, as the result of a direct short applied across the circuit (on the load side of the impedance), shall not exceed the power rating of the impedance and shall not exceed 15W.

11.7 When a single resistor serves as limiting impedance, the single fault conditions shall not include shorting of this single resistor.

11.8 When a single capacitor serves as limiting impedance, and the capacitor complies with requirements for class Y capacitors in CAN/CSA-E60384-14, the single fault conditions shall not include shorting of this single capacitor.

11.9 A limiting impedance shall not be a single electronic device that employs electron conduction in a vacuum, gas or semiconductor.

12 Batteries and Battery Charging

12.1 Battery charging and monitoring circuits shall be designed to minimize the risk of an explosion or fire as a result of:

a) An excessive rate of charge;

b) An excessive rate of discharge;

c) An incorrect polarity;

d) A failure of any single component; or

e) Charging of non-rechargeable batteries.

12.2 Markings shall warn against any of the below conditions and a warning shall be included in the manufacturer's instructions:

a) An incorrect battery chemistry for the charging circuit;

b) An insertion of a non-rechargeable battery in a battery charging circuit; or

c) An incorrect installation.

12.3 The battery compartment shall be designed so that there is no possibility of explosion or fire caused by build-up of flammable gases. This only applies to batteries that produce gas.

12.4 Batteries that can leak electrolyte shall be mounted so that any leakage of their electrolyte will not cause an increased risk of electric shock or risk of fire.

13 Service Switches

13.1 If provided with a service switch, the service switch shall comply with the endurance test requirements of CSA C22.2 No. 14, except a lesser number of operations may be performed with not less than 1000 close-open operations at the maximum rated voltage and current of the meter, with a power factor of 0.80 lagging (+0.0/-0.1). See also 26.4.

13.2 When tested in accordance with the requirements specified in 13.1, conformity with the test requirements shall be determined by meeting the following criteria at the completion of the test:

a) The service switch shall be operable with no electrical or mechanical breakdown;

b) There shall be no welding of contacts during the test; and

c) After the final operation, the meter shall comply with the Insulation Test of 17.3.

14 Printed Wiring Board

14.1 Printed wiring boards shall be made of material with a flammability classification of V-1 or better as described in CAN/CSA-C22.2 No. 0.17.

14.2 Coatings used on printed wiring boards shall comply with CAN/CSA-C22.2 No. 0.17. The combination of coating and printed wiring shall have a flammability classification of V-1 or better as described in CAN/CSA-C22.2 No. 0.17.

PERFORMANCE

15 General

15.1 Meters shall comply with the test requirements in Sections 15 – 25.

15.2 When conducting electrical tests on a detachable meter, the meter shall be placed in a properly rated meter socket complying with Meter-Mounting Devices, CAN/CSA C22.2 No. 115, in accordance with the meter manufacturer's instructions.

15.3 When conducting electrical tests on a bottom-connected meter, the meter shall be installed as per the manufacturer instructions. Alternatively, a metal enclosure having minimum dimensions of 150 % of the meter may be used.

15.4 When conducting electrical tests, connections shall be made with wire sized in accordance with the requirements for service entrance conductors in the Canadian Electrical Code, Part 1, CSA C22.1. The wire used for the test shall be copper wire, not less than 1.22 m (4 ft) per terminal, 2.44 m (8 ft) jumper between terminals, and shall not exceed 2.74 m (9 ft) per pole during the Effect of Temporary Overloads Test. See 17.5.

16 Testing in Single Fault Condition

16.1 General

16.1.1 Single fault condition tests shall be conducted, unless it can be demonstrated that no risk of fire or risk of electric shock could arise from a particular fault condition. Circuit analysis may be used as the method to determine if a specific single fault condition could result in a risk of fire or risk of electric shock.

16.1.2 The meter shall be operated under the least favorable test conditions within its rated operating conditions. Each test condition may be different for single fault conditions and they shall be recorded for each test.

16.1.3 The meter shall be operated under the least favorable test conditions within its rated operating conditions. Each test condition may be different for single fault conditions and they shall be recorded for each test.

