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Loss Prevention Standard

LPS® 1976: Issue 1.0

Requirements and testing procedures for the LPCB approval and listing of Video Flame Detectors

180319_LPCB

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PARTICIPATING ORGANISATIONS

This standard has been developed in conjunction with Industry Stakeholders and was the subject of public consultation via the BRE Global website.

The following organisations participated in the preparation of this standard:

Ciqurix Ltd
Dräger Safety AG & Co. KgaA
Fire Fighting Enterprises Ltd
Fire Industry Association
Johnson Controls
Micropack (Engineering) Ltd

REVISION OF LOSS PREVENTION STANDARDS

Loss Prevention Standards (LPSs) will be revised by issue of revised editions or amendments. Details will be posted on our website at www.redbooklive.com.

Technical or other changes which affect the requirements for the certification of the product or service will result in a new issue. Minor or administrative changes (e.g. corrections of spelling and typographical errors, changes to address and copyright details, the addition of notes for clarification etc.) may be made as amendments.

The issue number will be given in decimal format with the integer part giving the issue number and the fractional part giving the number of amendments (e.g. Issue 3.2 indicates that the document is at Issue 3 with 2 amendments).

USERS OF LPSS SHOULD ENSURE THAT THEY POSSESS THE LATEST ISSUE AND ALL AMENDMENTS.

FOREWORD

This Standard identifies the evaluation and / or testing practices undertaken by BRE Global for the purposes of LPCB certification and listing of products and services. LPCB certification and listing and of products and services is based on evidence acceptable to BRE Global:-

- that the product or service meets the standard;
- that the manufacturer or service provider has staff, processes and systems in place to ensure that the product or service delivered meets the standard

and on:-

- periodic audits of the manufacturer or service provider including testing as appropriate;
- compliance with the contract for LPCB certification and listing, including agreement to rectify faults as appropriate;

The responsibility for ensuring compliance with the technical and managerial process and requirements for the product or service lies with the manufacturer, service provider or supplier.

NOTES

Compliance with this LPS does not of itself confer immunity from legal obligations. Users of LPSs should ensure that they possess the latest issue and all amendments.

LPCB welcomes comments of a technical or editorial nature and these should be addressed to “the Technical Director” at Enquiries @bregroup.com.

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The Figures in this LPS are not to scale.

1 SCOPE

The purpose of a Video Flame Detector and of a Video Flame Detection System is to warn person(s) within or in the vicinity of a building of the occurrence of a fire emergency in order to enable such person(s) to take appropriate measures. However, such detectors can also be used in more remote, outdoor locations. These process live video images, within the field of view, to detect the characteristic properties of flames by means of digital signal processing algorithms.

Historically, EN 54-10 and other recognised international standards such as ISO 7240-10 and FM 3260 have been used to specify the requirements of flame detectors utilising sensors reacting to thermal radiations from hot sources which may be indicative of a flaming fire. However, these standards are not suited to the assessment of new generation flame detectors that analyse live video images of its surrounding environment to determine the presence of visible flaming.

LPS 1976 is based on the well-established requirements and test methodology of EN 54-10, to set out the requirements specific to the capture and analysis of video images of potential flaming fires, assesses the immunity to false alarms sources relevant to the new technology and provides the basis for regulatory approval of these new types of flame detectors/systems.

These types of detectors are suited to large open spaces at greater distances from the fire in environments in which there may be sources of contamination or causes of false alarms. Examples include challenging environments such as departure lounges, aircraft hangars, oil rigs, waste processing facilities, tunnels and factories. These detectors offer robust false alarm rejection as they can be programmed to reject common false alarm sources. They are spatially aware and can adapt to the local environment to maintain sensitivity. These detectors can offer a live video feed which can provide valuable information during or after a fire (if recorded).

Video Flame Detectors can be stand-alone, in which case the sensor, analytics and decision making are within the device. Video Flame Detection Systems are distributed in which case the critical analytics and decision making are performed remotely to the sensing device/s.

This Loss Prevention Standard allows manufacturers to specify the range of the Video Flame Detector and Video Flame Detection System over which it can detect a flaming fire. The range is tested by measuring the response of these to test fires at minimum and maximum distances, as declared by the manufacturer.

