



JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL 2684:2025

STANDARD FOR SAFETY

Video and Thermal Image Detectors for Fire Alarm Systems



SCC FOREWORD

National Standard of Canada

A National Standard of Canada is a standard developed by a Standards Council of Canada (SCC) accredited Standards Development Organization, in compliance with requirements and guidance set out by SCC. More information on National Standards of Canada can be found at www.scc.ca.

SCC is a Crown corporation within the portfolio of Innovation, Science and Economic Development (ISED) Canada. With the goal of enhancing Canada's economic competitiveness and social well-being, SCC leads and facilitates the development and use of national and international standards. SCC also coordinates Canadian participation in standards development, and identifies strategies to advance Canadian standardization efforts.

Accreditation services are provided by SCC to various customers, including product certifiers, testing laboratories, and standards development organizations. A list of SCC programs and accredited bodies is publicly available at www.scc.ca.

UL Standard for Safety for Video and Thermal Image Detectors for Fire Alarm Systems, ANSI/CAN/UL 2684

First Edition, Dated June 12, 2024

Summary of Topics

This revision of ANSI/CAN/UL 2684 dated August 22, 2025 includes Stability Test Correction, [34.4](#).

Text that has been changed in any manner or impacted by ULSE'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 April 18, 2025 and July 11, 2025.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of ULSE Inc. (ULSE).

ULSE provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will ULSE be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if ULSE or an authorized ULSE representative has been advised of the possibility of such damage. In no event shall ULSE's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

Users of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold ULSE harmless from and against any loss, expense, liability, damage, claim, or judgment (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

No Text on This Page



ANSI/UL 2684-2025



JUNE 12, 2024

(Title Page Reprinted: August 22, 2025)

1

ANSI/CAN/UL 2684:2025

Standard for Video and Thermal Image Detectors for Fire Alarm Systems

First Edition

June 12, 2024

This ANSI/CAN/UL Safety Standard consists of the First Edition including revisions through August 22, 2025.

The most recent designation of ANSI/UL 2684 as an American National Standard (ANSI) occurred on August 22, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This standard has been designated as a National Standard of Canada (NSC) on August 22, 2025.

© 2025 ULSE Inc. All rights reserved.

No Text on This Page

CONTENTS

Preface	7
---------------	---

INTRODUCTION

1 Scope	9
2 Assembly	10
3 Components	10
4 Units of measurement	10
5 Referenced publications	11
6 Glossary	12
7 Detector Reliability Prediction	14
8 Manufacturer's Published Instructions	15

CONSTRUCTION

ASSEMBLY

9 General	15
9.1 Remote accessories	15
9.2 Maintenance (field cleaning)	15
10 Power Over Ethernet (PoE)	15
11 Servicing and Maintenance Protection	16
12 Enclosures	17
12.1 General	17
12.2 Cast metal enclosures	17
12.3 Sheet metal enclosures	18
12.4 Nonmetallic enclosures	20
12.5 Ventilating openings	20
12.6 Covers	20
12.7 Glass panels	21
13 Corrosion Protection	22
14 Field Wiring Connections	23
14.1 General	23
14.2 Field wiring compartment	23
14.3 Field-wiring terminals (general)	23
14.4 Special field-wiring terminals (qualified application)	24
14.5 Field wiring leads	25
14.6 Grounding terminals and leads	25
14.7 Grounded supply terminals and leads	26
14.8 Isolated (nongrounded) detectors	26
15 Internal Wiring	27
15.1 General	27
15.2 Wireways	27
15.3 Splices	27
15.4 Barriers	28
15.5 Strain relief	28
16 Bonding for Grounding	28

COMPONENTS

17 General	29
17.1 Mounting of components	29

17.2	Operating components	29
17.3	Current-carrying parts	30
18	Bushings	30
19	Electrical Insulating Material	30
20	Visual Indicators	31
21	Motors	32
22	Protective Devices	32
23	Printed Wiring Boards	32
24	Switches	33
25	Transformers and Coils	33
26	Dropping Resistors	33
27	Batteries	33
27.1	General	33
27.2	Battery connections	34
28	Spacings	34

PERFORMANCE

29	General	36
29.1	Test units	36
29.2	Accessories	36
29.3	Test voltages	36
29.4	Test samples and data	37
29.5	Component reliability data	37
29.6	Detector guards	37
29.7	Indoor test conditions	38
29.8	Tests and analysis	38
30	Normal Operation Test	38
30.1	General	38
30.2	Response time ratio	39
31	Supervision Test	40
31.1	Electrical	40
31.2	Camera lens monitoring (video smoke and flame detectors only)	40
32	Sensitivity Test	41
32.1	General	41
32.2	Baseline test procedure	41
32.3	Thermal imaging camera response test	42
32.4	Uniformity of operation	43
33	Field of Detection Test	43
34	Stability Test	43
35	Fire Tests	44
36	Flaming Fires	47
36.1	Paper fire	47
36.2	Flaming wood fire	50
36.3	Flammable liquid fire	52
36.4	Flaming polyurethane foam test	53
37	Smoldering Fire Tests	57
37.1	Smoldering polyurethane foam test	57
37.2	Smoldering wood smoke test	59
38	Circuit Measurement Test	62
38.1	General	62
38.2	Battery trouble voltage determination	63
39	Overvoltage and Undervoltage Tests	64
39.1	Overvoltage test	64
39.2	Undervoltage test	65
40	Temperature Test	65

41	Vibration Test	68
42	Jarring Test	69
43	Variable Ambient Temperature Test	70
	43.1 Operation in high and low ambients	70
	43.2 Effect of shipping and storage	71
44	Humidity Test	71
45	Corrosion Tests	71
46	Alternate Corrosion Test (21 day)	72
47	Transient Tests	72
	47.1 General	72
	47.2 Internally induced transients	73
	47.3 Extraneous transients	73
	47.4 Supply line (ring wave surge voltage) transients	75
	47.5 Supply line (extra-low-voltage circuit) transients	75
48	Static Discharge Test	75
49	Overload Tests	76
	49.1 Detector	76
	49.2 Separately Energized Circuits	76
50	Endurance Test	77
51	Abnormal Operation Test	77
52	Locked Rotor Test – Motors	77
53	Dielectric Voltage-Withstand Test	78
54	Polarity Reversal Test	78
55	Tests on Polymeric Materials	79
	55.1 General	79
	55.2 Mold stress distortion	79
	55.3 Flammability	79
56	Strain Relief Test	79
	56.1 General	79
	56.2 Special field-wiring terminals	79
57	Survivability Test	80
58	Go/No-Go Field Test (Functional Test)	80
59	Battery Tests	80
60	Firmware Update (If Provided)	81
61	Conformal Coatings on Printed Wiring Boards	82
	61.1 General	82
	61.2 Low voltage printed wiring boards	83
	61.3 High voltage printed wiring boards	85
62	Evaluation of Reduced Spacings on Printed-Wiring Boards	85

MANUFACTURING AND PRODUCTION

63	General	86
64	Production Line Dielectric Voltage-Withstand Tests	86

MARKINGS

65	General	87
----	---------------	----

INSTRUCTIONS

66	Manufacturer's Published Instructions	89
	66.1 General	89
	66.2 RF Equipment	91
67	Technical Bulletin	91



ANNEX A (Normative) – RELIABILITY PREDICTION AND CRITERIA FOR ACCEPTANCE**INSTRUCTIONS FOR DETERMINING A RELIABILITY PREDICTION OF ELECTRONIC COMPONENTS AND MICROELECTRIC CIRCUITS**

A1	Methods of Determining Failure Rate.....	93
----	--	----

CRITERIA FOR ACCEPTANCE OF MICROELECTRONIC DEVICES

A2	General.....	102
A3	Part 1 – Quality Assurance Screening Program.....	102
A4	Part II – Determination of Failure Rate Number Supplemented by Burn-In Test.....	104
A4.1	General	104
A4.2	Determination sequence	104
A4.3	Test calculations and procedures.....	104
A4.4	Test conditions	106
A4.5	Failure rate number calculation.....	107

ANNEX B (Informative) – POWER OVER ETHERNET (PoE) REFERENCE

B1	Definitions	110
B2	Ratings (Per Pair)	110

ANNEX C (Informative) – ALARM POWER CONSUMPTION MEASUREMENTS**ANNEX D (Informative) – STANDARDS FOR COMPONENTS****ANNEX E (Normative) – FRENCH TRANSLATIONS OF REQUIRED MARKINGS**

Preface

This is the First Edition of ANSI/CAN/UL 2684, Standard for Video and Thermal Image Detectors for Fire Alarm Systems.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

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

This ANSI/CAN/UL 2684 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and 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.

