UL 228

STANDARD FOR SAFETY

Door Closers-Holders, With or Without Integral Smoke Detectors

UL Standard for Safety for Door Closers-Holders, With or Without Integral Smoke Detectors, UL 228

Fifth Edition, Dated January 26, 2006

Summary of Topics

These revisions to UL 228 dated March 11, 2022 include a steel ball diameter correction in the Jarring Test; 16.2.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated February 4, 2022.

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UL 228

Standard for Door Closers-Holders, With or Without Integral Smoke Detectors

The first edition was titled "Electromagnetic and Electromechanical Door Holder-Releasers and Combination Door Closer-Holders (With or Without Integral Smoke Detectors)".

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Second Edition – October, 1979
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Fifth Edition

January 26, 2006

This UL Standard for Safety consists of the Fifth Edition including revisions through March 11, 2022.

The Department of Defense (DoD) has adopted UL 228 on October 3, 1994. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements apply to swinging door closers equipped with integral electromechanical or electromagnetic holders and which may be provided with integral smoke detectors. These requirements also apply to electromagnetic door holder units which are for use with a separate door closer and separate automatic fire detector.

1.2 When integral smoke detectors are provided with the combination door closer-holder, the smoke detectors shall comply with requirements for smoke detectors of the photoelectric or combustion products type.

1.3 Requirements for the installation of these combination door closers-holders with or without smoke detector units are included in the Standards for Fire Doors and Fire Windows, NFPA 80, and National Fire Alarm Code, NFPA 72.

1.4 The combination door closers-holders (with or without integral smoke detectors) described in this Standard provide one of the following types of hold open functions:

a) Single point hold open.

b) Multiple point hold open. (Two, three, four, etc. discrete hold open points as set at the manufacturer's plant.)

c) Infinite hold open points with one as set by the user.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.1.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

2.1.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.1.4 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.

2.2 Units of measurement

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

2.3 Undated references

2.3.1 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.

CONSTRUCTION

3 General

3.1 The combination door closer-holder shall be designed so that the held door is capable of being released manually by simple and obvious operation, such as pulling on the door knob with a maximum force of 50 pounds (223 N), and upon release the door becomes self-closing and then latches closed.

3.2 The separate holder release device shall be designed so that the held door is capable of being released manually by simple and obvious operation, such as pulling on the door knob or leading edge with a maximum force of 50 pounds (223 N).

3.3 Combination door closer-holders (with or without integral smoke detectors) designed for National Electrical Code Class 1 circuits shall be for door frame mounting only.

3.4 Combination door closer-holders (with or without integral smoke detectors), intended for mounting within or on a door, shall be limited in design to a National Electrical Code Class 2 circuit.

3.5 For the purposes of this standard, a Class 2 circuit is defined as one that has a maximum of 30 volts alternating-current RMS (42.4 volts peak or direct current) and 100 volt-amperes.

4 Frame and Enclosure

4.1 A unit shall resist the abuses to which it is subjected without adversely affecting its performance due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

4.2 Electrical parts of a unit shall be located or enclosed so that protection against unintentional contact with uninsulated hazardous live or dead metal parts is provided.

4.3 Operating parts shall be protected against fouling by dust or by other material which affects their normal operation.

4.4 An enclosure shall have means for mounting which shall be accessible without disassembling any operating part of the unit.

4.5 With reference to the requirement in 4.4, removal of a completely assembled panel is not considered to be disassembly of any operating part.

4.6 Connectors and switches, which have a means for adjustment, shall also have a method by which that adjustment is positively locked in position.

4.7 Metallic combinations shall be such as to resist galvanic corrosion.

4.8 The thickness of cast metal for an enclosure shall be as indicated in Table 4.1, except that cast metal of lesser thickness is not prohibited from being used when, consideration being given to the shape, size, and function of the enclosure, it provides equivalent mechanical strength.

Table 4.1
Cast-metal electrical enclosures

Use, or dimensions of area involved[a]	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	inch	(mm)	inch	(mm)
Area of 24 square inches (155 cm^2) or less and having no dimension greater than 6 inches (152 mm).	1/16	1.6	1/8	3.2
Area greater than 24 square inches or having any dimension greater than 6 inches.	3/32	2.4	1/8	3.2
At a threaded conduit hole.	1/4	6.4	1/4	6.4
At an unthreaded conduit hole.	1/8	3.2	1/8	3.2

[a] The area limitation for metal 1/16 inch (1.6 mm) thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

4.9 Among the factors which are taken into consideration when evaluating a nonmetallic enclosure are the following, all of which are considered with regard to aging:

a) The mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Combustibility; and

e) Resistance to distortion at temperatures to which the material is capable of being subjected under conditions of normal or abnormal use.

4.10 The thickness of sheet metal employed for the enclosure of a unit shall not be less than that indicated in Table 4.2; except that sheet metal of lesser thickness is not prohibited from being used when, consideration being given to the shape, size, and function of the enclosure, it provides equivalent mechanical strength. At any point where conduit or metal-clad cable is to be attached, sheet metal shall be of such thickness or shall be formed or reinforced so that it has stiffness at least equivalent to that of an uncoated flat sheet of steel having a minimum thickness of 0.053 inch (1.35 mm) (No. 16 MSG).

Table 4.2
Sheet metal electrical enclosures

Maximum enclosure dimensions				Minimum thickness of sheet metal					
				Steel					
Any linear dimensions,		Area of any surface,		Zinc coated,		Uncoated,		Brass or aluminum,	
inch	(mm)	$inch^2$	(cm^2)	inch [CSG]	(mm)	inch [MSG]	(mm)	inch [AWG]	(mm)
12	305	90	584	0.034 [20]	0.86	0.032 [20]	0.81	0.045 [16]	1.14
24	610	360	2322	0.045 [18]	1.14	0.042 [18]	1.07	0.058 [14]	1.47
48	1219	1200	7742	0.056	1.42	0.053	1.35	0.075	1.91

Table 4.2 Continued on Next Page

Table 4.2 Continued

Maximum enclosure dimensions				Minimum thickness of sheet metal					
				Steel					
Any linear dimensions,		Area of any surface,		Zinc coated,		Uncoated,		Brass or aluminum,	
inch	(mm)	inch^2	(cm^2)	inch [CSG]	(mm)	inch [MSG]	(mm)	inch [AWG]	(mm)
60	1524	1500	9678	[16] 0.070	1.78	[16] 0.067	1.70	[12] 0.095	2.41
Over 60	1524	Over 1500	9678	[14] 0.097	2.46	[14] 0.093	2.36	[10] 0.122	3.10
				[12]		[12]		[8]	

4.11 Assembly screws that hold essential working parts and which must be loosened or removed in order to wire or install a connector or switch shall not thread into material other than metal.

5 Mounting of Parts

5.1 All parts shall be securely mounted in position and prevented from loosening or turning when such motion affects the performance of the equipment or affects the risk of fire or injury to persons incident to the operation of the equipment.

5.2 Uninsulated live parts shall be secured to their supporting surfaces so that they are prevented from turning or shifting in position when such motion results in a reduction of spacings to less than those indicated in 12.2 – 12.6.

5.3 Friction between surfaces is not to be used as a means to prevent turning, loosening, or shifting of a part as required in 5.1 and 5.2; however, a toothed-lock washer or equivalent means is not prohibited from being used.

6 Corrosion Protection

6.1 Iron and steel parts, other than bearings, etc., where such protection is impractical, shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means.