16.1.4 A separate meter may be used for each separate single fault condition test.

16.2 Application of fault conditions

16.2.1 Fault conditions shall include those specified in 16.2.2 – 16.2.5. The conditions shall be applied only one at a time and shall be applied in turn in any convenient order. Multiple simultaneous faults shall not be applied unless they are a consequence of an applied fault. During and after each application of a fault condition, the equipment or part shall meet the requirements of 16.4.

16.2.2 Discrete components, such as capacitors, diodes, resistors, and the like, shall be shorted and opened, one at a time. Where a circuit analysis shows that failure of a particular component will not result in overloading of other components or circuits, the component need not be subjected to this test.

16.2.3 Transformers connected to the mains circuit shall be subjected to short circuit tests on each secondary winding that is loaded in normal use. Each secondary winding shall be tested separately.

16.2.4 Transformers connected to the mains circuit shall be subjected to overload tests on each secondary winding that is loaded in normal use. Each secondary winding shall be tested separately by connecting a variable resistor across the secondary winding, and adjusting the resistor as quickly as possible and readjusting, if necessary, after 1 minute to maintain the applicable overload. No further readjustments shall be made. For each secondary winding, the overload test current shall be one of the following:

a) If a current interrupting device provides overcurrent protection, the overload test current is the maximum current which the overcurrent protection device will carry for 1 hour. Before the test, the device is replaced by a link with negligible impedance. If the maximum current cannot be determined from the device specifications, it shall be determined by test.

b) If the winding output voltage is designed to collapse when a specified overload current is reached, the test current is to be slowly increased to the point just before the output voltage collapses.

c) In all other cases, the test current shall be the current obtained at the maximum power output that can be obtained from the transformer.

16.2.5 Clearance and creepage distances which do not meet the requirements in 8.7 and 8.8, shall be shorted. Where a circuit analysis shows that bridging the insulation will not result in risk of fire or risk of electric shock, the distance need not be subject to this test.

16.3 Duration of tests

16.3.1 The meter shall be operated until further change as a result of the applied fault is unlikely. If there is an indication that a risk of electric shock, spread of fire or injury to persons may eventually occur, the test shall be continued for 4 hours unless one of these risks arises before then.

16.4 Conformity

16.4.1 During and at the conclusion of each single fault test, there shall be:

a) No exposure of live parts;

b) No molten metal, burning insulation, or flaming particles expelled from the meter; and

c) No charring, glowing, or flaming of the tissue paper or cheesecloth.

16.4.2 For meters having isolated secondary circuits that are intended for external connection, there shall be no breakdown when the Insulation test (ANSI C12.1, Test No. 15), as defined in 17.3, is conducted between the mains terminals and isolated secondary circuits.

17 Tests based on ANSI C12.1

17.1 General

17.1.1 Meters shall be subjected to the tests in ANSI C12.1 as specified in this Section. The test conditions shall be as described in 17.2 – 17.7. Compliance with the test requirements shall be determined in accordance with 17.8.1.

17.1.2 If a meter contains a service switch, it shall be set to both the opened and closed state for all testing, with the exception of the Temperature Rise Test and the Effects of Temporary Overloads Test which shall only be performed with the switch closed.

17.1.3 The selection of representative devices shall be as described in the test method specified in ANSI C12.1, except only one device is required per test.

17.2 Temperature rise

17.2.1 The Temperature Rise Test specified in ANSI C12.1, Test No. 9, shall be conducted with the additional requirements in this Section. For detachable meters (Type "S") Class 100, 200, and 320, the test installation shall be standardized using a simulated meter as specified in ANSI C12.1, Test No. 9: Temperature rise prior to conducting the Temperature Rise test on the meter.

17.2.2 Measured temperatures shall not exceed the temperature ratings of any components or insulating material, and insulating material of windings shall not exceed the limits specified in Table 17.1.