As contaminants on the sensing device window(s) could inhibit the transmission of signal from a flame to the sensor(s) an optional window monitoring facility test has been introduced in order to check whether this function operates correctly.

Video Flame Detectors and Video Flame Detection Systems are categorised in one of two application environment types, i.e. Type A and Type B. More severe climatic conditions are applied to devices that are primarily intended for outdoor applications (Type B) than those primarily intended for indoor applications (Type A).

This Loss Prevention Standard gives common requirements for the construction and robustness of Video Flame Detectors and Video Flame Detection Systems as well as for their performance under climatic, mechanical and electrical interference conditions which are likely to occur in the service environment.

In applications where the space to be protected has been classified as a hazardous area, it may be necessary to install Video Flame Detectors or Video Flame Detection Systems in areas where an explosive atmosphere could result from the presence of flammable gases, vapours or mists, or the presence of combustible dusts. In these situations, special protection measures are essential to ensure that the potential for ignition of the atmosphere by the installed system and its wiring is minimized. This may lead to the systems falling outside the scope of the standard, so special consideration to this should be made in selection of components.

If a system comprises separate components, the interconnection between them would be expected to comply with the relevant installation code/s of practice.

This Loss Prevention Standard specifies requirements, test methods and performance criteria for Video Flame Detectors and Video Flame Detection Systems. These detectors detect changes in video images characterised by the properties of flames generated during the combustion of carbon-based materials. These detectors are installed in and around buildings as well as in broader applications but are intended to be used as part of fire detection systems.

Video Flame Detectors and Video Flame Detection Systems having special characteristics suitable for the detection of specific fire risks are not covered by this standard, although the standard may be used as guidance in assessing such products. The performance requirements of any additional functions are beyond the scope of this standard (e.g. additional features or enhanced functionality for which this standard does not define a test or assessment method).

This standard approaches this technology with performance requirements for Video Flame Detectors and Video Flame Detection Systems intended to operate as primary systems, offering comparable levels of protection as other fire detectors to EN 54 standards.

2 DEFINITIONS

For the purposes of this Loss Prevention Standard, the terms and definitions in EN 54-1:2021 and the following apply.

2.1 Active field of view

The area, potentially a subset of the FoV, which is actively monitored to detect fire

2.2 Detection capability

The maximum and minimum distances from the sensing device at which the VFD/VFDS can detect a fire, measured in accordance with 3.2.5.

2.3 Distributed video flame detection system

System comprising sensing device/s and processing hub, in which the critical analytics and decision making are performed remotely

2.4 Field of view

The entire image (encapsulating maximum horizonal and vertical angles) captured by the video flame detector/sensor

2.5 Functional tester

A method or piece of hardware equipment that is used to produce a repeatable and reproducible signal to stimulate the sensing device into fire condition

NOTE: This can be defined by the manufacturer and agreed with the test body.

2.6 Processing hub

Collates data from sensing device/s and performs the critical analytics and decision making

NOTE: This term, in the context of this standard, could be referred to elsewhere as central analysing computer, multi-input digital video recorder, central processing unit or a server.

2.7 Reference point

Point representing the optical centre within or on the surface of the sensing device specified by the manufacturer

2.8 Response point

Distance D, measured in accordance with **3.2.1.5**, at which the VFD/VFDS gives an alarm signal

2.9 Root mean square error

The metric used to quantify the cumulative pixel changes within a series of images taken from a video sequence

2.10 Sensing device

Unit incorporating the element used for capturing the radiation emitted by a flame

2.11 Stand-alone video flame detector

Detectors in which the sensor, analytics and decision making are within it

2.12 Type A video flame detector or detection system

Detector or detection system primarily intended for indoor applications

NOTE Type A detectors or systems may be suitable for some protected outdoor situations.

2.13 Type B video flame detector or detection system

Detector or detection system primarily intended for outdoor applications

NOTE: Type B detectors or systems may be more suitable than type A for some indoor situations where damage is more likely, such as where visible airborne particles and/or high temperature and/or humidity are present.