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

Our Standards for Safety are copyrighted by ULSE Inc. Neither a printed nor electronic copy of a Standard should be altered in any way. All of our Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of ULSE Inc.

This Edition of the Standard has been formally approved by the Technical Committee (TC) on Video and Thermal Image Detectors for Fire Alarm Systems, TC 2684.

This list represents the TC 2684 membership when the final text in this Standard was balloted. Since that time, changes in the membership may have occurred.

TC 2684 Membership

Name	Representing	Interest Category	Region
Maggy Baetens	ARAANI	Producer	Belgium
Thomas Cleary	National Institute Of Standards & Technology	Government	USA
Joshua Dinaburg	CSA Group	Testing & Standards Org.	USA
Jeremy Dusing	Fire Rover LLC	Producer	USA
Brent Early	Province of Manitoba	General Interest	Canada
Grayson Flake	UL Standards & Engagement	TC Project Manager – Non-voting	USA
Daniel M. Grosch	Standards Individual	General Interest	USA
Diane Haithcock	UL Standards & Engagement	TC Chair – Non-voting	USA
Rick Jeffress	Fike Corporation	Producer	USA

TC 2684 Membership Continued on Next Page

TC 2684 Membership Continued

Gerry Landmesser	Retired, Director Canadian Fire Alarm Association	General Interest	Canada
Scott Lang	Honeywell International INC	Supply Chain	USA
William Liang	Applus + / QPS Evaluation Services	Testing & Standards Org.	Canada
Dave Mills	UL Solutions	Testing & Standards Org.	USA
Faheemuddin Mohammed	Emirates Safety Laboratory	Testing & Standards Org.	UAE
Mark Peters	Westinghouse Electric Company of Canada	General Interest	Canada
Maheshkumar Shaji	Dubai Airports	Consumer	UAE
Kevin Sein	Intertek	Testing & Standards Org.	USA
Alex Stratis	Standards Individuals	Supply Chain	Canada
Soeren Wittmann	Bosch Sicherheitssysteme GmbH	Producer	Germany
Iman Yavari	SenezCo – Fire Science & Engineering	Commercial / Industrial User	Canada

International Classification for Standards (ICS): 13.220.01, 13.220.20

For information on ULSE Standards, visit <https://www.shopulstandards.com>, call toll free 1-888-853-3503 or email us at ClientService@shopULStandards.com.

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 sets forth requirements for video and thermal image fire detectors and accessories for non-dwelling units, including mechanical guards to be employed in indoor locations (for video and thermal) and outdoor (for thermal) in accordance with the following:

a) In the United States:

- 1) National Fire Alarm and Signaling Code, NFPA 72;
- 2) National Electrical Code, NFPA 70.

b) In Canada:

- 1) Standard for the Installation of Fire Alarm Systems, ULCS-S524;
- 2) National Building Code of Canada; and
- 3) National Fire Code of Canada.

1.2 A detector as covered by this standard consists of an assembly of electrical and mechanical components to sense:

- a) Smoke in the visible and/or infrared wavelengths; and/or
- b) Flame in the visible and/or infrared wavelengths; and/or
- c) Heat in the infrared wavelengths.

The heat, smoke, and flame are sensed using a focal plane array (imager). The detector includes provision for the connection to a source of power, signaling, and optional remote-control circuits. Additional functionality is permitted to be incorporated as part of the detector assembly.

1.3 This standard covers detectors intended for open area protection and for connection to a compatible power supply or control unit for operation as part of a fire alarm system.

1.4 This standard does not cover the following:

a) In the United States (1) – (7):

- 1) Single pixel/integrating (non-imaging) flame detectors;
- 2) Wildfire detectors;
- 3) Control units to which the detectors are intended to be connected that are covered by the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864;
- 4) Self-contained single and multiple station smoke alarms, not intended for connection to a system control unit, that are covered by the Standard for Smoke Alarms, UL 217;
- 5) A gas and vapor detector or sensor incorporated as a part of a smoke detector assembly, and covered by the Standard for Gas and Vapor Detectors and Sensors, UL 2075;
- 6) Commercial-residential detectors not intended for connection to a system control unit that are covered by the Standard for Smoke Detector Monitors and Accessories for Individual Living Units of Multifamily Residences and Hotel/Motel Rooms, UL 1730;

7) Detectors for monitoring the smoke density within flues or stacks.

b) In Canada (1 – 6):

1) Single pixel/integrating (non-imaging) flame detectors;

2) Wildfire detectors;

3) Control units that are covered by the Standard for Control Units and Accessories for Fire Alarm Systems, ULC 527;

4) Self-contained single and multiple station smoke alarms that are covered by the Standard For Smoke Alarms, ULC-S531;

5) A heat detector incorporated as a part of a smoke detector assembly, and covered by the Standard For Heat Actuated Fire Detectors for Fire Alarm Systems, ULC-S530 and/or when part of a multi-criteria smoke detector;

6) Detectors for monitoring the smoke density within flues or stacks.

1.5 These requirements also cover all remote accessories that are intended to be connected to a detector.

2 Assembly

2.1 A detector shall be so constructed that it will be reliable and sufficiently durable for its intended installation and use.

2.2 A component of a detector shall comply with the requirements for that component, except that such requirements may be modified for the particular application.

3 Components

3.1 Except as indicated in [3.2](#), a component of a product covered by this standard shall comply with the requirements for that component. See Annex [D](#) for a list of standards covering components generally used in the products covered by this standard.

3.2 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 statement; or

b) Is superseded by a requirement in this standard.

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

3.4 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.

4 Units of measurement

4.1 The metric unit shall be designated as the official unit for purposes of this standard. Where values of measurement are specified in both SI and English units, either unit is used. In cases of dispute, the metric unit shall be used.

5 Referenced publications

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 The following publications are referenced in this Standard:

ASTM MNL12, *Manual on the Use of Thermocouples in Temperature Measurement* – Edition 4

CSA C22.1, *Canadian Electrical Code, Part I, Safety Standard for Electrical Installations*

CSA C22.2 No. 0.17, *Evaluation of Properties of Polymeric Material*

CSA C22.2 No. 77-95, *Motors with Inherent Overheating Protections*

CSA C22.2 No. 65, *Wire Connectors*

CSA C22.2 No. 153, *Quick-Connect*

CSA C22.2 No. 158, *Terminal Blocks*

Department of Justice, Canada, Nuclear Safety and Control Act (S.C. 1997, c.9)

IEEE C62.41, *IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits*

IEEE 802.3af, *Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications – Data Terminal Equipment (DTE) Power Via Media Dependent Interface (MDI)*

IEEE 802.3at, *Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications – Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements*

MIL-HDBK-217F (2) – February 2, 1995, *Reliability Prediction of Electronic Equipment*

MIL-STD-883B, *Microcircuits*

National Research Council of Canada, National Building Code of Canada

National Research Council of Canada, National Fire Code of Canada

NFPA 70, *National Electrical Code*

NFPA 72, *National Fire Alarm and Signaling Code*

TIA-568-C.2, *Balanced Twisted-Pair Telecommunications Cabling and Components*

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 217, *Smoke Alarms*

UL 310, *Electrical Quick-Connect Terminals*

UL 486A-486B, *Wire Connectors*

UL 486E, *Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors*

UL 506, *Specialty Transformers*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 746E, *Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used In Printed-Wiring Boards*