Table 17.1
Maximum Temperatures for Insulation Material of Windings

Class of insulation (see IEC 60085)	Normal condition °C
Class A	105
Class B	130
Class E	120
Class F	155
Class H	180

17.2.3 Maximum temperature is determined by measuring the temperature rise under reference test conditions and adding this rise to 40 °C, or to the maximum rated ambient temperature if higher.

17.2.4 The temperature rise measured at the jaw of the meter socket shall be no greater than 65 °C in accordance with CSA C22.2 No. 115.

17.2.5 The surface temperature limits specified in Table 17.2 are based on meters operating in a 40 °C external ambient. When the rated ambient temperature for a meter exceeds 40 °C, and the temperature limits in Table 17.2 are not met when operating at the rated ambient temperature, installation instructions shall include a warning in accordance with 28.3.

NOTE: Operating temperature range may include higher temperatures than the rated ambient temperature. In this case, the meter may not comply with the temperature limits of Table 17.2 when operated in ambient temperatures higher than the rated ambient temperature.

Table 17.2
Surface Temperature Limits in Normal Condition

Part	Limit °C
1. Outer surface of enclosure (unintentional contact)	
a) metal, uncoated or anodized	65
b) metal, coated (paint, non metallic)	80
c) plastics	85
d) glass and ceramics	80
e) small areas (< 2 cm^2) that are not likely to be touched in normal use	100
2. Knobs and handles (normal use contact)	
a) metal	55
b) plastics	70
c) glass and ceramics	65
d) non-metallic parts that in normal use are held only for short periods (1 s – 4 s)	70

17.3 Insulation (ANSI C12.1 Test No. 15)

17.3.1 Before the dielectric strength testing of solid insulation, the meter shall be subject to humidity pre-conditioning as follows:

a) The meter enclosure door or cover shall be closed (normal operating position) for the duration of the test;

b) The meter shall not be energized during pre-conditioning; and

c) The pre-conditioning duration shall be 48 hours at 40 °C ±2 °C and 93 % ±3 % relative humidity.

After the meter is removed from the pre-conditioning chamber, it is allowed a recovery period of 2 hours at 15 – 35 °C and a relative humidity between 30 and 55 % in a de-energized condition with the cover removed.

17.3.2 The humidity preconditioning of 17.3.1 is required only for the initial insulation test, and is not required for an insulation test following any other test.

17.4 Effect of High Voltage Line Surges (ANSI C12.1 Test No. 17)

17.4.1 This test shall be performed using the cheesecloth and tissue paper indicators as described in 16.1.3. Conformance with this test is determined using the criteria outlined in 16.4 in addition to the criteria of 17.8.1.

17.5 Effect of Temporary Overloads (ANSI C12.1 Test No. 20)

17.5.1 Only the portion titled "Effect on mechanical structure and insulation" shall be applied (as modified by 17.5.2), with the test current equal to the short circuit current magnitudes specified in 17.5.3.

17.5.2 The Effect of Temporary Overloads test may be conducted on a separate representative device, and shall be followed by the Insulation test.

17.5.3 When conducting the effect on mechanical structure and insulation portion of the Effect of Temporary Overloads test, the following additional requirements apply:

a) The current level for Current Class 200A or 320A shall not be less than 12,000 amperes rms symmetrical. The current level for Current Class 100A meters shall not be less than 10,000 amperes rms symmetrical.

b) For meters with a short circuit rating exceeding the minimum levels specified in 17.5.3(a), the unit shall be subjected to the Effects of Temporary Overload test with the test current equal to the short-circuit current rating. The minimum peak current shall be 30,000 amperes;

c) The Temporary Overloads test is applicable to both self contained and current transformer rated meters. For current transformer rated type meters, the test shall consist of an overload current equal to no less than 20 times the class current applied for 0.5 seconds. For this test, current circuits shall be connected as follows:

1) For 3 element polyphase, the direction of current flow through each current circuit is from line side to load side. Alternately for a 3 element polyphase meter, a polyphase source may be used.