6.2 The requirement of 6.1 applies to all enclosing cases of sheet steel or cast iron and to all springs and other parts upon which proper mechanical operation depends. It does not apply to washers, screws, bolts, and other minor parts, when failure of such unprotected parts is not capable of resulting in a hazardous condition or in the equipment's operation being affected. Parts made of stainless steel, polished or treated, when required, do not require additional protection against corrosion. Bearing surfaces shall be of such materials and design as to resist binding due to corrosion.

7 Insulating Material

7.1 A base for the support of live parts shall be of moisture-resistant insulating material such as porcelain, phenolic, or cold-molded composition.

7.2 A base mounted on a metal surface which may be grounded shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base which are not staked, upset, sealed, or equivalently prevented from loosening so as to prevent such parts and the ends of replaceable terminal screws from contacting the supporting surface.

7.3 Hard fiber is not prohibited from being used for insulating bushings, washers, separators, and barriers, but not for the sole support of live parts where shrinkage, current leakage, or warping of the fiber introduces a hazard.

7.4 A countersunk sealed live part shall be covered with a waterproof insulating compound which will not melt at a temperature of 15°C (27°F) higher than the maximum normal operating temperature of the assembly, and at not less than 65°C (149°F) in any case. The depth or thickness of sealing compound shall not be less than 1/8 inch (3.2 mm).

8 Current-Carrying Parts

8.1 A current-carrying part shall be of silver, copper, a copper alloy, or equivalent.

8.2 Bearings, hinges, etc., are not acceptable for carrying current between fixed and moving parts.

8.3 A wire-binding screw shall thread into metal.

8.4 A wiring terminal shall be prevented from turning.

8.5 Except as noted in 8.6, a terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) in thickness for a No. 8 (4.2 mm diameter) or larger screw, and not less than 0.030 inch (0.76 mm) in thickness for a No. 6 or a No. 4 (3.5 or 2.8 mm diameter) screw, and shall have no fewer than two full threads in the metal.

8.6 A terminal plate is not prohibited from having the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Other constructions are capable of being used when they provide equivalent ruggedness of the terminal plate and thread security of the wire-binding screw.

9 Wiring Methods

9.1 An open-circuit device shall be provided with terminals or leads so that its connections to the protective circuit can be supervised to prevent removal.

10 Internal Wiring

10.1 General

10.1.1 Internal wiring shall have thermoplastic or rubber insulation not less than 1/64 inch (0.4 mm) thick or equivalent, for 0 – 300 volts where power is less than indicated in footnote b of Table 18.1, and no flexing or mechanical abuse is capable of occurring. Otherwise, insulation thickness shall not be less than 1/32 inch (0.8 mm).

10.1.2 Leads connected to parts mounted on a hinged cover shall possess the length to permit the full opening of the cover without applying stress to the leads or their connections. The leads shall be secured or equivalently arranged to prevent abrasion of insulation and jamming between parts of the enclosure and shall be of a flexible type.

10.1.3 Insulation, such as coated fabric and extruded tubing, shall not be affected by the temperature or other environmental conditions to which it is subjected in service.

10.1.4 Wireways shall be smooth and entirely free from sharp edges, burrs, fins, moving parts, etc., which cause abrasion of the conductor insulation. Holes in sheet metal walls through which insulated wires

pass shall be provided with a bushing when the wall is 0.042 inch (1.07 mm) or less in thickness. Holes in walls thicker than 0.042 inch (1.07 mm) shall have smooth, rounded edges.

10.1.5 All joints and connections shall be mechanically secure and shall provide adequate and reliable electrical contact without strain on connections and terminals.

10.1.6 Stranded conductors clamped under wire-binding screws or similar parts shall have the individual strands soldered together or equivalently arranged to assure reliable connections.

10.1.7 A splice shall be provided with insulation equivalent to that required for the wires involved when permanence of required spacing between the splice and uninsulated metal parts is not assured.

10.1.8 When a printed wiring assembly employs insulating coatings or encapsulation, the compound shall be investigated. Samples of the assembly shall be tested for dielectric withstand before and after being treated, except that when it is impractical to use untreated samples, finished samples shall be tested for dielectric withstand after they are subjected to humidity, temperature, and other applicable tests described in this standard.

10.2 Semiconductors

10.2.1 Semiconductors shall be rated for the intended application under all environmental conditions to which they are exposed in service.

10.2.2 The performance tests of the complete unit are intended to show the effects of these conditions. The prescribed tests may be supplemented where conditions exceeding those represented by the tests indicated in this standard are encountered.

11 Installation Wiring Methods

11.1 General

11.1.1 Except as noted in 10.1.4, openings for the entry of a conductor or conductors shall be provided with insulating bushings.

11.1.2 It should be noted that according to the National Electrical Code, 14 AWG (2.1 mm^2) is the smallest conductor which the installer shall use for branch circuit wiring and thus is the smallest conductor that shall be anticipated at a terminal for the connection of a power supply wire.

11.1.3 A wire-binding screw, at a field wiring terminal, shall not be smaller than 10 AWG (4.8 mm diameter).

Exception No. 1: A 8 AWG (4.2 mm diameter) screw may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

Exception No. 2: A 6 (3.5 mm diameter) screw may be used for the connection of a 16 AWG (1.3 mm^2) or 18 AWG (0.82 mm^2) control-circuit conductor.

11.1.4 A terminal plate for a wire binding screw shall be of metal not less than 0.030 inch (0.76 mm) in thickness for a 14 AWG (2.1 mm^2) or smaller wire and not less than 0.050 inch (1.27 mm) in thickness for a wire larger than 14 AWG (2.1 mm^2). In either case, there shall not be less than two full threads in the metal.

11.1.5 A terminal plate formed from stock having the minimum required thickness may have the metal extruded at the tapped hole for the binding screw to provide two full threads.

Exception: Two full threads are not required if a lesser number of threads results in a connection in which the threads will not strip with normal tightening torque in accordance with the values indicated in the Standard for Wire Connectors, UL 486A-486B.

11.1.6 A wire binding screw shall thread into metal.

11.1.7 When leads are provided in lieu of wiring terminals, they shall not be less than 6 inches (152 mm) long. No such leads shall be smaller than 18 AWG (0.81 mm^2).

11.2 Strain relief

11.2.1 Strain relief shall be provided so that a mechanical stress on a flexible cord or cable is not transmitted to terminals, splices, or interior wiring.

11.2.2 When a knot in a flexible cord serves as strain relief, a surface against which the knot bears or with which it comes into contact shall be free from projections, sharp edges, burrs, fins, etc., which are capable of causing abrasions to the insulation on the conductors.

11.3 Bushings

11.3.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent which shall provide a smoothly rounded surface against which the cord bears.

11.3.2 When the cord hole is in phenolic composition or other nonconducting material, a smoothly rounded surface is considered to be the equivalent of a bushing.

11.3.3 Ceramic materials and some molded compositions are not prohibited from being used for insulating bushings; however, bushings of wood and of hot-molded shellac are not to be used.

11.3.4 Fiber is not prohibited from being used where it is not subjected to a temperature higher than 90°C (194°F) under normal operating conditions when the bushing is not less than 1/16 inch (1.6 mm) in thickness [with a minus tolerance of 1/64 inch (0.4 mm) for manufacturing variations] and when it is not exposed to moisture.

12 Spacings

12.1 A device shall provide reliably maintained spacings between uninsulated live parts and between uninsulated live parts and dead metal parts. Except as indicated in 12.6, the spacings shall not be less than those indicated in 12.2 – 12.5.

12.2 The spacing between an uninsulated live part and a wall or cover of a metal enclosure or a metal piece attached to a metal enclosure, where deformation of the enclosure is liable to reduce spacings, shall not be less than that indicated in Table 12.1.