UL 864, *Control Units and Accessories for Fire Alarm Systems*

UL 1059, *Terminal Blocks*

UL 1730, *Smoke Detector Monitors and Accessories for Individual Living Units of Multifamily Residences and Hotel/Motel Rooms*

UL 2075, *Gas and Vapor Detectors and Sensors*

UL 2111, *Overheating Protection for Motors*

UL 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

UL 62368-1, *Audio/Video, Information Technology and Communication Technology Equipment – Part 1: Safety Requirements*

ULC-S524, *Installation of Fire Alarm Systems*

ULC 527, *Control Units and Accessories for Fire Alarm Systems*

ULC-S530, *Heat Actuated Fire Detectors for Fire Alarm Systems*

ULC-S531, *Smoke-Alarms*

ULC-S536, *Inspection and Testing of Fire Alarm Systems*

ULC-S537, *Verification of Fire Alarm Systems*

ULC-S545, *Residential Fire Warning System Control Units*

6 Glossary

6.1 For the purpose of this standard the following definitions apply.

6.2 **ALARM SIGNAL** – A signal intended to indicate an emergency condition that requires immediate action, such as a signal indicative of fire.

6.3 ANNUNCIATOR – A unit containing one or more indicator lamps, alphanumeric displays, or other equivalent means in which each indication provides status information about a circuit, condition, or location.

6.4 RELIABLE COMPONENT – A component that is not expected to fail or be periodically replaced and is not monitored. A reliable component shall have a predicted failure rate of 2.5 or less failures per million hours as determined for a "Ground Fixed" (GF) environment by MIL-HDBK 217, or equivalent (see Annex A).

6.5 CONFORMAL COATING – A protective covering applied on a printed-wiring board capable of conforming to the configuration of objects coated, used to increase the dielectric voltage-withstand capability between conductors and/or to protect against environmental conditions. Conformal coatings may be used on printed wiring boards where electrical spacing's are insufficient between uninsulated live parts of opposite polarity or between such parts and accessible dead-metal parts.

6.6 DETECTOR – A video image smoke detector, video image flame detector, or thermal image fire detector consistent with the scope of this standard. The detector may be battery operated or direct wired via terminals, use a plug-in terminal block, or plug into a separate mounting plate/base.

6.7 FIRMWARE – For the purpose of this standard, software programs residing permanently on a microprocessor or in a non-volatile memory chip within smoke alarm and accessory devices.

6.8 FIELD OF VIEW (FOV) – The image displayed of the cameras output.

6.9 FIELD OF DETECTION – The detection area within the field of view (FOV) of coverage in which the manufacture specifies detection is to be intended.

6.10 LOW BATTERY TROUBLE POINT – Any combination of battery voltage and series resistance that results in an audible trouble signal from a battery-operated detector.

6.11 MANUFACTURER'S PUBLISHED INSTRUCTIONS – Published installation and operating documentation provided for each product or component. The documentation includes directions and necessary information for the intended installation, maintenance, and operation of the product or component.

(Reproduced with permission from NFPA 72®-2022, National Fire Alarm and Signaling Code® Copyright © 2015, National Fire Protection Association. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety which may be obtained from the NFPA website at www.nfpa.org.)

(NFPA 72® and National Fire Alarm and Signaling Code® are registered trademarks of the National Fire Protection Association, Inc., Quincy, MA.)

6.12 POWER OVER COMMUNICATIONS CABLES (POWER OVER ETHERNET) – A means to supply DC power to a network device over communications cabling. The power supplied to the device may or may not be on the same conductors supporting data.

6.13 POWER INJECTOR – Power Sourcing Equipment (PSE) similar to a midspan device, comprising three ports. These are:

- a) Data in, typically from a network switch;
- b) Data and power – nominal 48 or 53 VDC out; and
- c) Line voltage from a utility supply.

6.14 POWER SOURCING EQUIPMENT (PSE) – The power supply that provides DC power to the powered device (PD) through the communications cabling. It may be an endspan device, such as an enabled network switch, or a midspan device that is located in between the network switch and the powered device.

6.15 RISK OF ELECTRIC SHOCK – A risk of electric shock exists at any part when:

- a) The potential between the part and earth ground or any other accessible part is more than 42.4 volts peak; and
- b) The continuous current flow through a 1500 ohm resistor connected across the potential exceeds 0.5 milliamperes.

6.16 RISK OF FIRE – A risk of fire exists at any point in a circuit where:

- a) The open circuit voltage is more than 42.4 volts peak and the energy available to the circuit under any condition of load including short circuit, results in a current of 8 amperes or more after 1 minute of operation; or
- b) A power of more than 15 watts shall only be delivered in an external resistor connected between the two points.

6.17 DETECTOR RESPONSE TIME – The time it takes a detector to detect the fires described in Section [35](#), Fire Tests.

6.18 TROUBLE SIGNAL – A signal initiated by the fire alarm system or device indicative of a fault in a monitored circuit or component.

6.19 VOLTAGE CLASSIFICATION – Unless otherwise indicated, all voltage and current values specified in this standard are root-mean-square (rms).

- a) Extra-Low-Voltage Circuit – A circuit classified as extra-low-voltage is one involving a potential of not more than 30 volts alternating current (AC) [42.4 volts peak or direct-current (DC)], and supplied from a circuit whose power is limited to a maximum of 100 volt-amperes (VA).
- b) Hazardous-Voltage Circuit – A circuit having characteristics in excess of those of an extra-low-voltage circuit.

7 Detector Reliability Prediction

7.1 Detectors shall be constructed to a maximum failure rate of 4.0 failures per million hours as calculated by a full part stress analysis prediction as described in Section 2.0 of MIL-HDBK 217 or 3.5 failures per million hours as calculated by a simplified parts count reliability prediction as described in Section 3.0 of MIL-HDBK 217, or equivalent. See Annex [A](#). A “Ground Fixed” (GF) environment is to be used for all calculations. When actual equivalent data is available from the manufacturer, it is permissible that it be used in lieu of the projected data for the purpose of determining reliability.

7.2 A component is not required to be included in the failure rate calculation in the event of a failure as a result of any of the following conditions:

- a) Energization of an audible trouble signal;
- b) Energization of a separate visual indication (orange or yellow);
- c) De-energization of a power-on light;

- d) Does not affect the normal operation; or
- e) Is evaluated by specific performance tests included in this Standard.

Examples of components include but are not limited to the audible signal appliance, non-compulsory thermostat, test switch, and battery contacts.

7.3 An application specific integrated circuit (ASIC) employed in a detector shall have a predicted failure rate of not greater than 2.5 failures per million hours. The failure rate is to be determined through evaluation of data in a 3000 hours burn-in test, or equivalent.

7.4 An integral or remote accessory is not required to be included in the reliability prediction except for those components whose failure affects the normal operation of the alarm.

8 Manufacturer's Published Instructions

8.1 A copy of the manufacturer's published instructions, which includes installation and operating instructions, related schematic wiring diagrams and installation drawings shall be used as a reference in the examination and test of the detector. For this purpose, a printed edition is not required. It is permissible that the information be included in a manual or technical bulletin. See Section [65](#), Markings, General; Section [66](#), Manufacturers Published Instructions; and Section [67](#), Technical Bulletin.

8.2 The manufacturer's published instructions and drawings shall include such directions and information as deemed by the manufacturer to be required for proper installation, testing, maintenance, operation, and use of the detector.

CONSTRUCTION

ASSEMBLY

9 General

9.1 Remote accessories

9.1.1 Unless specifically indicated otherwise, the construction requirements specified for a detector shall apply also for any remote accessories with which it is to be employed.