ABBREVIATIONS

BRE	Building Research Establishment
CASE	Computer-aided software engineering
EMC	Electromagnetic compatibility
FoV	Field of View
Hz	Hertz
IR	Infra-red
LPCB	Loss Prevention Certification Board
LPS	Loss Prevention Standard
RMSE	Root Mean Square Error
RTV	Response threshold value
VFD	Video flame detector
VFDS	Video flame detection system
VFS	Video flame sensor

3 REQUIREMENTS

3.1 General

3.1.1 Individual alarm indication

Each VFD or VFS shall be provided with an integral red visual indicator, that can be on permanently or flashing at a rate of no less than 0.2 Hz, by which the individual VFD or VFS, which when activated by an alarm, may be identified, until the alarm condition is reset. Where other conditions of the VFD or VFS may be visually indicated, they shall be clearly distinguishable from the alarm indication, except when the VFD or VFS is switched into a service mode. The visual indicator shall be visible from a minimum distance of 6 m directly facing the indicator, in an ambient light intensity up to 500 lux.

3.1.2 Connection of ancillary devices

Where the VFD or VFDS provides for connections to ancillary devices (e.g. remote indicators, control relays etc.), failures of these connections shall not prevent the correct operation of the VFD or VFDS.

3.1.3 Manufacturer's adjustments

It shall not be possible to change the manufacturer's settings except by special means (e.g. the use of a special code or tool) or by breaking or removing a seal.

3.1.4 On-site sensitivity adjustment

If there is provision for on-site sensitivity adjustment of the VFD/VFDS, then:

a) for each setting, at which the manufacturer claims compliance with this standard, the VFD or VFDS shall comply with the requirements of this standard and shall achieve a detection capability corresponding to that marked (on the VFD, VFS or processing hub) for that setting;

b) for each setting in a), access to the adjustment means shall only be possible by the use of a code or special tool;

c) any setting(s), at which the manufacturer does not claim compliance with this standard, shall only be accessible by the use of a code or special tool, and it shall be clearly marked on the VFD or processing hub or in the associated data, that if these setting(s) are used, it does not comply with the standard.

3.1.5 Software controlled VFD/VFDS

3.1.5.1 General

For VFD/VFDS which rely on software control in order to fulfil the requirements of this standard, the requirements of 3.1.5.2, 3.1.5.3 and 3.1.5.4 shall be met.

3.1.5.2 Software documentation

3.1.5.2.1 Design overview

The manufacturer shall submit documentation which gives an overview of the software design. This documentation shall be in sufficient detail for the design to be inspected for compliance with this standard and shall include at least the following:

a) a functional description of the main program flow (e.g. as a flow diagram or structogram) including, when applicable:

   1) a brief description of the modules and the functions that they perform;

   2) the way in which the modules interact;

   3) the overall hierarchy of the program;

   4) the way in which the software interacts with the hardware of the VFD/VFDS;

   5) the way in which the modules are called, including any interrupt processing.

b) a description of which areas of critical memory are used for the various purposes (e.g. the program, site specific data and running data);

c) a designation, by which the software and its version can be uniquely identified.

3.1.5.2.2 Design detail

The manufacturer shall have available detailed design documentation, which only needs to be provided, if required, by the testing authority. It shall comprise at least the following:

a) an overview of the complete configuration of the product, including all software and hardware components;

b) a description of each module of the program, containing at least:

   1) the name of the module;

   2) a description of the tasks performed;

   3) a description of the interfaces, including the type of data transfer, the valid data range and the checking for valid data.

c) full source code listings, as hard copy or in machine-readable form, including all global and local variables, constants and labels used, and sufficient comment for the program flow to be recognized;

d) details of any software tools used in the design and implementation phase.

3.1.5.3 Software design

In order to ensure reliability, the following requirements for software design shall apply:

a) the software shall have a modular structure;

b) the design of the interfaces for manually and automatically generated data shall not permit invalid data to cause error in the program operation;

c) the software shall be designed to avoid the occurrence of deadlock of the program flow.