Table 12.1
Minimum spacings

Point of application	Minimum spacings[a,b]				
	Voltage range, volts	Through air, inch	(mm)	Over surface, inch	(mm)
To walls of enclosure:					
Cast metal enclosures	0 – 300	1/4	6.4	1/4	6.4
Sheet metal enclosures	0 – 300	1/2	12.7	1/2	12.7
Installation wiring terminals:					
With barriers	0 – 30	1/8	3.2	3/16	4.8
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Without barriers	0 – 30	3/16	4.8	3/16	4.8
	31 – 150	1/4	6.4	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Rigidly clamped assemblies:[c]					
100 volt-amperes maximum[d]	0 – 30	1/32	0.8	1/32	0.8
Over 100 volt-amperes	0 – 30	3/64	1.2	3/64	1.2
	31 – 150	1/16	1.6	1/16	1.6
	151 – 300	3/32	2.4	3/32	2.4
Other parts					
	0 – 30	1/16	1.6	1/8	3.2
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5

[a] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material used where spacings are otherwise insufficient, shall not be less than 0.028 inch (0.71 mm) in thickness; except that a liner or barrier not less than 0.013 inch (0.33 mm) in thickness is not prohibited from being used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it is not affected adversely by arcing. Insulating material having a thickness less than that specified is not prohibited from being used when it is suitable for the particular application.

[b] Measurements are to be made with solid wire of adequate ampacity for the applied load connected to each terminal. In no case is the wire to be smaller than 18 AWG (0.82 mm^2).

[c] Rigidly clamped assemblies include such parts as contact springs on relays or cam switches, printed wiring boards, and the like.

[d] Spacings less than those indicated, but not less than 1/64 inch (0.4 mm), are acceptable for the connection of integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 1/32 inch (0.8 mm).

12.3 Except as noted in 12.6, the spacings between an uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded dead metal part other than the enclosure, or an exposed dead metal part which is isolated (insulated) shall be not less than that indicated in Table 12.1.

12.4 When a short circuit between uninsulated live parts of the same polarity prevents the normal signaling operation of the device without simultaneously producing an alarm signal, the spacings between such parts shall not be less than those indicated for "Other parts" in Table 12.1, except in the case of rigidly clamped assemblies.

12.5 Enamel-insulated wire is considered to be a bare current-carrying part in determining compliance of a device with the spacing requirements, but enamel is acceptable as turn-to-turn insulation in coils.

12.6 Minimum values of spacings are not specified for printed wiring assemblies operating at 50 volts or less where the energy between the parts is limited to 100 volt-amperes or less.

PERFORMANCE

13 General

13.1 Six samples of each design shall be provided in commercial form.

13.2 A door holder-release device or a door closer-holder with or without an integral smoke detector shall be subjected to the following tests except as modified or supplemented by requirements outlined under the section covering a specific device.

14 Normal Operation

14.1 A door closer-holder with or without an integral smoke detector shall release and the door shall come to the closed (latched) position in the event of interruption of electrical power to the device.

14.2 A door-holder release shall release in the event of interruption of electrical power to the device.

14.3 When equipment must be mounted in a definite position in order to function properly, it shall be tested in that position.

14.4 A unit shall be capable of performing its normal function when installed in accordance with 14.5 and 14.6.

14.5 The unit is to be mounted in the intended manner and its terminals connected as in service.

14.6 Devices are to be connected to circuits of rated voltage, current and frequency.

15 Endurance Test

15.1 When the design of a separate electromagnetic or electromechanical holder-release is such that binding or jamming of its parts prevents a fire door from being closed, the holder-release device shall be mounted in its intended manner and subjected to 100,000 cycles of operation. The unit shall be fully operable after this test and there shall be no undue wear of parts.

15.2 For the endurance test of a combination door closer-holder with or without an integral smoke detector device, the test assembly shall consist of a single swinging door, ball bearing hinges, a door cycling mechanism, a door cycle counter, and the test sample.

15.3 The combination door closer-holder with or without integral smoke detector shall be installed in accordance with the manufacturer's instructions for a 90 ±5 degree door opening.

15.4 Before starting the cycling test, the door closer adjustable closing speed is to be examined by manually opening the door 90 degrees and then releasing the door:

a) With the door closer valve(s) shut off, the door shall take 90 seconds or longer to fully close.

b) With the door closer valve(s) open, the door shall fully close in 3 seconds or less.

15.5 The electrical control system of the test assembly is to be programmed to interrupt power to the electromagnet after a minimum of 3 seconds to hold open time, allowing the closer mechanism to bring the door to the closed position in 4 to 6 seconds and start a new cycle. This cycling rate of a minimum of 3 cycles per minute (average) is to be continued through 100,000 cycles.

15.6 At 4,000 cycles of the endurance test, the test door is to be placed in the hold open position by disconnecting the electrical timing features of the test apparatus and the door closer part of the combination closer-holder closing force is to be measured along a base line perpendicular to the closed test door and 30 inches (762 mm) from the test door pivot center with two marks provided, one at 3 inches (76.2 mm) and the other 1/2 inch (12.7 mm) from the door face.

15.7 The door closer is to be adjusted to provide the optimum closing force as specified by the manufacturer. The weight of the test door shall be in accordance with Table 15.1.

Table 15.1
Minimum closing forces

Test door weight,		Minimum closing force,	
pounds	(kg)	pounds	(N)
100	45	3	13
125	57	5	22
150	68	8	36
200	90	11	49
250	114	14	62

15.8 The test door is to be opened beyond the 3 inch (76.2 mm) mark. Holding the door open with a mechanical force gauge, the door is to be allowed to close slowly under the power of the door closer. The greatest force developed during closing is to be recorded as the door travels between the 3 inch (76.2 mm) and 1/2 inch (12.7 mm) marks.

15.9 The recorded force shall equal or exceed the minimum values as specified in Table 15.1 for the test door used.

15.10 At periodic intervals of operation, the cycle rate shall be measured and the closer readjusted, when required, to close the door at a closing rate of 4 to 6 seconds.

15.11 At every 20,000 cycles of operation, the test door is to be placed in the hold open position by disconnecting the electrical timing features of the test apparatus, and the force required to override the hold open feature of the combination door closer-holder is to be measured.

15.12 The measurement is to be made with the test door open to a 90 degree opening position. A mechanical force gauge is to be connected to the latch edge of the test door at a position 38 – 40 inches (965 – 1016 mm) from the bottom of the door and at a point 30 inches (762 mm) from the pivot center of the door. The force required to override the hold open device is to be recorded and shall not exceed 50 pounds (223 N) of pull.

15.13 Similar measurements are to be made with the test door held open at 45 degrees as well as at 30 degrees. The force required to override the holding device shall not exceed 50 pounds (223 N) of pull.

15.14 After completion of the cycle tests, the power is to be adjusted to provide 85 and 110 percent of the rated voltage. Each device is to be cycled ten times when subjected to the under and overvoltage sources, and the hold open feature is to be observed to ensure proper operation and holding ability.

15.15 After completion of the tests, each combination closer-holder shall be dismantled and the parts inspected for wear, pitting, or other defects which impair its reliability.