9.2 Maintenance (field cleaning)

9.2.1 If recommended by the manufacturer, the detector shall be cleaned without:

- a) Degradation of performance, when tested in accordance with [30.2](#); and
- b) Disturbance of field wiring.

9.2.2 The procedures in [9.2.1](#) shall be described in the manufacturer's published instructions.

10 Power Over Ethernet (PoE)

10.1 This section provides requirements for the evaluation of power over ethernet (PoE) devices. Power sources (injectors) may be provided integral with the equipment or as a separate device supplying power.

10.2 The equipment is intended to comply with the following sections of the National Electrical Code, NFPA 70:

a) Where the power supplied over a communications cable is less than or equal to 60 watts: NFPA 70 – Article 725.121, Power Sources for Class 2 and Class 3 Circuits; or

b) Where the power supplied over a communications cable is greater than 60 watts: NFPA 70 – Article 725.144, Transmission of Power and Data.

10.3 The power sourcing equipment (PSE) shall comply with UL 60950-1, and/or UL 62368-1, as well as meeting the requirements of this Standard. Powered Devices (PD) shall comply with this Section, as well as all other applicable requirements of this Standard.

10.4 These requirements apply to all connected equipment and interconnections necessary to ensure normal operation of the network powered system.

10.5 A power over communications circuit shall be power-limited and shall not exceed 60 V DC, 8.0 amperes, and/or 100 watts.

10.6 Products shall be evaluated at the marked input/output circuit ratings.

11 Servicing and Maintenance Protection

11.1 An uninsulated live part of a hazardous voltage circuit and hazardous moving parts that present a risk of injury to persons within the enclosure shall be located, guarded, or enclosed to reduce the risk of unintentional contact by persons performing service functions performed with the equipment energized.

11.2 Manual switching devices may be located or oriented with respect to uninsulated live parts or hazardous moving parts so that manipulation of the mechanism can be accomplished in the normal direction of access if uninsulated live parts or hazardous moving parts are not located in front (in the direction of access) of the mechanism, or not located within 150 mm of any side or behind the mechanism, unless guarded.

11.3 In determining compliance with [11.2](#) only exposed uninsulated hazardous-voltage circuits shall be considered.

11.4 An electrical control component, which may require examination, adjustment, servicing, or maintenance while energized (excluding voltage measurements except for jacks or terminals specifically intended for that purpose), shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for electrical service functions without subjecting persons to the likelihood of shock hazard from adjacent uninsulated live parts or to accidental hazard from adjacent hazardous moving parts.

11.5 Other arrangements of location of components and/or guarding shall be also acceptable where electrical components are accessible for service as indicated by [11.4](#).

11.6 The following are not identified as uninsulated live parts:

- a) Coils of controllers, relays, and solenoids, and transformer windings, when the coils and windings are provided with appropriate insulating overwraps;
- b) Enclosed motor windings;
- c) Terminals and splices with insulation appropriate to the application; and
- d) Insulated wire.

11.7 An assembled part intended to be removed during installation shall be protected against damage from normal handling.

12 Enclosures

12.1 General

12.1.1 The enclosure of a detector shall be constructed to resist the abuses encountered in service. The degree of resistance to abuse inherent in the detector shall preclude total or partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other serious defects, which alone or in combination result in an increase in the risk of fire, electric shock, or injury to persons.

12.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two shall be evaluated in determining compliance with the requirement specified in [12.1.1](#).

12.1.3 All electrical parts of a detector shall be enclosed to reduce the risk of contact with uninsulated live parts. A separate enclosure for field-wiring terminals that are intended to be enclosed by a back box is not required. An electrical part of a sampling chamber may be exposed if contact with such part does not result in a hazard or affect the operation of the detector or system supervision.

12.1.4 The enclosure of a detector shall be provided with means for mounting in the intended manner. Any fittings, such as brackets or hangers, required for mounting shall be furnished with the detector. The mounting means shall be accessible without disassembling any operating part of the detector. The removal of a completely assembled panel, cover, or equivalent, to mount the detector is not identified as disassembly of an operating part.

12.1.5 An enclosure shall have provision for the connection of metal-clad cable, non-metallic sheathed cable, or conduit. A detector intended for permanent connection only to a wiring system other than metal-clad cable or conduit shall be marked to indicate the system or systems for which it is suitable. The marking shall be so located that it will be visible when power-supply connections to the detector are made, or may appear on the installation wiring diagram.

NOTE: An enclosure without provision for such connection may be acceptable if the unit is intended for mounting on an outlet box.

12.2 Cast metal enclosures

12.2.1 The thickness of cast metal used for an enclosure shall be as indicated in [Table 12.1](#).

12.2.2 Cast metal having a thickness 0.8 mm (1/32 inch) less than that indicated in [Table 12.1](#) shall be employed only when the surface under consideration is curved, ribbed, or otherwise reinforced, or when the shape of the surface, size of the surface, or both, are such that equivalent mechanical strength is determined to be provided.

Table 12.1
Cast Metal Enclosures

Use or dimensions of area involved	Minimum thickness			
	Die-cast metal		Cast metal of other than the die-cast type	
	mm	(inch)	mm	(inch)
Area of 155 cm ² (24 square inches) or less and having no dimension greater than 152 mm (6 inches)	1.6	(1/16 ^a)	3.2	(1/8)
Area greater than 155 cm ² (24 square inches) or having any dimension greater than 152 mm (6 inches)	2.4	(3/32)	3.2	(1/8)
At a threaded conduit hole	6.4	(1/4)	6.4	(1/4)
At an unthreaded conduit hole	3.2	(1/8)	3.2	(1/8)
^a The area limitation for metal 1.6 mm (1/16 inch) thick is obtained by the provision of reinforcing ribs subdividing a larger area.				

12.2.3 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than 3.5 nor more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing can be properly attached.

12.2.4 When threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

12.3 Sheet metal enclosures

12.3.1 The thickness of sheet metal employed for the enclosure of a detector shall not be less than that indicated in [Table 12.2](#), except that sheet metal of two gage sizes lesser thickness shall be employed only when the surface under consideration is curved, ribbed, or otherwise reinforced, or when the shape of the surface, the size of the surface, or both, are such that equivalent mechanical strength is determined to be provided.

Table 12.2
Sheet Metal Enclosures

In the United States												
Maximum dimensions of enclosure				Maximum thickness of sheet metal								
Length or width		Area		Steel, zinc-coated			Steel, uncoated			Brass, aluminum		
mm	(in)	cm ²	(in ²)	mm	(in)	GSG	mm	(in)	GSG	mm	(in)	AWG
305	(12)	581	(90)	0.86	(0.034)	20	0.81	(0.032)	20	1.14	(0.045)	16
610	(24)	2322	(360)	1.14	(0.045)	18	1.07	(0.042)	18	1.47	(0.058)	14
1219	(48)	7742	(1200)	1.42	(0.056)	16	1.35	(0.053)	16	1.91	(0.075)	12
1524	(60)	9678	(1500)	1.78	(0.070)	14	1.70	(0.067)	14	2.41	(0.095)	10
1524	(Over 60)	9678	(Over 1500)	2.46	(0.097)	12	2.36	(0.093)	12	3.1	(0.122)	8
In Canada												
Maximum enclosure dimensions				Minimum thickness of sheet metal								
				Steel				Aluminum		Brass		
Length or width (mm)		Area of any surface (cm ²)		Zinc-coated (mm)		Uncoated (mm)		(mm)		(mm)		
(305)		(580)		(1.0)		(1.0)		(1.2)		(1.2)		
(610)		(2320)		(1.2)		(1.2)		(1.6)		(1.6)		
(1220)		(7740)		(1.6)		(1.6)		(2.0)		(2.0)		
(1524)		(9670)		(2.0)		(2.0)		(2.5)		(2.5)		
(Over 1524)		(Over 9670)		(2.8)		(2.8)		(3.5)		(3.5)		

12.3.2 At any point where conduit or metal-clad cable is to be attached, sheet metal shall have a thickness in accordance with the following:

- a) In the United States: Sheet metal shall have a thickness not less than 0.032 inch (0.81 mm) when of uncoated steel, not less than 0.034 inch (0.86 mm) when of galvanized steel, and not less than 0.045 inch (1.14 mm) when of nonferrous metal.
- b) In Canada: Sheet metal shall be of such thickness or shall be so formed or reinforced that it will have a stiffness at least equivalent to that of an uncoated, flat, sheet steel having a minimum thickness of 1/16 inch (1.6 mm).