2) For 2 element polyphase or single phase, the direction of current flow is from line to load on phase A and from load to line on phase C.

d) For self contained meters, when conducting the Temporary Overloads test, all normally grounded metal is to be connected through a 30-ampere, non-time delay type cartridge fuse to ground, if the short circuit supply is a grounded system. When testing with an ungrounded short circuit supply, the connection is to be made to the line side of the pole least likely to arc to the enclosure. The connection shall be made by a 10 AWG (5.3 mm^2) copper wire 1.2 – 1.8 m (4 – 6 feet) long. The fuse shall not open during the test; and

e) For meters containing a service switch, the test shall be performed using a high power source with prospective current as specified in (a) or (b) above, at the rated voltage of the meter.

17.6 Mechanical Shock (ANSI C12.1 Test No. 32)

17.7 Transportation Drop Test (ANSI C12.1 Test No. 33)

17.8 Test results

17.8.1 When tested in accordance with the requirements specified in 17.2 and 17.4 – 17.7, conformity with the test requirements shall be determined as detailed in 17.8.2 – 17.8.7.

17.8.2 For meters equipped with a service switch, the service switch shall be operable after all the tests in 17.2 – 17.7 are completed except that the service switch may have welded contacts after completion of the Effect of Temporary Overloads Test, 17.5. During the tests in 17.2 – 17.6, the service switch shall not have changed state unexpectedly.

17.8.3 No meter parts where the risk of electrical shock exists shall become accessible.

17.8.4 There shall be no damage to the meter enclosure that results in reduction in the IP rating, as defined in Section 7. In cases of doubt, the tests for IP ratings shall be performed following the preceding tests.

17.8.5 There shall be no loss of structural integrity to a degree that the equipment collapses or experiences such displacement of parts that there is a risk of short-circuiting or grounding of current-carrying parts.

17.8.6 There shall be no reduction in the ability of the meter to pass the Insulation Test of 17.3.

17.8.7 Additionally, when tested in accordance with 17.4 or 17.5, the testing shall not result in any of the following conditions:

a) Ejection of a detachable meter from the meter mounting equipment. For purposes of this requirement, ejection is considered to be any condition in which any blade of the meter is no longer held within the corresponding jaw of the meter mounting equipment by the inherent spring pressure of the jaw itself.

b) Ejection of any part or subcomponent of the meter through any opening already existing or an opening created as a result of testing the device.

18 Flammability – 127 mm (5 inch) Flame

18.1 General

18.1.1 All polymeric enclosure parts shall be subjected to this test.

Exception: Materials rated 5VA at the thickness used in accordance with CAN/CSA C22.2 No. 0.17 need not be subjected to this test.

18.1.2 The purpose of this test is to demonstrate the ability of the enclosure parts to contain a flame that results from an internal fault within the meter.

18.2 Test specimens and conditioning

18.2.1 Three representatives of the complete equipment or three representative specimens of the part(s) thereof shall be subjected to this test. Consideration is to be given to leaving in place components and other parts that might influence the performance, including installation within the intended meter mounting equipment.

18.2.2 Other than as noted in 18.2.3, the test devices are to be conditioned in a full draft circulating air oven for 7 days at 10 °C greater than the maximum use temperature but not less than 70 °C in any case.

18.2.3 The conditioning of the test devices specified in 18.2.2 is not required if both of the following conditions are met:

a) The material used does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging.

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

18.3 Test equipment

18.3.1 The test equipment shall comply with 18.3.2 – 18.3.6.

18.3.2 A laboratory type burner having a tube with a length of 100 ±10 mm (3.94 ±0.39 inch) and an inside diameter of 9.5 ±0.3 mm (0.374 ±0.012 inch) is to be used. The barrel is not to be equipped with an end attachment, such as a stabilizer. The burner shall be in compliance with ASTM D5025.