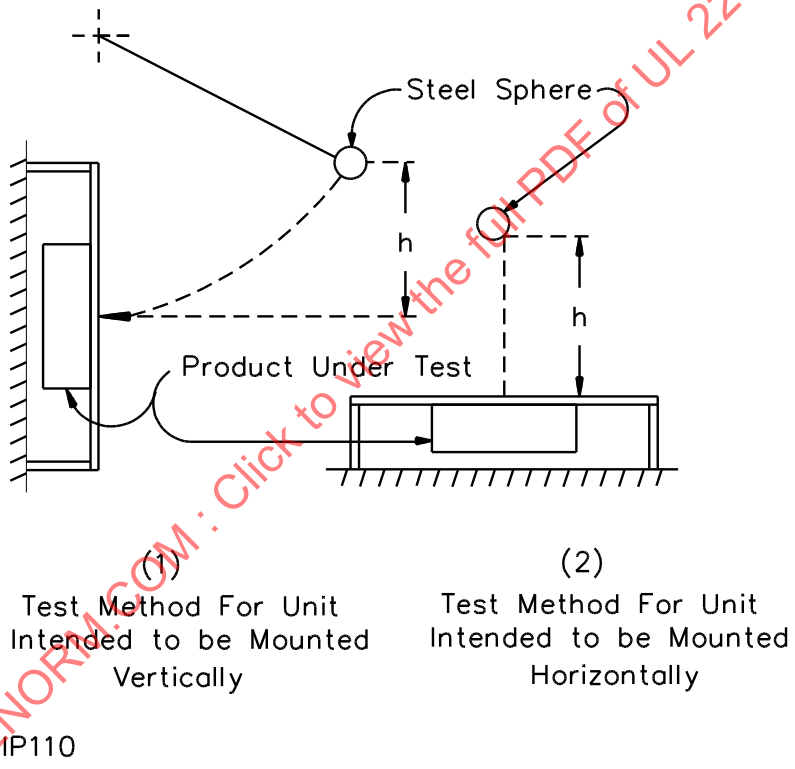
16 Jarring Test

16.1 A device shall be capable of withstanding jarring resulting from impact and vibration, such as that experienced in service, without affecting its subsequent normal operation.

16.2 The device is to be mounted in a position of intended use to the center of a 6 by 4 foot (1.83 by 1.22 m), 3/4 inch (19.1 mm) thick plywood board which is secured in place at four corners. A 3 foot-pound (4.08 J) impact is to be applied to the center of the reverse side of this board. This impact is to be applied to the center of the reverse side of this board by means of a 1.18 pound (0.54 kg), 2 inch (50.8 mm) diameter steel sphere either swung through a pendulum arc, or dropped from a height (h) of 2.54 feet (775 mm), depending upon the mounting of the equipment. See Figure 16.1.

Figure 16.1

Jarring test



17 Input Test

17.1 The power input to an electromagnetic fire door holder or smoke detector shall not exceed its marked rating by more than 10 percent when it is operated under the conditions of normal use and with the unit connected to a supply circuit of rated voltage and frequency.

18 Temperature Test

18.1 The materials employed in the construction of an electromagnetic holder or smoke detector shall not be adversely affected by the temperatures attained under any condition of normal operation.

18.2 A material is considered to be adversely affected when it is subject to a temperature rise greater than that indicated in Table 18.1.

Table 18.1
Maximum temperature rises

Device or material	Normal standby, °C	Normal standby, (°F)	Alarm condition, °C	Alarm condition, (°F)
A. MOTORS				
1. Class A insulation systems on coil windings of alternating current motors:				
a. In open motors and on vibrator coils				
Thermocouple or resistance method	75	135	75	135
b. In totally enclosed motors				
Thermocouple or resistance method	80	144	80	144
2. Class B insulation systems on coil windings of alternating current motors:				
a. In open motors				
Thermocouple or resistance method	95	171	95	171
b. In totally enclosed motors				
Thermocouple or resistance method	100	180	100	180
B. COMPONENTS				
1. Capacitors	25	45	40	72
2. Fuses	25	45	65	117
3. Rectifiers – at any point				
a. Germanium	25	45	50	90
b. Selenium	25	45	50	90
c. Silicon	25	45	75	135
4. Relays and other coils with:				
a. Class 105 insulated windings				
Thermocouple method	25	45	65	117
Resistance method	35	63	75	135
b. Class 130 insulated windings				
Thermocouple method	45	81	85	153
Resistance method	55	99	95	171
5. Resistors				
a. Carbon	25	45	50	90
b. Wire wound	50	90	125	225
6. Solid-state devices	See Note a			
C. INSULATED CONDUCTORS[b]				
1. Appliance wiring material	25°C (45°F) less than the temperature limit of the wire			
2. Flexible cord – Types SJO, SJT	35	63	35	63
D. ELECTRICAL INSULATION – GENERAL				
1. Fiber used as electrical insulation or cord bushings	25	45	65	117
2. Phenolic composition used as electric insulation or as parts where failure results in a hazardous condition	25	45	125	225
3. Varnished cloth	25	45	60	108
E. GENERAL				
1. Mounting surfaces	25	45	65	117

Table 18.1 Continued on Next Page

Table 18.1 Continued

Device or material	Normal standby, °C	Normal standby, (°F)	Alarm condition, °C	Alarm condition, (°F)
2. Wood or other combustible material	25	45	65	117

[a] The temperature of a solid-state device (e.g., transistor, SCR, integrated circuits), shall not exceed 50 percent of its rating during the "Normal standby" condition. The temperature of a solid-state device shall not exceed 75 percent of its rated temperature under "Alarm condition" or any other condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) shall be considered as 0 percent. For integrated circuits, the loading factor shall not exceed 50 percent of its rating under "Normal standby" condition and 75 percent under any other condition of operation. Both solid-state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:

1) The component complies with the requirements of MIL-STD. 883C.

2) A quality control program is established by the manufacturer consisting of inspection and test of 100 percent of all components, either on an individual basis, or as part of a subassembly, or equivalent.

3) Each assembled production unit is subjected to a burn-in test, under the condition which results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F) followed by a recalibration of the sensitivity and retested.

[b] For standard insulated conductors other than those specified, reference shall be made to the National Electrical Code; the maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.

18.3 All values for temperature rises given in Table 18.1 apply to equipment intended for use with ambient temperatures normally prevailing in occupiable spaces which are not higher than 25°C (77°F) but capable of being as high as 49°C (120°F) occasionally and for brief periods. Tests of equipment for service with such ambient temperatures shall be conducted (without correction) with any ambient temperature in the range of 0 – 49°C (32 – 120°F). When equipment is intended specifically for use with a prevailing ambient temperature constantly more than 25°C (77°F), the test of the equipment is made with such higher ambient temperature, and the allowable temperature rises specified in the table are to be reduced by the amount of the difference between the higher ambient temperature and 25°C (77°F). A temperature is considered to be constant when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change.

18.4 Except at coils, temperatures are to be measured by means of thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2). The preferred method of measuring the temperature of a coil is the thermocouple method; however, a temperature measurement by either the thermocouple or resistance method is not prohibited, except that the thermocouple method is not to be used for a temperature measurement at any point where supplementary thermal insulation is used.

18.5 When thermocouples are used in the determination of temperatures in connection with the heating of electrical devices, it is standard practice to use thermocouples consisting of 30 AWG (0.06 mm^2) iron and constantan wires and a potentiometer-type indicating instrument. Such equipment is to be used whenever referee temperature measurements by thermocouples are required.

18.6 The temperature of a copper coil winding is determined by the resistance method by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature by means of the formula:

$$T = \frac{R}{r}(234.5 + t) - 234.5$$

in which:

T is the temperature to be determined in degrees C;

R is the resistance in ohms at the temperature to be determined;

r is the resistance in ohms at the known temperature; and

t is the known temperature in degrees C.

18.7 A unit is to be connected to a supply circuit of rated voltage and frequency and operated continuously under representative normal service conditions that produce the highest temperature.

18.8 The circuit of a current-regulating resistor or reactor provided as a part of a detector is to be adjusted for the maximum resistance or reactance at normal current.