12.3.3 A ferrous plate or plug closure for an unused conduit opening or other hole in the enclosure shall have a thickness not less than 0.027 inch (0.69 mm) or 0.032 inch (0.81 mm) nonferrous metal for a hole having a 1-3/8 inches (34.9 mm) diameter maximum dimension.

12.3.4 A closure for a hole larger than 1-3/8 inches (35 mm) diameter shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted. See [17.1](#), Mounting of Components.

12.3.5 A knockout in a sheet metal enclosure shall be secured and shall be capable of being removed without excessive deformation of the enclosure.

12.3.6 A knockout shall be provided with a surrounding surface for seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout used during installation does not result in spacings between uninsulated live parts and the bushing of less than those indicated in Spacings, Section [28](#).

12.4 Nonmetallic enclosures

12.4.1 An enclosure or parts of an enclosure of nonmetallic material shall be formed so that operating parts are protected against damage. The mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in [Table 12.2](#). See also the Tests on Polymeric Materials, Section [55](#).

12.4.2 The continuity of any grounding system intended for a detector connection shall not rely on the dimensional integrity of the nonmetallic material.

12.4.3 Polymeric material used for an enclosure shall comply with the following requirements:

- a) Enclosures containing parts including a risk of fire – minimum flammability rating of 5VA or V-0;
- b) Enclosures containing power limited circuits with a voltage not exceeding 30 volts AC, 42.4 volts-peak, or 60 volts DC – minimum flammability rating of V-2 or HB; and
- c) Enclosures containing circuits powered by sources with energy limited to 15 watts – minimum flammability rating of HB.

Flammability ratings are defined: in the United States in UL 94; and in Canada in CSA C22.2 No. 0.17.

12.5 Ventilating openings

12.5.1 Ventilating openings in an enclosure for hazardous-voltage circuits, including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening permits passage of a rod having a diameter of 33/64 inch (13 mm). An enclosure for a fuse(s) or other overload protective device and provided with ventilating openings shall not permit the emission of flame or molten metal. Openings provided which permit cleaning of internal parts shall not permit damage to functional internal components during such cleaning operations.

12.5.2 Perforated sheet metal and sheet metal employed for expanded metal mesh shall be not less than 0.042 inch (1.0 mm) in average thickness, 0.046 inch (1.2 mm) when zinc coated.

12.5.3 When the indentation of the guard enclosure does not alter the clearance between uninsulated live parts and grounded metal so as to reduce spacings below the minimum values required, it is permissible for 0.5 mm (0.021 inch) expanded metal mesh or perforated sheet metal, 0.6 mm (0.024 inch) when zinc coated, to be employed under the following conditions:

- a) The exposed mesh on any one side or surface of the device so protected has an area of not more than 465 cm² (72 in²) and has no dimension greater than 300 mm (12 inches); and
- b) The width of an opening so protected is not greater than 90 mm (3.5 inches).

12.5.4 The wires forming a screen protecting current-carrying parts shall be not smaller than 16 AWG and the screen openings shall be not greater than 3 cm² (0.465 in²) in area.

12.5.5 The wires forming a screen employed as a smoke chamber cover shall be not less than 22 AWG for steel and not less than 20 AWG for aluminum.

12.6 Covers

12.6.1 An enclosure cover of a detector shall be hinged, sliding, pivoted, or similarly attached when:

- a) It provides ready access to fuses or any other overcurrent protective device, the intended protective functioning of which requires renewal; or
- b) It is required to periodically open the cover in connection with the intended operation of the detector.

For the purpose of this requirement, intended operation is identified as operation of a switch for testing or for silencing an audible signal appliance or operation of any other component of a detector that requires such action in connection with its intended performance.

12.6.2 A cover that is intended to be removed only for periodic cleaning of the sensing chamber or replacement of a lamp shall be secured by any one of the following or equivalent means: snap catch, plug-in or twist action, snap tab with one screw, or two screws.

12.6.3 When a detector cover is not intended to be removed for cleaning, maintenance, or both, and the detector is intended to be returned to the factory for servicing, the cover shall be secured so that it cannot be readily removed. Exposed screw slots or nuts, other than a tamper proof type, shall be sealed or covered. See [65.1\(n\)](#) for marking.

Exception: These requirements do not apply when the detector cover is intended to be removed for cleaning, maintenance, or both, even though the detector is intended to be returned to the manufacturer for servicing.

12.6.4 A hinged cover is not required where the only fuse(s) enclosed is intended to provide protection to portions of internal circuits, such as a fuse on a separate printed wiring board or circuit subassembly, to prevent excessive circuit damage resulting from a fault. The use of such a fuse(s) shall be used only when the word "CAUTION" and the following or equivalent marking is indicated on the cover of a detector employing hazardous-voltage circuits: "Circuit Fuse(s) Inside – Disconnect Power Prior To Servicing."

NOTE: In Canada, there are two official languages, French and English. Attention is drawn to the fact that some Canadian authorities may require markings to be in both official languages. Annex [E](#) lists acceptable French translations of the markings specified in this standard.

12.6.5 A hinged cover shall be provided with a latch, screw, or catch to hold it closed. An unhinged cover shall be securely held in place by screws or the equivalent.

12.7 Glass panels

12.7.1 Glass covering an enclosure or observation opening shall be held securely in place so that it cannot be displaced in service and shall provide mechanical protection of the enclosed parts. The thickness of a glass cover shall not be less than the applicable value indicated in [Table 12.3](#).

Table 12.3
Thickness of Glass Covers

Maximum size of opening				Minimum thickness	
Length or width		Area			
mm	(inches)	cm ²	(in ²)		
102	(4)	103	(16)	1.6	(1/16)
305	(12)	929	(144)	3.2	(1/8)
Over 305	(Over 12)	Over 929	(Over 144)	See footnote a	See footnote a

^a 3.2 mm (1/8 inch) or more, based upon the size, shape, and mounting of the glass panel. A glass panel for an opening having an area greater than 929 cm² (144 square inch), or having any dimension greater than 305 mm (12 inch), shall be supported by a continuous groove not less than 4.8 mm (3/16 inch) deep along all four edges of the panel.

12.7.2 A transparent material other than glass employed as a cover over an opening in an enclosure shall have mechanical strength equivalent to that of glass, shall not become a fire hazard or distort, and shall not become less transparent at the temperature to which it may be subjected under normal or abnormal service conditions.

12.7.3 A lens, light filter, or similar part of a detector shall be constructed of a material the transparency of which is not impaired by the conditions to which it is exposed in service as represented by the performance tests described in Sections [29](#) – [62](#).

13 Corrosion Protection

13.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other means determined to be equivalent.

Exception: Parts made of stainless steel, polished or treated when required, do not require additional protection.

13.2 The requirement of [13.1](#) applies to all enclosures, whether of sheet steel or cast iron, and to all springs and other parts upon which proper operation depends. It does not apply to minor parts such as washers, screws, and bolts, when the deterioration of such unprotected parts does not result in noncompliance with this standard, result in a hazardous condition, or impair the operation of the detector.

13.3 Bearing surfaces shall be of such materials that reduce the risk of binding due to corrosion.

13.4 Iron and steel parts, except bearings, and the like, where such protection is impracticable, shall be suitably protected against corrosion by enameling, galvanizing, sherardizing, plating, or other equivalent means.