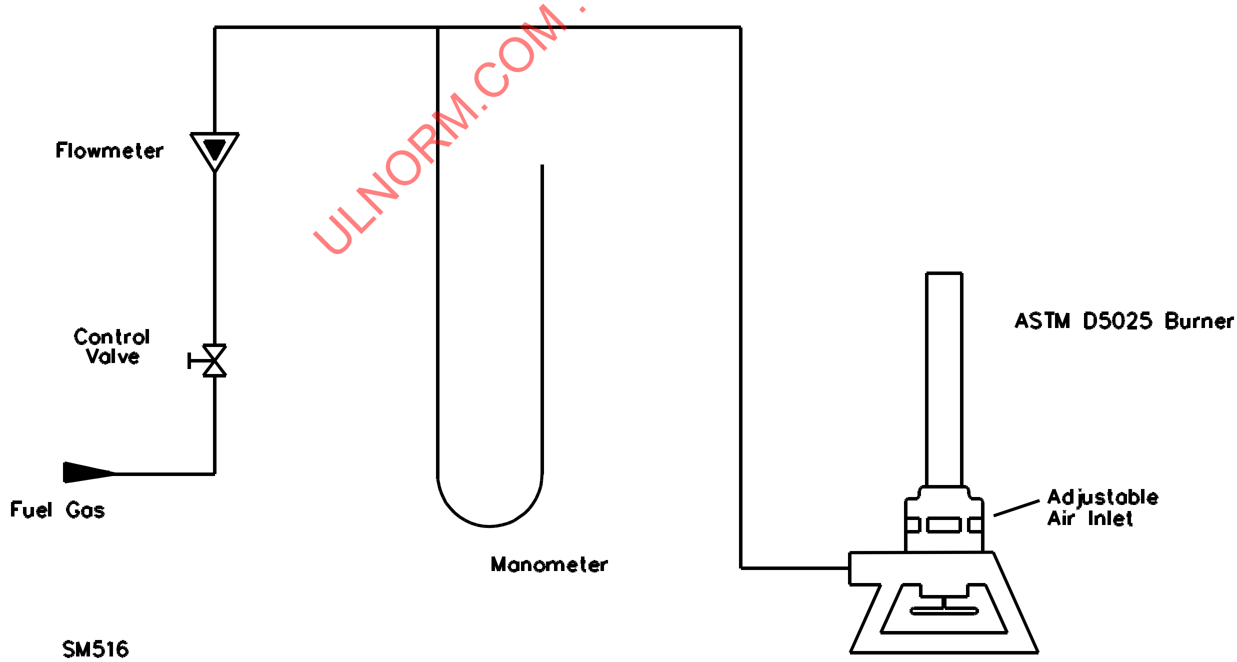
18.3.3 The burner shall be adjusted to produce a blue flame 125 ±10 mm high (5 inch nominal). The flame is obtained by adjusting the gas supply and air ports of the burner until a 40 ±2 mm (1.5 inch nominal) yellow-tipped blue flame is produced. The air supply shall be increased until the yellow tip just disappears. The height of the flame shall be measured again and readjusted it if necessary.

18.3.4 The test flame shall be calibrated in accordance with ASTM D5207, at least once a month and when the gas supply is changed, test equipment is replaced, or when data is questioned.

18.3.5 Other than as noted in 18.3.6, a supply of technical-grade methane gas (minimum 98 % pure) is to be used with a regulator and meter for uniform gas flow. The methane gas supply to the burner shall be arranged as in Figure 18.1 and adjusted to produce a gas flow rate of 965 ±30 ml/min with a back pressure of 125 ±25 mm of water. See ASTM D5207. The flow meter shall be a rotameter calibrated in accordance with ASTM D3195, with correlation curves appropriate for the gas, or a mass flow meter with ±2 % accuracy.

Figure 18.1

Burner Supply Arrangement



18.3.6 Natural gas having a heat content of approximately 37 MJ/m^3 (1000 Btu/ft^3) at 23 °C has been found to provide similar results, and may be used in lieu of technical-grade methane gas.

18.4 Test method

18.4.1 Prior to application of the flame, the representative meters are to be maintained for a minimum of 4 hours at 23.0 ±2.0 °C and 50 ±5 % relative humidity in a de-energized condition.

18.4.2 Each representative meter is to be mounted or positioned as intended in service, in a draft-free test chamber, enclosure, or laboratory hood. A layer of absorbent 100 % cotton is to be located 305 mm (12 inch) below the point of application of the test flame.