3.1.5.4 The storage of programs and data

The program necessary to comply with this standard and any pre-set data, such as manufacturer's settings, shall be held in non-volatile memory. Writing to areas of memory containing this program and data shall only be possible by the use of a special tool or code and shall not be possible during normal operation. Site-specific data shall be held in memory which will retain data for at least two weeks without external power to the VFD/VFDS, unless provision is made for the automatic renewal of such data, following loss of power, within 1 hour of power being restored.

3.1.6 Enclosure protection

No requirement shall apply to a type A VFD or VFDS.

Type B VFD or VFDS shall comply with Code IP54C of EN 60529:1992 as amended by EN60529:1992+A2:2013 and shall meet the requirements specified in 3.2.2.1.

To enable correct operation of the VFD or VFDS, these data should describe the requirements for the correct processing of the signals from the device or system. This may be in the form of a full technical specification of these signals, a reference to the appropriate signalling protocol or a reference to suitable types of control and indicating equipment etc.

3.2 Testing methods

3.2.1 General

Annexes A-D provide details of the equipment and test methodologies detailed in this section.

3.2.1.1 Atmospheric conditions for tests

Unless otherwise stated in a test procedure, the testing shall be carried out after the sensing device has been allowed to stabilize in the standard atmospheric conditions for testing as described below:

a) temperature: (15 to 35) °C;

b) relative humidity: (25 to 75) %;

c) air pressure: (86 to 106) kPa;

d) ambient light level:(200 to 800) lux.

NOTE: If variations in these parameters have a significant effect on a measurement, then such variations should be kept to a minimum during a series of measurements carried out as part of one test on one sensing device.

NOTE: The ambient light level should be measured in the centre of the room, at eye level, taking the average of four measurements from the walls (at 90° increments) and one from the ceiling.

3.2.1.2 Operating conditions for tests

If a test method requires the VFDS or VFD to be operational, then the VFDS or VFD shall be connected to suitable supply and monitoring equipment with characteristics as required by the manufacturer's data. Unless otherwise specified in the test method, the supply parameters applied to the VFDS or VFD shall be set within the manufacturer's specified range(s) and shall remain within the specified limits of the standard throughout the tests. The value chosen for each parameter shall normally be the nominal value, or the mean of the specified range. If a test procedure requires a VFDS or VFD to be monitored to detect any alarm or fault signals, then connections shall be made to any necessary ancillary devices to allow a fault signal to be recognised.

Unless otherwise specified in the test method, a VFDS or VFD having adjustable sensitivity shall be set to its highest sensitivity for the conditioning.

NOTE: The details of the supply and monitoring equipment and the alarm criteria used should be given in the test report.

3.2.1.3 Mounting arrangements

The sensing device shall be mounted by its normal means of attachment in accordance with the manufacturer's instructions. If these instructions describe more than one method of mounting then the method considered to be most unfavourable shall be chosen for each test.

3.2.1.4 Tolerances

If a specific tolerance or deviation limit is not specified in a requirement or test procedure a deviation limit of ± 5 % shall be applied.

3.2.1.5 Determination of response point

3.2.1.5.1 Principle

The response point shall be measured by exposing the sensing device to a test stimuli to determine the greatest distance at which the VFDS or VFD will reliably produce an alarm condition within a time of 30 s.

3.2.1.5.2 Test apparatus

The test apparatus shall be as described in Annex A.

The design and construction of the apparatus, and the surfaces surrounding the test area, shall be such that no stimuli reaches the sensing device apart from the test stimuli. As an example, there shall be no reflection of test stimuli from the walls or other parts of the apparatus, that could reach the sensing device.

Throughout this test method it is necessary to align the sensing device relative to its optical axis and to measure distances relative to the plane of the sensing device. If it does not have a well-defined optical axis, then the manufacturer shall nominate an optical axis for the purposes of this test method. The position of this axis relative to an easily identifiable plane on the sensing device shall be noted in the test report.

3.2.1.5.3 Initial determination

A suitable test distance (between stimuli and sensing device, chosen at random) shall be determined experimentally before the commencement of the test programme. The stimuli (flame characteristics and distance) used shall be recorded and shall be kept constant throughout the test programme. For VFDS of VFDs having adjustable sensitivity settings, it will be necessary to determine an appropriate test configuration for each sensitivity.