13.5 Metal shall not be used in combinations such as to result in galvanic action that results in deterioration of cabinets or enclosures.

13.6 Hinges and other attachments shall be resistant to corrosion.

13.7 Nonferrous cabinets and enclosures do not require special corrosion protection.

14 Field Wiring Connections

14.1 General

14.1.1 A detector shall be provided with wiring terminals or leads for the connection of conductors corresponding to the electrical rating of the detector and sized in accordance with:

- a) In Canada: CSA C22.1.
- b) In the United States: NFPA 70.

14.1.2 Duplicate terminals or leads, or an equivalent arrangement, shall be provided for circuits supplying operating power to the detector (where the operating power is monitored by an end-of-line device) and for circuits transmitting alarm signals from the detector to the control unit, one for each incoming and one for each outgoing wire. It is permissible that a common terminal be used in lieu of duplicate terminals when it is intended to prevent the looping of an unbroken wire around or under a terminal screw in a manner that permits the looped wire to remain unbroken during installation, thereby precluding monitoring in the event the wire becomes dislodged from under the terminal. A notched clamping plate under a single securing screw, where separate conductors are intended to be inserted in each notch, is an equivalent arrangement. When duplicate terminals or leads are used and there is no provision to prevent looping an unbroken wire around or under one terminal, the marking in [66.1.4\(c\)](#) shall be provided.

14.2 Field wiring compartment

14.2.1 The field wiring compartment area shall be of sufficient size for completing all field wiring connections as specified by the installation wiring diagram. There shall be space within the compartment to permit the use of a standard conduit bushing on conduit connected to the compartment when a bushing is required for installation.

14.2.2 Protection from sharp edges for internal components in the wiring area and wire insulation shall be provided by insulating or metal barriers having smooth, rounded edges or equivalent means of protection.

14.2.3 The location of an outlet box or compartment in which field wiring connections are to be made shall be such that these connections may be inspected after the detector is installed as intended. The removal of not more than two mounting screws, or equivalent arrangement, to view the field wiring connections, is considered to comply with this requirement.

14.3 Field-wiring terminals (general)

14.3.1 A field-wiring terminal to which field-wiring connections are made shall comply with the requirements in [14.3.2](#) – [14.3.5](#):

- a) In Canada only:
 - 1) CSA C22.2 No. 153;
 - 2) CSA C22.2 No. 65;
 - 3) UL 486E; or
 - 4) CSA C22.2 No. 158, rated for field-wiring (FW) Code 2 applications and also suitable for the voltage, current, wire range, and wire type of the intended application.
- b) In the United States only:

- 1) The field-wiring requirements in UL 310;
- 2) UL 486A-486B;
- 3) UL 486E; or
- 4) UL 1059, rated for field-wiring (FW) Code 2 applications and also suitable for the voltage, current, wire range, and wire type of the intended application.

14.3.2 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 10 AWG (5.3 mm²) and larger wires. When the connectors or lugs are secured to a plate, the plate thickness shall not be less than 0.050 inch (1.3 mm) thick. Securing screws of plated steel have been determined to meet the requirements.

14.3.3 A wire-binding screw used at a wiring terminal shall not be smaller than No. 8 (4.2 mm) diameter. Plated screws are not prohibited.

Exception: A No. 6 (3.5 mm) diameter screw is appropriate for use for the connection of a 14 AWG (2.1 mm²) and a No. 4 (2.8 mm) diameter screw is appropriate for use for the connection of a 19 AWG (0.65 mm²) or smaller conductor.

14.3.4 Terminal plates tapped for wire-binding screws shall:

- a) Have not less than two full threads in the metal (the terminal plate metal may be extruded to provide the two full threads) and shall have upturned lugs, clamps, or the equivalent, to hold the wires in position. Other constructions may be used if they provide equivalent thread security of the wire-binding screw.
- b) Be of a nonferrous metal not less than 1.3 mm (0.050 inch) thick when used with a No. 8 (4.2 mm) diameter or larger screw, and not less than 0.76 mm (0.030 inch) thick when used with a No. 6 (3.5 mm) diameter or smaller screw.

14.3.5 When two or more conductors are intended to be connected by wrapping under the same screw, a nonferrous intervening metal washer shall be used for each additional conductor. A separator washer is not required when two conductors are separated and intended to be secured under a common clamping plate. When the wires protrude above terminal barriers, the nonferrous separator shall include means, such as upturned tabs or sides, to retain the wire.

14.4 Special field-wiring terminals (qualified application)

14.4.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in [14.4.2](#) are met:

- a) Quick-Connect Terminals – Nonferrous, quick-connect (push-type) terminals consisting of male posts permanently secured to the device and provided with compatible, female connectors for connection to field wiring. These require a special tool for crimping of field wires. Mating terminals shall be shipped with the control unit with instructions for their installation;
- b) Push-In Terminals – Nonferrous (screwless), push-in terminals of the type used on some switches and receptacles. Solid conductors are pushed into slots containing spring-type contacts. The leads are removable by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals are not to be used with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used; and
- c) Other Terminals – Other terminal connections are not prohibited when determined to be equivalent to item a and b and are limited to the same restrictions.

14.4.2 Any of the terminal configurations listed in [14.4.1](#) are appropriate for connection of field wiring provided all of the following indicated conditions are met.

- a) When a special tool is required for connection, it shall be provided and its use indicated on the installation wiring diagram by name of the manufacturer and the model number or equivalent.
- b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size to be used shall not be less than 26 AWG (0.13 mm²) for a jacketed, multi-conductor cable or 18 AWG (0.82 mm²) for a single conductor wire.
- c) The wire size to be used shall be rated for the current-carrying capacity of the circuit application.
- d) The special field-wiring terminal assembly shall comply with the strain relief test as outlined in [56.2](#), Special Field Wiring Terminals.

14.5 Field wiring leads

14.5.1 Leads provided for field connections shall meet the following requirements:

- a) Shall not be less than 152 mm (6 inches) long;
- b) Shall be provided with strain relief;
- c) Shall not be smaller than 18 AWG (0.82 mm²);
- d) Shall have the individual strands soldered together; and
- e) The insulation, when of rubber or thermoplastic, shall not be less than 0.8 mm (1/32 inch) thick.

14.5.2 Wire shall be bunched tinned stranded copper.

14.6 Grounding terminals and leads

14.6.1 A hazardous-voltage detector which is provided with an overall nonmetallic enclosure and cover, is intended to be serviced internally, and employs internal dead metal parts which become energized under fault conditions, requires an equipment grounding terminal or lead, or the equivalent.

14.6.2 An equipment grounding terminal or lead is not required for:

- a) An extra-low voltage detector;
- b) A hazardous-voltage detector provided with an overall nonmetallic enclosure and cover and that is not intended to be internally serviced; or
- c) A hazardous-voltage detector provided with an overall nonmetallic enclosure and cover, and:
 - 1) That does not employ internal dead-metal parts which are energized under a fault condition and be contacted during servicing; or
 - 2) Having internal dead metal parts that are insulated.
- d) A hazardous-voltage detector provided with an overall nonmetallic enclosure and cover that includes internal dead metal parts which are contacted during servicing, and employs a 2-pole disconnect switch which de-energizes both legs of the supply circuit upon removal of the cover.

14.6.3 The grounding means shall be connected to all exposed dead metal parts that become energized and all dead metal parts within the enclosure that are exposed to contact during servicing and maintenance. See Bonding for Grounding, Section [16](#).

14.6.4 The surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be green, with or without one or more yellow stripes, and no other leads visible to the installer, other than grounding conductors, shall be so identified. A field wiring terminal intended for connection of an equipment grounding conductor shall be plainly identified, such as by being marked "G," "GR," "Ground," "Grounding," or the equivalent, or by a marking on a wiring diagram provided on the detector. The field wiring terminal shall be located so that it won't to be removed during servicing of the detector.