NOTE: "mounted or positioned as intended in service" does not require the use of a meter mounting device.

18.4.3 The 127 mm (5 inch) flame is to be applied to any portion of the interior of the part judged as likely to be ignited (by its proximity to live or arcing parts, coils, wiring, and the like).

18.4.4 When testing complete assemblies, it may be necessary to modify the assembly to provide an opening through which the burner may be inserted to apply the flame to the interior of the part under test. The size of this opening shall be such as to allow insertion of the burner, while minimizing the impact on the enclosure integrity. The flame may be applied to the outside of an enclosure if the equipment is of the encapsulated type or of such size that the flame cannot be applied inside.

18.4.5 The flame is to be applied at an angle of approximately 20 degrees in so far as possible from the vertical so that the tip of the blue cone touches the specimen.

18.4.6 The test flame is to be applied to three different locations (one on each of the three representative meters tested). Consideration shall be given to material types, material thickness, and proximity to high energy components when determining the test locations.

18.4.7 For detachable meters that may be installed through an opening in the meter-mounting equipment enclosure, the base of the meter shall be subjected to applications of the flame on both the inside and outside surfaces of the base.

18.4.8 The flame is to be applied for 5 seconds and removed for 5 seconds. The operation is to be repeated until the specimen has been subjected to five applications of the test flame.

18.4.9 When testing complete assemblies, if the flame extinguishes due to oxygen starvation during one or more of the 5 second applications, the burner is to be withdrawn, re-ignited, and testing shall be continued until five applications of the test flame (including any application that self-extinguishes) are conducted.

18.5 Assessment of test results

18.5.1 When tested as described in 18.4, all of the following results shall be obtained:

a) The material shall not continue to burn for more than 1 minute after the fifth 5-second application of the test flame, with an interval of 5 seconds between the applications of the flame,

b) Flaming drops or flaming or glowing particles that ignite surgical cotton 305 mm (12 inch) below the test specimen shall not be emitted by the test meter at any time during the test, and

c) No flame shall be observed outside the enclosure. In addition, no opening greater than 3 mm shall appear after the test and the test meter has cooled for 30 seconds.

18.5.2 All three representative meters shall exhibit the acceptable performance described in 18.5.1.

19 Temporary Overvoltage Test

19.1 General

19.1.1 The meter shall be subjected to this test in accordance with one of the methods described in 19.2 and 19.3. If the test method of 19.2 is chosen and the test results are not acceptable, the test in 19.3 may be conducted at the manufacturer's discretion. If the test results of 19.3 are acceptable, the meter shall be considered in compliance with this requirement.

19.1.2 The representative meter shall be mounted as intended in service in a suitably rated meter-mounting device.

19.1.3 Single-phase meters shall be connected to a single-phase source. Poly-phase meters shall be powered from a poly-phase source.

19.1.4 The meter need not be loaded during test (current coils open). If the meter has a service switch it shall be closed during the test.

19.1.5 At the conclusion of the testing in 19.2 or 19.3, the meter shall comply with the requirements of 19.4.

19.1.6 The temporary overvoltage test shall not apply to the meter auxiliary power terminals, unless these terminals are rated for connection to the measured circuit (mains).

19.2 Testing with a current limited source

19.2.1 The test voltage source shall be capable of providing a minimum of 30A rms continuously per phase, at the full test voltage.

19.2.2 The source may be current limited by an electronic feedback control circuit, fuse, or circuit breaker.

19.2.3 If the source is not current limited in accordance with 19.2.2, a fast acting (non-time delay) fuse rated no greater than the continuous current rating of the source shall be connected between the source and the meter. The rating of the fuse shall be no less than the required test voltage, and the fuse shall have a current interrupting capacity of no less than 10 kA.