3.2.1.5.4 Source stability

After determining suitable stimuli, and before any determination of response points, the irradiance on the optical axis of the source shall be checked for stability and variance in accordance with Annex A. Any movement of air around the test equipment shall be less than 0.3 m/sec. The configuration and measured value of RMSE shall be recorded and used as a reference throughout the test programme to verify that the source radiance remains at a similar value throughout the test programme.

During measurements of the response point the test stimuli should be video recorded and an RMSE performed to ensure that the stability and variations were within permitted boundaries during the tests, as described in Annex A.

3.2.1.5.5 Test procedure

The VFDS or VFD shall be connected to its supply and monitoring equipment and shall be allowed to stabilise for a period of 15 minutes or for a time specified by the manufacturer. During the stabilisation period the sensing device shall be shielded from all sources which may affect the determination of the response point.

The distance of the sensing device from the source shall be varied and at each distance it shall be exposed to the source for 30 s. The response point D is the greatest distance, measured between the source and the plane of the sensing element(s), at which the VFDS or VFD will reliably produce an alarm response within each 30 s exposure. If the VFDS or VFD response is known to be dependent on previous exposure to the test stimuli then sufficient time shall be allowed or another method specified by the manufacturer may be used before each exposure, to ensure that previous exposures do not affect the measurement of the response point.

In some cases the VFD/VFDS may respond with an alarm condition, after the 30 second exposure, due to processing/reporting delays. A suitable method to account for this should be agreed between the test house and manufacturer.

If, after 2 subsequent response point measurements, VFDs or VFDSs have demonstrated a variation in D of greater than 5% then further measurements shall be taken until the mean of those values changes by less than 5%. If this is the case, then every time a response point measurement is taken the same number of measurements need to be performed. If, however, the variation is initially found to be less than 5% between the two measurements then only one measurement shall be required to determine the response point.

3.2.1.6 Reduced functional tests

Where the test procedure calls for a reduced functional test, the sensing device shall be exposed to a source using a functional tester. The nature of the source used and the duration of the exposure shall be appropriate to the product in question and shall be defined or supplied by the manufacturer.

3.2.1.7 Provision for tests

The following shall be provided for testing compliance with this LPS:

a) for VFD, eight detectors and suitable support equipment (if required); for VFDS, eight systems each comprising one sensor and one processing hub;

b) the data required in 5.2.

The specimens submitted shall be representative of the manufacturer’s normal production with regard to their construction and calibration.

NOTE: This implies that the mean response point of the eight specimens, found in the reproducibility test should also represent the production mean, and that the limits specified in the reproducibility test should also be applicable to the manufacturer’s production.

3.2.1.8 Test schedule

The VFDs or VFDSs shall be tested according to the test schedule given in Table 2. After the reproducibility test (at the highest sensitivity setting) the specimen with the largest value of response point (i.e. most sensitive) shall be numbered 1 and the least sensitive shall be number 8. The specimens in between these shall be numbered in order of decreasing sensitivity. If the VFDs or VFDSs fail the reproducibility test, then no further testing shall be performed.