NOTE: In Canada, there are two official languages, French and English. Attention is drawn to the fact that some Canadian authorities may require markings to be in both official languages. Annex E lists acceptable French translations of the markings specified in this standard.

14.7 Grounded supply terminals and leads

14.7.1 A field wiring terminal for the connection of the grounded supply conductor shall be identified by means of a metallic plated coating substantially white in color and shall be readily distinguishable from the other terminals, or identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram.

14.7.2 A field wiring lead provided for connection of the grounded supply conductor shall be finished to show a white or gray color and shall be readily distinguishable from other leads, and no other leads visible to the installer, other than grounded conductors, shall be so identified.

14.7.3 A terminal or lead identified for the connection of the grounded supply conductor shall not be electrically connected to a single-pole manual switching device which has an OFF position or to a single-pole over-current (not thermal) protective device.

14.8 Isolated (nongrounded) detectors

14.8.1 When a detector is constructed such that the exposed metal enclosure serves as a current-carrying part of the circuit, an insulated (nonmetallic) mounting plate, or a metal mounting plate with insulated bushed holes through which metal mounting screws are employed, or an equivalent arrangement shall be provided for installation between the detector current-carrying parts and metal back box.

14.8.2 The arrangement described in [14.8.1](#) is permitted only on a detector intended for connection to a low-voltage circuit. In addition, the word "CAUTION" « MISE EN GARDE » and the following or equivalent marking is to be displayed in letters at least 3.2 mm (1/8 inch) high adjacent to the detector wiring area: "INSTALL ENCLOSURE ISOLATED FROM GROUND PER MANUFACTURER'S INSTRUCTIONS AND HARDWARE PROVIDED. GROUNDING COULD RESULT IN A FALSE ALARM." « INSTALLER ENCEINTE ISOLE DE LA TERRE SELON LES INSTRUCTIONS ET MATERIELS DU CONSTRUCTEUR PREVUE. TERRE POURRAIT ENTRAINER UNE FAUSSE ALARME ».

NOTE: In Canada, there are two official languages, French and English. Attention is drawn to the fact that some Canadian authorities may require markings to be in both official languages. Annex E lists acceptable French translations of the markings specified in this Standard.

15 Internal Wiring

15.1 General

15.1.1 The internal wiring of a detector shall consist of conductors having:

- a) Insulation rated for the potential involved;
- b) Insulation rated for the temperatures to which they are subjected; and
- c) The current-carrying capacity for the service.

15.1.2 The wiring shall be routed away from the moving parts and sharp projections and held in place with clamps, string, ties, or the equivalent, unless the wiring is determined to be rigid enough to retain a shaped form.

15.1.3 Leads or a cable assembly connected to parts mounted on a hinged cover shall be of sufficient 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. Wire shall be stranded copper.

15.1.4 When the use of a short length of insulated conductor is not feasible, such as for a short coil lead or the like, it is permissible for electrical insulating tubing to be employed. The tubing shall not be subjected to sharp bends, tension, compression, or repeated flexing and shall not contact sharp edges, projections, or corners. The wall thickness of the tubing shall comply with the requirements for such tubing, except that the wall thickness at any point for polyvinyl chloride tubing of 9.5 mm (3/8 inch) diameter or less shall not be less than 0.43 mm (0.017 inch). For insulating tubing of other types, the wall thickness shall not be less than that required to at least equal the mechanical strength, dielectric properties, and heat and moisture resistance characteristics of polyvinyl chloride tubing having a wall thickness of 0.43 mm (0.017 inch).

15.1.5 Internal wiring of circuits which operate at different potentials shall be reliably separated by barriers or shall be segregated, unless the conductors of the circuits of lower voltage are provided with insulation equivalent to that required for the highest voltage involved. Segregation of insulated conductors may be accomplished by clamping, routing, or an equivalent means, which ensures permanent separation. See [15.4](#), Barriers.

15.1.6 Stranded conductors clamped under wire-binding screws or similar parts shall have the individual strands soldered together or be equivalently arranged to provide secure connections.

15.2 Wireways

15.2.1 Wireways shall be smooth and free from sharp edges, burrs, fins, moving parts and the like, which may cause abrasion of the conductor insulation.

15.3 Splices

15.3.1 All splices and connections shall be mechanically secured and bonded electrically. Tack soldering of components or electrical leads is permitted where the construction precludes mechanical security only when 5 samples resist a pull-force of 8.9 N (2 lbs) applied for 3 seconds and the connection is subjected to 100 % inspection and testing with the same pull force by the manufacturer.

15.3.2 A splice shall be provided with insulation determined to be equivalent to that of the wires involved when permanence of electrical spacings between the splice and uninsulated metal parts is not provided.

15.3.3 Splices shall be located, enclosed, and supported so that flexing, movement, or vibration does not damage the insulation or affect the integrity of the splice.

15.4 Barriers

15.4.1 A metal barrier shall have a thickness at least equal to that required by [Table 12.2](#) as determined by the size of the barrier. A barrier of insulating material shall not be less than 0.71 mm (0.028 inch) thick and shall be thicker when it is possible for deformation which defeats its purpose to be easily accomplished. Any clearance between the edge of a barrier and a compartment wall shall not be more than 1.6 mm (1/16 inch).

15.5 Strain relief

15.5.1 A strain relief means shall be provided for the field supply leads, battery leads and all internally connected wires or cords that are subject to movement in conjunction with the installation, operation, or servicing of a detector to reduce the risk of any mechanical stress being transmitted to internal connections and terminals. Inward movement of the cord or leads provided with a ring-type cord grip shall not damage internal connections or components, or result in a reduction of the electrical spacings required. See the Strain Relief Test, Section [56](#).

16 Bonding for Grounding

16.1 An exposed non-current-carrying metal part of a detector operating at more than 30 Vrms that is liable to become energized, shall be reliably bonded to the point of connection of the field-equipment grounding terminal or lead, if provided or required, and to the metal surrounding the knockout, hole, or bushing provided for field power-supply connections. This requirement also applies to a detector equipped with auxiliary function contacts rated at more than 30 Vrms.

16.2 Except as indicated in [16.3](#), uninsulated metal parts of electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors, and other electrical components shall be bonded for grounding when it is possible that they be contacted by the user or by a serviceman in servicing or operating the equipment.

16.3 Metal parts as described below are not required to comply with the requirement specified in [16.2](#):

- a) Adhesive attached metal foil markings, screws, and handles, that are located on the outside of the detector enclosure and isolated from electrical components or wiring by grounded metal parts so that they shall not become energized.
- b) Isolated metal parts, such as small assembly screws, that are separated from wiring and uninsulated live parts.
- c) Panels and covers which do not enclose uninsulated live parts, when wiring is positively separated from the panel or cover so that it shall not become energized.
- d) Panels and covers which are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 0.8 mm (1/32 inch) thick and secured in place.

16.4 A bonding conductor shall be of material determined to be capable for use as an electrical conductor. When of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The conductor shall not be smaller than the maximum size wire employed in the circuit wiring of the component or part. A separate bonding conductor or strap shall be installed in such a manner that it is protected from mechanical damage.

16.5 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, brazing, or welding. The bonding connection shall penetrate nonconductive coatings such as paint. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material.

NOTE 1: A bolted or screwed connection that incorporates a star washer under the screw head is considered acceptable for penetrating non-conductive coatings.

NOTE 2: Where the bonding means depend upon screw threads, two or more screws or two full threads of a single screw engaging metal are considered acceptable. Metal-to-metal hinge-bearing members for doors or covers may be considered as a means for bonding the door or cover for grounding providing that a multiple bearing, pin-type hinge is employed.