19.2.4 For single phase meters, for the purposes of this test, nominal voltage (V_{nom}) is the highest line-to-neutral rated voltage per the manufacturer. For meter forms that do not have a neutral connection, V_{nom} is considered to be the line-to-line voltage. Testing of single-phase meters shall be conducted as follows:

a) The test voltage shall be between 190 % V_{nom} to 200 % V_{nom}. A higher test voltage may be specified and tested at the discretion of the manufacturer.

b) The test voltage shall be applied line to neutral except for those meters where a neutral is not available (e.g. form 2 and form 4 meters).

c) The test voltage shall be applied line to line where a neutral is not available (e.g. form 2 and form 4 meters).

19.2.5 For poly-phase meters that have a neutral connection, for the purpose of this test, nominal voltage (V_{nom}) is the highest line-to-neutral rated voltage per the manufacturer. The meter's neutral connection is to be removed from the service neutral, then each phase of the meter is to be successively shorted to the meter's neutral connection and the test voltage is to be applied between the meter's un-shorted phases and the meter's neutral connection. Testing of poly-phase meters shall be conducted as follows:

a) The service type to be used for testing a 3-element meter shall be 4 wire wye. The phase angle between the poly-phase test voltages shall be 60° ±3°.

b) The service type to be used for testing a 2-element meter shall be 2 phases of a 4 wire wye service. The test voltage shall be single phase.

The line to neutral voltage of the service is to be set to between 110 % and 115 % of V_{nom}. Thus, the service line to line voltage will be between 190 % and 200 % of V_{nom}.

19.2.6 For poly-phase meters specified for use with services that do not have a neutral connection (such as 3 wire delta), the meter is to be connected as specified by the manufacturer and subject to a line-to-line voltage between 115 % and 120 % of the highest line-to-line rated voltage. The phase angle between the poly-phase test voltages shall be 60° ±3°.

19.2.7 The time to ramp from minimum to maximum voltage shall be as short as possible but in no case shall the time exceed 100ms.

19.2.8 The test voltage shall be applied to the meter for 1 hour or until one of the following conditions has been met:

a) A protective device, component, wire, or printed wiring board trace within the meter opens, causing current to cease to flow in the test circuit; or

b) The test fuse required by 19.2.3 opens; or

c) The current limiting function of the voltage source is activated (if so equipped).

19.3 Testing with a high current source

19.3.1 The meter shall be connected to a source having an available short circuit current of no less than 10,000 ampere rms symmetrical, at the full required test voltage. For meters with a short-circuit current rating exceeding this minimum level, the available short circuit current shall be no less than the short-circuit current rating of the meter.

19.3.2 The power factor of the test circuit shall be between 0.45 and 0.50 lagging for meters with short current ratings of 10,000 amperes or less; between 0.25 and 0.30 lagging for meters with short circuit ratings of 10,001 – 20,000 amperes; and between 0.15 and 0.20 lagging for meters with short circuit ratings above 20,000 amperes.

19.3.3 The test voltage shall be as described in 19.2.4 – 19.2.8.

19.3.4 The test voltage shall be applied to the representative meter using random closing for three phase devices. For single phase devices, controlled closing shall be employed so the closing angle with respect to the zero point of the supply voltage is within +10 degrees.

19.3.5 The enclosure of the meter socket shall be connected through a 30 A, non-time delay fuse to the line lead of the phase which is having the greatest clearance distance from the enclosure. The fuse shall have voltage rating no less than the test voltage, and a short circuit interrupting rating no less than the short circuit rating of the meter.

19.3.6 The test voltage shall be applied for no fewer than 30 electrical cycles.

19.3.7 If current flows for the entire 30 electrical cycles, the test shall be repeated using a new representative meter, with the test voltage applied for one hour, or until a protective device, component, or printed wiring board foil trace within the meter opens, causing current to stop flowing in the circuit (prior to completion of the one hour duration). Alternatively, a new representative meter may be subjected to the test in 19.2 rather than repeating this test for 1 hour.