18.9 The duration of the test-operating condition is to be not less than:

a) Operation until constant temperatures are attained during the normal supervisory condition.

b) Operation for 1 hour during the normal alarm signaling condition of a detector designed to produce a continuous signal until it is restored to normal.

18.10 A transistor shall be operated so as to obtain not more than 50 percent of its rated operating temperature during the normal supervisory condition. The temperature of a solid-state device shall not exceed 75 percent of its rated operating temperature under any condition of operation of the complete unit which produces the maximum temperature dissipation of its components. For reference purposes, 0°C (32°F) shall be considered as 0 percent.

19 Holding Power Test

19.1 The holding power of an electromagnetic door holder shall be measured when the unit is connected to a source of rated voltage, to 85 percent of rated voltage, and also to 110 percent of rated voltage. The minimum force allowable is 15 pounds (67 N) when connected to 85 percent of rated voltage and a maximum of 50 pounds (223 N) when connected to 110 percent of rated voltage.

20 Dielectric Voltage-Withstand Test

20.1 A device shall be capable of withstanding, for 1 minute without breakdown, the application of a 60 hertz alternating potential as follows:

a) Between all live parts and the enclosure or metal mounting surface;

b) Between all live parts and exposed dead-metal parts; and

c) Between live parts of circuits operating at different potentials or at different frequencies, except as indicated in 20.3.

20.2 In 20.1(c), the test potential shall be the value determined by the higher voltage of the different circuits. The test potential shall be:

a) 500 volts for circuits operating at 50 volts or less.

b) 1000 volts plus twice rated voltage for circuits operating at more than 50 volts.

20.3 Exposed dead-metal parts referred to in 20.1 are noncurrent-carrying metal parts which become energized and accessible from outside of the enclosure of a unit during normal operation.

20.4 To determine when a device complies with the requirements of 20.1 – 20.3, it is to be tested by means of a 500 volt-ampere or larger capacity testing transformer, the output voltage of which is capable of being regulated; the wave form of the voltage should approximate a sine wave as closely as possible.

The applied potential is to be increased gradually from zero until the required test value is reached, and is to be held at that value for 1 minute.

20.5 A printed-wiring assembly shall be capable of withstanding without breakdown for a period of 1 minute the application of a direct-current potential as follows:

a) Between printed wiring parts of opposite polarity and

b) Between printed wiring parts of different potential or different frequency.

20.6 In 20.5(b) the test potential shall be the value determined by the higher voltage of the different circuits. The test potential shall be:

a) 500 volts for circuits operating at 50 volts or less where the location and relative arrangement of the parts are such that separation is assured.

b) 1000 volts plus twice the rated voltage for circuits operating at more than 50 volts.

20.7 Rated voltage is the maximum peak potential between the parts measured with the unit connected to a supply circuit of maximum rated voltage as described in 14.4.

21 Abnormal Operation Test

21.1 Failure of electrical components of an electromagnetic fire door holder (such as opening or shorting of a rectifier or capacitor) shall not prevent release of an electromagnet and shall not result in a risk of fire or electric shock.

22 Fire Tests of Swinging Door Closer-Holders With Integral Smoke Detectors

22.1 Corridor test

22.1.1 Each detector integral with a door closer-holder, subjected to the following tests, shall operate for alarm when installed as intended in service and exposed to the following four types of controlled test fires. The maximum response time shall be 4 minutes for Tests A, B, and D, and 3 minutes for Test C. All combustibles shall be ignited with the device as described in 22.6.1. The bottom of the container for all combustibles is to be 3 feet (0.9 m) above the floor. Both the paper and wood brand are to be preconditioned in a relative humidity of 50 ±5 percent at a temperature of 23 ±2°C (73.4±3.0°F) for at least 48 hours prior to the test.

22.2 Paper fire – test A

22.2.1 The following materials and procedures shall be used for the paper fire test:

a) Combustible – Shredded newsprint (black printing only) is to be cut in strips 1/4 to 3/8 inch (6 to 10 mm) wide, 1 to 4 inches (25.4 to 102 mm) long, total weight 1-1/2 oz (42.6 g). The paper is to be poured into the receptacle, see 22.2.1(b), with the bottom covered temporarily by a flat plate. The receptacle is to be tamped periodically during the pouring operation until the paper contents are even with the top of the receptacle. The paper is then to be further tamped by hand or by a rod 1 inch (25.4 mm) in diameter until the paper level is 4 inches (102 mm) below the top edge of the receptacle. A hole 1 inch (25.4 mm) diameter is to be formed through the center from top to bottom of the paper. The temporary bottom plate is then to be removed and the assembly mounted 3 feet (0.9 m) above the floor on a 5 inch (127 mm) diameter ring support.

b) Receptacle – To be formed of 1/32 inch (0.79 mm) thick sheet metal, 4 inches (102 mm) in diameter and 12 inches (0.3 m) high and seamed together, with no air gap at the seam, with support rods at the bottom.

c) Point of Ignition – The probe tips of the igniter are to be placed at the bottom center of the receptacle touching the paper and arcing sustained for up to 5 seconds.

d) Smoke Profile – For this test the following conditions apply:

1) Flame breakthrough shall occur between 1 – 3 minutes.

2) The first principal peak of light obscuration shall occur between 1 – 3 minutes.

3) Smoke shall peak at 10 – 16.8 percent per foot obscuration, 0.046 – 0.080 optical density per foot (0.15 – 0.26 OD/m).

4) There shall be at least 5 – 20 seconds of 4 percent per foot, 0.018 optical density per foot (0.058 OD/m) or higher obscuration.

5) The secondary peak shall not exceed 10 percent per foot obscuration, 0.046 optical density per foot (0.15 OD/m).

6) Length of test shall be 4 minutes.

22.3 Wood fire – test B

22.3.1 The following materials and procedures shall be used for the wood fire test:

a) Combustible[a] – A wood brand formed of three layers of kiln-dried fir strips, each strip 3/4 inch (19.1 mm) square in cross section, 6 inches (152 mm) long with six strips in each layer, is to be used. Wood strips are to be nailed or stapled together with adjacent layers at right angles to each other. Overall dimensions of the wood brand are to be 6 by 6 by 2-1/2 inches (152 by 152 by 64 mm). The brand is to be supported on a 5-inch (127-mm) diameter ring support 3 feet (0.9 m) above the test room floor.

b) Promoter – The wood brand is to be ignited by burning 3 – 5 milliliters of denatured alcohol consisting of 190 proof (95 percent) ethanol to which 5 percent methanol is added as a denaturant. The alcohol is to be placed in a 1-1/2 inch (38 mm) diameter, 1 inch (25.4 mm) deep metal container, the bottom of which is to be 3-1/2 inches (89 mm) below the bottom of the wood brand and centered so that the flame does not break through the top of the wood brand. The container is to be supported by a 1/4 inch (6.4 mm) hardware cloth. The alcohol is to be placed in the container no earlier than 30 seconds prior to ignition.

c) Point of Ignition – Ignition is to be by probes in alcohol. Probe tips of the igniter are to be placed as near the container lip as possible without arcing to the sides.

d) Smoke Profile – For this test the following conditions apply:

1) Smoke buildup shall begin at 80 – 120 seconds.

2) There shall be at least 30 seconds of 4 percent per foot, 0.018 optical density per foot (0.058 OD/m), or higher obscuration.

3) Maximum obscuration shall not exceed 17 percent per foot, 0.081 optical density per foot (0.265 OD/m).

4) Flame breakthrough shall occur at 150 – 190 seconds.

5) Length of test shall be 4 minutes.