16.6 Splices shall not be employed in conductors used to bond electrical enclosures or components.

COMPONENTS

17 General

17.1 Mounting of components

17.1.1 All parts of a detector shall be securely mounted in position and prevented from loosening or turning.

Exception: It is not required that a switch be prevented from turning when all four of the following conditions are met:

- a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is subject to forces that tend to turn the switch during operation of the switch.*
- b) The switch mounting means is constructed so that it is not loosened by the switch operation.*
- c) The spacings are not reduced below the minimum required values when the switch rotates.*
- d) The operation of the switch is by mechanical means rather than by the direct contact by persons.*

17.1.2 Uninsulated live parts shall be secured to the base or mounting surface so that they shall not turn or shift in position, when it is possible that such motion results in a reduction of spacings, below the acceptable values. Friction between surfaces shall not be used as a means to prevent shifting or turning of live parts, a lock washer applied as intended is permissible.

17.1.3 Uninsulated live parts, for example, field wiring terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they shall not turn or shift in position when such motion results in reduction of spacings below the minimum values required. This is to be accomplished by two screws or rivets, by square shoulders or mortices, by a dowel pin, lug, or offset, by a connecting strap or clip fitted into an adjacent part, or by any method determined to be equivalent.

17.2 Operating components

17.2.1 Operating components and assemblies, such as switches, relays, and similar devices, shall be protected by individual protection (i.e. dust covers) or dust tight cabinets against fouling by dust or by other material which affect their operation.

17.2.2 Adjusting screws and similar adjustable parts shall not loosen under the conditions of actual use. The use of a lock washer, applied as intended, to reduce the risk of loosening is permissible.

17.2.3 Moving parts shall have sufficient play at bearing surfaces to prevent binding.

17.2.4 Manually operated parts shall have sufficient strength to withstand the stresses to which they will be subjected in operation.

17.2.5 An electromagnetic device shall be reliable and ensure positive electrical and mechanical performance under all conditions of normal operation.

17.3 Current-carrying parts

17.3.1 A current-carrying part shall have adequate mechanical strength and current-carrying capacity for the service, and shall be a metal such as silver, copper or copper alloy, or other material, which will provide equivalent performance.

17.3.2 Bearings, hinges, and the like shall not be acceptable for carrying current between interrelated fixed and moving parts.

18 Bushings

18.1 When a lead or wire harness passes through an opening in a wall, barrier, or enclosing case, there shall be a metal or insulating type bushing, or the equivalent, that shall be substantial, secured in place, and have a smooth, rounded surface to provide support for the wire.

18.2 When the opening is in a phenolic composition or other nonconducting material or in metal of thickness greater than 1.07 mm (0.042 inch) at the opening, a smooth surface having rounded edges is identified as the equivalent of a bushing.

18.3 Ceramic materials and some molded compositions are permissible for insulating bushings, separate bushings of wood and of hot-molded shellac are prohibited.

18.4 Fiber shall be employed only where:

- a) It is not subjected to a temperature higher than 90 °C (194 °F) under normal operating conditions;
- b) The bushing is not less than 1.6 mm (1/16 inch) thick, with a tolerance of 0.4 mm (1/64 inch) for manufacturing variations; and
- c) It does not deteriorate in normal ambient humidity conditions.

18.5 When a soft rubber bushing or similar material that deteriorates with age is employed in a hole in metal, the hole shall be free from sharp edges, burrs, projections, and other anomalies which cut into the bushing and wire insulation.

18.6 An insulating metal grommet shall be used in lieu of an insulating bushing, only when the insulating material used is not less than 0.8 mm (1/32 inch) thick and completely fills the space between the grommet and the metal in which it is mounted.

19 Electrical Insulating Material

19.1 Material for the mounting of current-carrying parts shall be porcelain, phenolic composition, cold-molded composition, or equivalent material which is suitable for the particular application.

19.2 Polymeric materials shall be used for the sole support of uninsulated live parts only when determined to be equivalent to the materials indicated in [19.1](#).

19.3 When vulcanized fiber is used for insulating bushings, washers, separators, and barriers, it shall not be the sole support for uninsulated current-carrying parts of other than extra-low-voltage circuits.

19.4 The thickness of a flat sheet of insulating material, such as impregnated asbestos-cement composition or phenolic composition employed for panel mounting of parts, shall not be less than the applicable value indicated in [Table 19.1](#).

Table 19.1
Thickness of Flat Sheets of Insulating Material

Maximum dimensions					
Length or width		Area		Minimum thickness ^a	
mm	(inches)	cm ²	(in ²)	mm	(inch)
152	(6)	232.4	(36)	1.6	(1/16)
305	(12)	928.8	(144)	3.2	(1/8)
610	(24)	2322	(360)	9.5	(3/8)
1219	(48)	7432	(1152)	12.7	(1/2)
1219	(48)	11148	(1728)	15.9	(5/8)
Over 1219	(Over 48)	Over 11148	(Over 1728)	19.1	(3/4)
^a Material less than the minimum thickness shown shall be used for a panel only when the panel is supported or reinforced to provide equivalent rigidity.					

19.5 A terminal block mounted on a metal surface which is capable of being grounded shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base to reduce the risk of the parts and the ends of replaceable terminal screws from reducing spacings below the minimum thickness specified in [Table 19.1](#).

Exception: Such insulation is not required when the parts are staked, upset, sealed, or equivalently kept from loosening.

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

20 Visual Indicators

20.1 Visual indicators shall be rated for the circuit in which they are employed when the detector is operated under any condition of normal service.

20.2 A visual indicator shall be installed so that uninsulated live parts other than a screw shell will not be exposed to contact by persons removing or replacing lamps in normal service.

20.3 A visual indicator employing a metal shell, such as a screw shell, used in a circuit rated at 30 Vrms or greater shall be wired so that the metal shell is connected to an identified (grounded circuit) conductor.

20.4 When more than one visual indicator employing a metal shell is provided, the metal shells of all such visual indicators shall be connected to the same grounded circuit conductor.

20.5 A lamp or equivalent means shall be provided on a detector or base to identify it as the unit from which the alarm was initiated.

Exception: The alarm-indicating means is not required on a detector when video imaging is provided at a specific control unit that identifies the area of alarm.

20.6 When a detector has more than one visual indicator, lamp colors are required as follows:

- a) A "power-on" lamp, white or green;
- b) An alarm indicating lamp, red; and
- c) A trouble lamp, amber or yellow.

When the "power-on" indicator is of a different color it shall be marked to identify the function.

20.7 When two or more color indications are used to visually annunciate detector status, one color shall be designated for normal indication and mode of operation. If the color for normal operation is other than white or green, the lamp shall be marked to identify the function. An alarm indication shall be red. Use of alternate colors or indication flash rates for non-alarm conditions shall be permitted.

20.8 A means shall be provided to indicate a latched-in alarm condition. The indication shall be red and shall be distinctive from the normal state. If flashing is used, the flash rate shall be no less than 12 flashes/minute in the alarm condition.

21 Motors

21.1 A motor shall be protected against overheating under normal and abnormal operating conditions.

21.2 A fan motor shall be protected by thermal or overcurrent protective devices or shall be of the impedance-protected type. See the Locked Rotor Test, Section [52](#). A thermal or overcurrent protective device shall not open the circuit during the Temperature Test, Section [40](#).

21.3 A motor employing thermal protection is considered to comply with the requirement of [21.2](#) when evaluated to the following standards:

- a) In Canada, CSA C22.2 No. 77;
- b) In the United States, UL 2111.

21.4 A motor having openings in the enclosure or frame shall be arranged so that particles dropping out of the motor shall not fall onto flammable material within or under the detector.

22 Protective Devices

22.1 Fuseholders, fuses, and circuit breakers shall be rated for the application.

23 Printed Wiring Boards

23.1 The components of a printed wiring board shall be attached securely and the spacings between circuits shall comply with the spacing requirements of Section [28](#), Spacings, for rigidly clamped assemblies (see [Table 28.1](#)). The board shall be mounted so that deflection of the board during servicing shall not result in damage to the board or in a reduction of electrical spacings below those required in this