19.4 Assessment of test results

19.4.1 Upon completion of the tests described in 19.2 and 19.3, the following conditions shall not result:

a) Ejection of a detachable meter from the meter-mounting equipment. For purposes of this requirement, ejection is considered to be any condition in which any blade of the meter is no longer held within the corresponding jaw of the meter-mounting equipment by the inherent spring pressure of the jaw itself.

b) Ejection of any part or subcomponent of the meter through any opening already existing or an opening created as a result of testing the device.

c) Emission of flame, molten metal, glowing or flaming particles through any openings (pre-existing or created as a result of the test) in the product.

d) The meter or mounting device catches on fire or becomes hot enough to ignite adjacent components.

e) Live circuits become exposed or the creation of any openings in the enclosure.

f) Loss of structural integrity to a degree that the equipment collapses or experiences such displacement of parts that there is a risk of short-circuiting or grounding of current-carrying parts.

g) The test voltage source fuse or circuit breaker opens, or the current is limited by an electronic feedback control circuit when the test is conducted in accordance with 19.2.

h) When tested in accordance with 19.3, the 30 A fuse connected between the enclosure and the line lead shall not have opened.

19.4.2 Immediately following this test, the meter shall be subjected to the Insulation Resistance Test of 17.3.

20 Tests for Cemented Joints

20.1 If required by 8.15, three representative cemented joints are to be subjected ten times to the following thermal cycling sequence:

a) 68 hours at T_1 ±2 °C

b) 1 hour at 25 °C ±2 °C

c) 2 hours at 0 °C ±2 °C

d) Not less than 1 hour at 25 °C ±2 °C

$T_1 = T_2 + 10$ °C, or 85 °C, whichever is higher. However, the 10 °C margin is not added if the temperature is measured by an embedded thermocouple or by the resistance method.

T_2 is the temperature of the parts measured during the Temperature Rise Test of 17.2.

The period of time taken for the transition from one temperature to another is not specified, but the transition is permitted to be gradual.

There shall be no evidence of insulation breakdown during this conditioning.

20.2 Before testing a cemented joint, any winding of solvent-based enameled wire used in the component is replaced by metal foil or by a few turns of bare wire, placed close to the cemented joint.

20.3 The three representative cemented joints are then tested as follows:

a) One of the cemented joints is subjected to the Insulation Test of 17.3 immediately after the last period at T_1 °C during thermal cycling; and

b) The other cemented joints are subjected to the Insulation Test of 17.3 after the humidity conditioning of 17.3(c), except that the test voltage is 4.0 kV ac.

20.4 Compliance is checked by inspection and measurement as follows:

a) Except for cemented joints on the same inner surface of a printed board, compliance is checked by inspection of the cross-sectional area, and there shall be no visible voids, gaps or cracks in the insulating material.

b) In the case of insulation between conductors on the same inner surface of printed boards and the insulation between conductors on different surfaces of multilayer boards, compliance is checked by measurement and external visual inspection. There shall be no delamination.

21 Enclosure Tests

21.1 General

21.1.1 To demonstrate compliance with 7.1, meters shall be tested as Category 2 devices as defined in IEC 60529, for protection against solid objects in accordance with 21.1.2 or 21.1.3 as applicable.

21.1.2 Detachable meters shall be tested while mounted in a meter-mounting device in accordance with CAN/CSA C22.2 No. 115, and in accordance with the meter manufacturer's instructions. Both a ringless meter-mounting device and a meter-mounting device intended to have a ring shall be used for the test. A ring will always be used if the meter-mounting device is designed to have one. The ring opening shall be at the bottom or as intended by the manufacturer. In accordance with IEC 60529, the meter-mounting device is not to be considered part of the meter enclosure but is to be used as it will contribute to integrity of the meter enclosure. Water shall be applied to exposed surfaces of the meter.

21.1.3 Bottom connected meters shall be tested with the meter mounted in accordance with the manufacturer's instructions. Water shall be applied to exposed surfaces of the meter. If the manufacturer's instructions specify placing the meter completely inside an enclosure rated for the intended environment in accordance with Table 7.1, additional testing for the ingress of solid foreign objects or ingress of water is not required.

21.1.4 During the tests of 21.1.1, water shall not be applied to conduit openings, hinges, seals and other attributes of the meter-mounting device that do not contribute to ingress protection of exposed surfaces of the meter.