[a] Douglas fir, type S4 (smooth on all sides) clear of knots and holes, weight of 1.05 – 1.32 pounds per 10-foot length.

22.4 Gasoline fire – test C

22.4.1 The following materials and procedures shall be used for the gasoline fire test:

a) Combustible – Consists of 50 ml of regular leaded gasoline to be burned in a metal receptacle.

b) Receptacle – Stainless steel, 6-1/4 inches (158 mm) in diameter and 1-1/4 inch (32 mm) deep, the bottom having a 1/2 inch (12.7 mm) rounded base, located 3 feet (0.9 m) above the test room floor and centered with a ring support. The gasoline is to be poured into the receptacle 30 seconds prior to ignition.

c) Point of Ignition – The probe tips of the igniter are to be placed so that they are above the lip of the pan and not extending into the pan. This results in ignition of the vapors above the gasoline.

d) Smoke Profile – For this test the following conditions apply:

1) Smoke buildup shall begin at 20 – 30 seconds.

2) The flame shall not extinguish before 120 seconds.

3) 10 percent per foot obscuration, 0.046 optical density per foot (0.15 OD/m), shall occur at 140 – 160 seconds.

4) Maximum obscuration shall not exceed 17 percent per foot, 0.081 optical density per foot (0.265 OD/m).

5) Length of test shall be 3 minutes.

6) At the termination of the test (180 seconds) smoke buildup shall be between 11 – 15 percent per foot obscuration, 0.051 – 0.071 optical density per foot (0.166 – 0.232 OD/m).

22.5 Polystyrene fire – test D

22.5.1 The following materials and procedures shall be used for the polystyrene fire test:

a) Combustible – Consists of 2 ounces (56.8 g) of foam, polystyrene-type packing material, density between 1.5 – 2.0 lb/ft^3 (24 – 32 kg/m^3), with no flame inhibitor, each piece being a truncated prism 1 inch (25.4 mm) on each side and 1/2 inch (12.7 mm) high.

b) Receptacle – To be formed of 1/4 inch (6.4 mm) mesh hardware cloth, 18 inches (457 mm) high by 6 inches (152 mm) in diameter with a hardware cloth bottom, centered on a ring support. The combustible is to be poured into the receptacle and leveled out.

c) Promoter – The combustible is to be ignited with 5 milliliters denatured alcohol placed in a 4 inch (102 mm) diameter 1-1/2 inch (38 mm) deep metal container under the wire basket. The 4 inch (102 mm) container shall be placed in a larger, 9-inch (230-mm) diameter, container. The containers are to be centered on the support ring upon which the wire-mesh basket rests and placed as close to the bottom of the wire mesh basket as possible allowing for probe placement.

d) Point of Ignition – Alcohol is to be poured over one piece of polystyrene and placed between the probe tips of the igniter in the smaller container 30 seconds prior to ignition. Ignition is to be by a 2 second arc.

e) Smoke Profile – For this test the following conditions apply:

1) Smoke buildup shall occur at 40 – 60 seconds.

2) 10 percent per foot obscuration, 0.046 optical density per foot (0.15 OD/m), shall occur at 210 – 220 seconds.

3) After obtaining 10 percent per foot obscuration, the buildup shall remain between 10 – 16.75 percent per foot, 0.046 – 0.077 optical density per foot (0.15 – 0.25 OD/m).

4) Length of test shall be 4 minutes.

22.6 Igniter assembly

22.6.1 The igniter assembly is to consist of the following or equivalent components:

a) Igniter Probes – The metal probes, 1/4 inch (6.4 mm) diameter and tapered at the ends to form a point and maintained 1/2 inch (12.7 mm) apart, are to be connected to the high-voltage insulated output leads of an oil burner ignition transformer; see 22.6.1(c). Adjustment and support for the probes is to be provided by metal clamps affixed to a vertical steel bar integral with the igniter assembly.

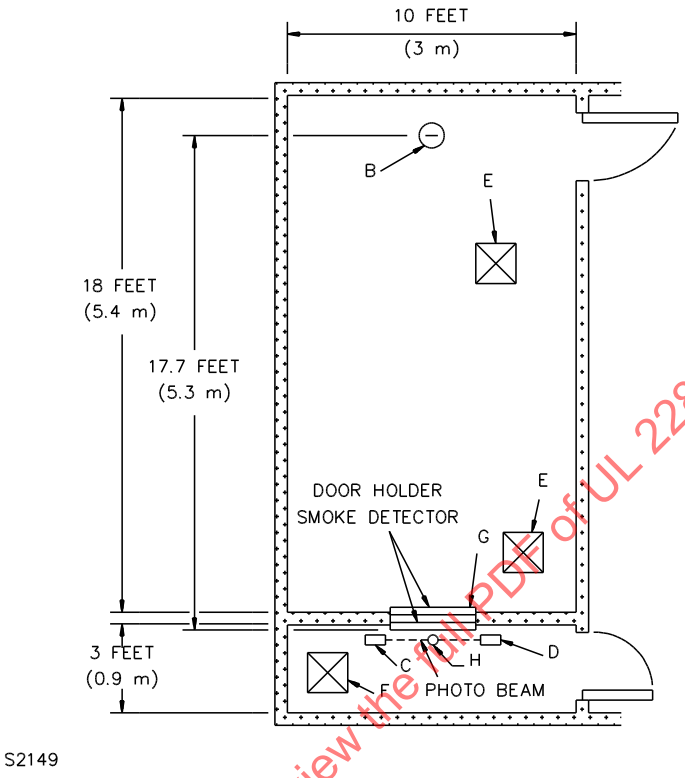
b) Support – A ring clamp, 5 inches (128 mm) diameter is clamped to a ring stand to support the container holding the combustible.

c) Ignition Source – Consists of a 120-volt, 60-hertz primary, 10,000-volt, 23-ma secondary oil burner ignition transformer, the output of which is to be connected to the igniter probes. The arc used for ignition is to be obtained by the closure of a remote, low-voltage, momentary-contact switch which energizes a relay whose contacts control the transformer primary.

22.6.2 The fire tests are to be conducted in an 18 by 10 by 10 foot (5.45 by 3.1 by 3.1 m) corridor having a smooth ceiling with no physical obstructions. Air movement in the test room shall be essentially zero. The distance from the base of the combustible to the ceiling shall be 7 feet (2.1 m). The room is to be provided with a means for the removal of smoke. Heating, humidity, and air conditioning are to be provided for maintaining the room ambient, when required, and are to be shut down during the test trial. All monitoring equipment and personnel shall be located outside the corridor during the test. See Figure 22.1.

Figure 22.1

Corridor layout



A. Fire Test Corridor Dimensions.

1) Length – 22 feet (6.7 m).

2) Width – 10 feet (3.0 m).

3) Ceiling – Height 10 feet (3.0 m) suspended type. Consists of 2 by 4 feet (0.6 by 1.2 m) and by 5/8 inch (15.9 mm) thick incombustible, fissured, mineral-fiber panels.

B. Test Fire

1) 3 feet (0.91 m) above floor.

C. Lamp Assembly – Low-voltage, automotive spotlight-type 4515, rated at 6 volts DC. The distance from the lamp (lens face) to photocell is to be exactly 5 feet (1.52 m). The lamp is to be operated from a regulated voltage supply at 2.40 volts, which yields a lamp color temperature 2373°K±50°K. At that level, the photocell current should be 100 ±25 microamperes into 100 ohms. The lamp shall not cause random meter fluctuations.

D. Photocell Assembly – Selenium barrier layer type, 1.5 inch (38 mm) diameter for active area. Photovoltaic cell active material is sealed against environment. Photocell has a 25 percent maximum deviation from true linearity at 200 foot-candles (2152 lm/m^2) with a 200-ohm load resistance, and has a sensitivity of 4.4 ±0.3 microamperes per foot-candle (0.416 ±0.046 microamperes per lm/m^2) flowing through a 200-ohm load (meter resistance or other). The photocell (in use) is loaded with a nominal 100 ohms, 1 percent load, trimmed with a 5000-ohms, 10-turn potentiometer, and is nominally illuminated at 22 foot-candles (236.7 lm/m^2). Spectral response peak is between 530 and 580 nanometers with 30 percent sensitivity response at 350 and 660 nanometers.

E. Air Supply.

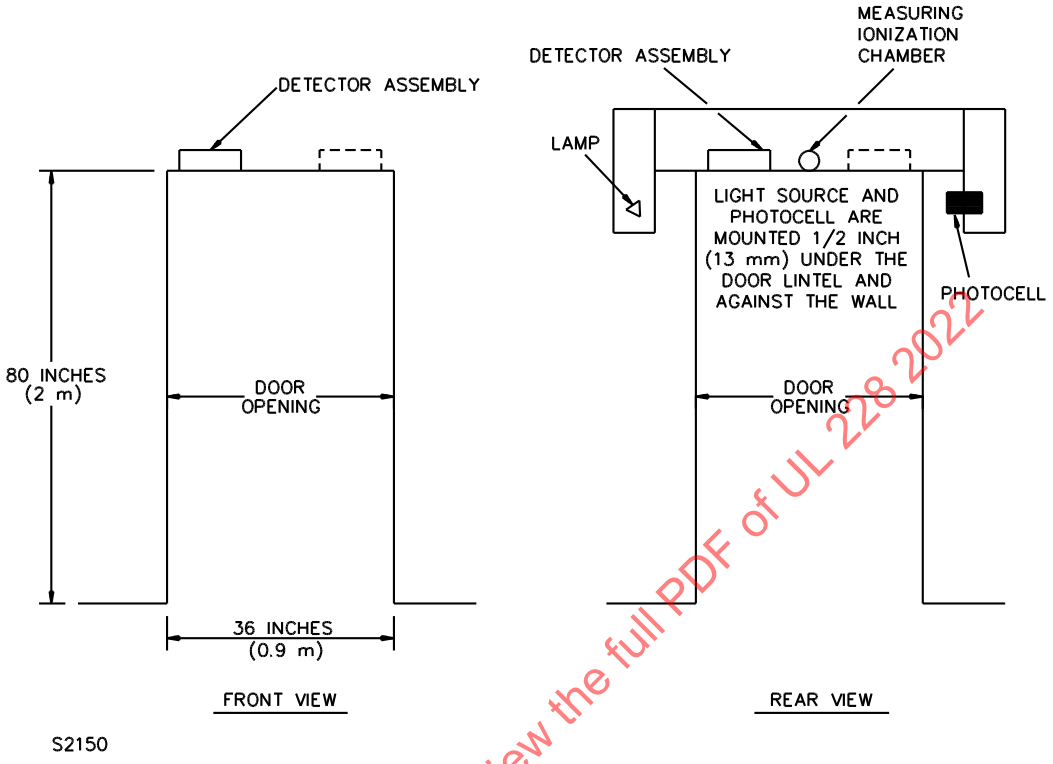
F. Exhaust Vents.

G. Test Panel, Door Mounted Detectors – See Figure 22.2.

H. Measuring Ionization Chamber (MIC), See 23.8.

Figure 22.2

Detector and photobeam mounting for corridor tests



22.6.3 The tests are to be conducted in an ambient temperature between 20.0 and 25.5°C (68 and 78°F) and a relative humidity of 50 ±5 percent. The detector samples are to be energized from a source of supply in accordance with the manufacturer's instructions. The smoke detector sensitivities shall be within ±25 percent of each other.

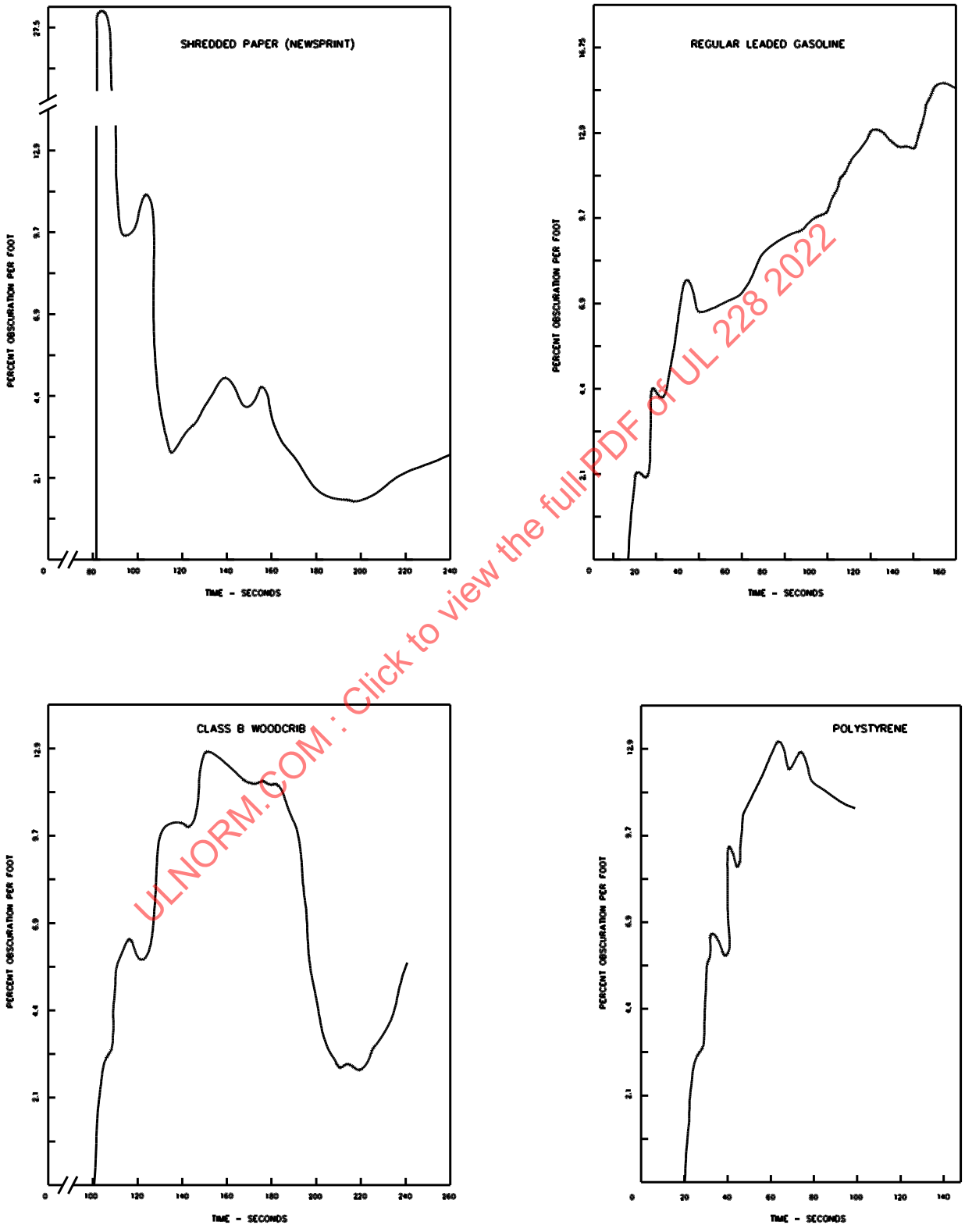
22.6.4 All detector samples, each adjusted to its least sensitive setting, shall respond to each combustible. The test time is to start at ignition. The smoke obscuration level is to be monitored by a photocell/light beam assembly mounted and spaced 5 feet (1.5 m) apart. See notes (c) and (d) to Figure 22.1 for a description of this assembly.

22.6.5 Two samples of door closer-holders with integral smoke detectors are to be mounted on a 36 by 80 inch (0.9 by 2 m) door which is framed in at the exhaust end of the corridor and left open during each test to simulate an actual field installation. The samples are to be installed just above the door lintel, one unit on the front and one on the rear. The detectors shall be staggered so as not to interfere with smoke flow under the lintel, and are to be mounted in their end-use enclosures. See Figure 22.2.

22.6.6 To determine the acceptability of each test fire, the smoke profile curves as described in each fire test shall be obtained for the applicable combustible. For typical profiles, see the smoke profile curves in Figure 22.3.

Figure 22.3

Typical profiles



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22.7 Limited open-area test (optional)

22.7.1 When limited open-area protection is desired, such as may be employed for a hospital room, the following optional fire test may be performed. Each detector shall operate for alarm when installed as intended in service and exposed to the same combustibles used in the Corridor Tests. The maximum response time shall be 4 minutes for Tests A and B, 3 minutes for Test C, and 2 minutes for Test D.

22.8 Paper fire – test A

22.8.1 Same as Test A, 22.2, except for the following smoke profile conditions:

a) Flame breakthrough shall occur between 1 – 3 minutes.

b) The first principal peak of light obscuration shall occur between 1 – 3 minutes.

c) Smoke shall peak at 27 – 37 percent per foot obscuration, 0.136 – 0.2 optical density per foot (0.45 – 0.66 OD/m).

d) There shall be at least 20 – 40 seconds of 4 percent per foot, 0.018 optical density per foot (0.058 OD/m) or higher obscuration.

e) The secondary peak shall not exceed 13 percent per foot obscuration, 0.061 optical density per foot (0.198 OD/m).

f) Length of test shall be 4 minutes.

22.9 Wood fire – test B

22.9.1 Same as Test B, 22.3, except for the following smoke profile conditions:

a) Smoke buildup shall begin at 80 – 120 seconds.

b) There shall be at least 60 seconds of 4 percent per foot, 0.018 optical density per foot (0.058 OD/m), or higher obscuration.

c) Maximum obscuration shall not exceed 17 percent per foot, 0.081 optical density per foot (0.265 OD/m).

d) Flame breakthrough shall occur at 150 – 190 seconds.

e) Length of the test shall be 4 minutes.

22.10 Gasoline fire – test C

22.10.1 Same as Test C, 22.4, except that 30 ml of the combustible are used, and with the following smoke profile conditions:

a) Smoke buildup shall begin at 20 – 30 seconds.

b) The flame shall not extinguish before 120 seconds.

c) 10 percent per foot obscuration, 0.046 optical density per foot (0.15 OD/m), shall occur at 90 – 130 seconds.

d) Maximum obscuration shall not exceed 17 percent per foot, 0.081 optical density per foot (0.265 OD/m).

e) Length of test shall be 3 minutes.

f) At the termination of the test (180 seconds) smoke buildup shall be between 11 – 15 percent per foot obscuration, 0.051 – 0.071 optical density per foot (0.166 – 0.232 OD/m).

22.11 Polystyrene fire – test D

22.11.1 Same as Test D, 22.5, except that 1 ounce (28.4 g) of the combustible is used, and with the following smoke profile conditions:

a) Smoke buildup shall occur at 35 – 45 seconds.

b) 10 percent per foot obscuration, 0.046 optical density per foot (0.15 OD/m), shall occur at 70 – 90 seconds.

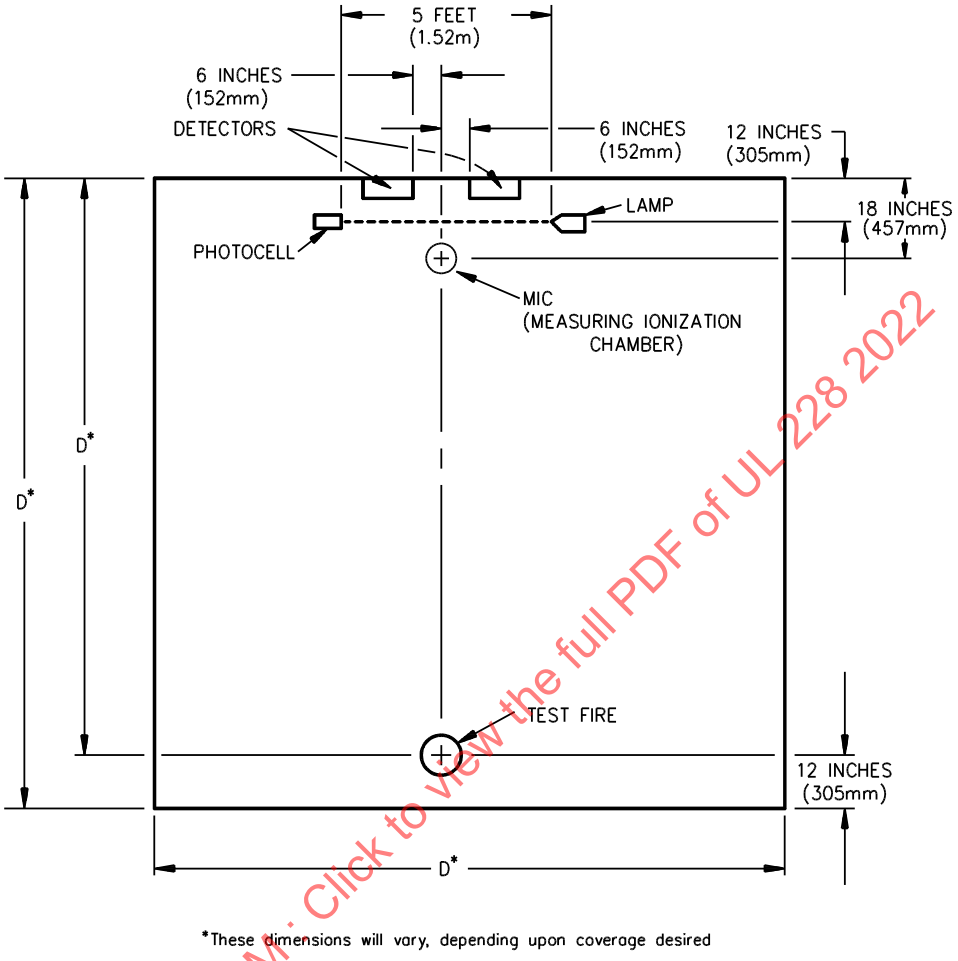
c) After obtaining the 10 percent per foot obscuration, the buildup shall remain between 10 – 13 percent per foot, 0.046 – 0.061 optical density per foot (0.15 – 0.198 OD/m).

d) Length of test shall be 2 minutes.

22.11.2 The limited open-area fire tests are to be conducted in a room having a smooth ceiling with no physical obstructions. Actual room dimensions will vary depending upon coverage desired. Air movement in the test room shall be essentially zero. The distance from the base of the combustible to the ceiling shall be 7 feet (2.1 m). The room is to be provided with humidity, temperature, and smoke removal control. All monitoring equipment and personnel shall be located outside the room during the test. See Figure 22.4.

Figure 22.4

Limited open-area protection test area



*These dimensions will vary, depending upon coverage desired

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