Table 2 — Test Schedule

Test	**Clause**	**Specimen Number**	
		Type A	Type B
Enclosure protection	3.2.2.1	N/A	3
Static IR test	3.2.2.2	2	2
Light saturation test	3.2.2.3	2	2
Water reflection test	3.2.2.4	N/A	2
Window monitoring facilities (option)	3.2.2.5	2	2
Reproducibility	3.2.3.1	1-8	1-8
Repeatability	3.2.3.2	1	1
Directional dependence	3.2.3.3	1	1
Variation in supply parameters (operational)	3.2.4.1	1	1
Fire sensitivity	3.2.5.1	1,2,7,8	1,2,7,8
Dry heat (operational)	3.2.6.1.1	3	3
Dry heat (endurance)	3.2.6.1.2	-	3
Cold (operational)	3.2.6.1.3	3	3
Operational extreme temperature test (option)	3.2.6.1.4	3	3
Damp heat, cyclic (operational)	3.2.6.2.1	6	6
Damp heat, cyclic (endurance)	3.2.6.2.2	-	7
Damp heat, steady state (endurance)	3.2.6.2.3	6	6
Sulphur dioxide (SO_2) corrosion (endurance)	3.2.6.3.1	5	5
Shock (operational)	3.2.6.4.1	8	8
Impact (operational)	3.2.6.4.2	7	7
Vibration, sinusoidal (operational)	3.2.6.4.3	4	4
Vibration, sinusoidal (endurance)	3.2.6.4.4	4	4
Electromagnetic Compatibility (EMC), Immunity tests	3.2.6.5		
- Electrostatic discharge		4[a]	4[a]
- Radiated electromagnetic fields		8[a]	8[a]
- Conducted disturbances induced by EM fields		8[a]	8[a]
- Fast transient bursts		8[a]	8[a]
- Slow high energy voltage surge		4[a]	4[a]

[a] In the interests of test economy, it is permitted to use the same specimen for more than one EMC test. In that case, intermediate functional test(s) on the specimen(s) used for more than one test may be deleted, and the functional test conducted at the end of the sequence of tests. However it should be noted that in the event of a failure, it may not be possible to identify which test exposure caused the failure (see clause 4 of EN 50130-4:2011).

3.2.2 Test apparatus

3.2.2.1 Enclosure protection

3.2.2.1.1 Object

To demonstrate that the degree of protection provided by the enclosure of the sensing device, with regard to the ingress of solid foreign objects and the harmful effects due to the ingress of water, meets the minimum requirements of this standard.

3.2.2.1.2 Enclosure of the sensing device

The enclosure of the sensing device shall be taken as comprising any parts of the outer physical envelope of the device which prevent or restrict access of solid foreign objects to the sensor/s, electronic assembly(ies) and wiring terminals.

NOTE: Ingress of liquid inside the enclosure may be possible, but should not adversely affect the operation of the device.

3.2.2.1.3 Test procedure

3.2.2.1.3.1 **Reference**

The test apparatus and procedures shall be as described in EN 60529:1992 as amended by EN60529:1992+A2:2013. The following tests shall be conducted:

a) Protection against solid foreign objects indicated by the first characteristic numeral;

b) Protection against water indicated by the second characteristic numeral;

c) Protection against access to hazardous parts indicated by the additional letter.

3.2.2.1.3.2 **State of the specimen during conditioning**

The specimen under test shall be:

a) Unpowered during the test for protection against solid foreign objects;

b) Powered during the test for protection against water;

c) Unpowered during the test for protection against access to hazardous parts.

The specimen under test shall be mounted as specified in EN 60529:1992 as amended by EN60529:1992+A2:2013 and shall include all wiring termination boxes which form part of the sensing device when installed.

3.2.2.1.3.3 Conditioning

The test conditions specified in EN 60529:1992 as amended by EN60529:1992+A2:2013 shall be applied for the following IP Codes:

a) Type A, indoor use: no test

b) Type B, outdoor use: IP54C.

3.2.2.1.3.4 Final measurements

At the end of the conditioning period for the test for protection against water:

a) The response point of the specimen shall be measured as described in 3.2.1.5;

b) The specimen shall be examined for ingress of water inside the enclosure.

3.2.2.1.4 Requirements

The sensing device shall be deemed to comply with the requirements of this subclause if:

a) The specimen tested complies with the acceptance conditions for the test for protection against solid foreign objects of EN 60529:1992 as amended by EN60529:1992+A2:2013;

b) After the conditioning period for the test for protection against water (see 3.2.2.1.3):

c) The specimen tested complies with the acceptance conditions for the test protection against access to hazardous parts of EN 60529:1992 as amended by EN60529:1992+A2:2013:

    1) The mean ratio D_{max}:D_{min} shall not be greater than 1.26 from that measured for the same specimen in the reproducibility test and

    2) No water has penetrated the enclosure or, if water has penetrated the enclosure, the device incorporates adequate provision for drainage.

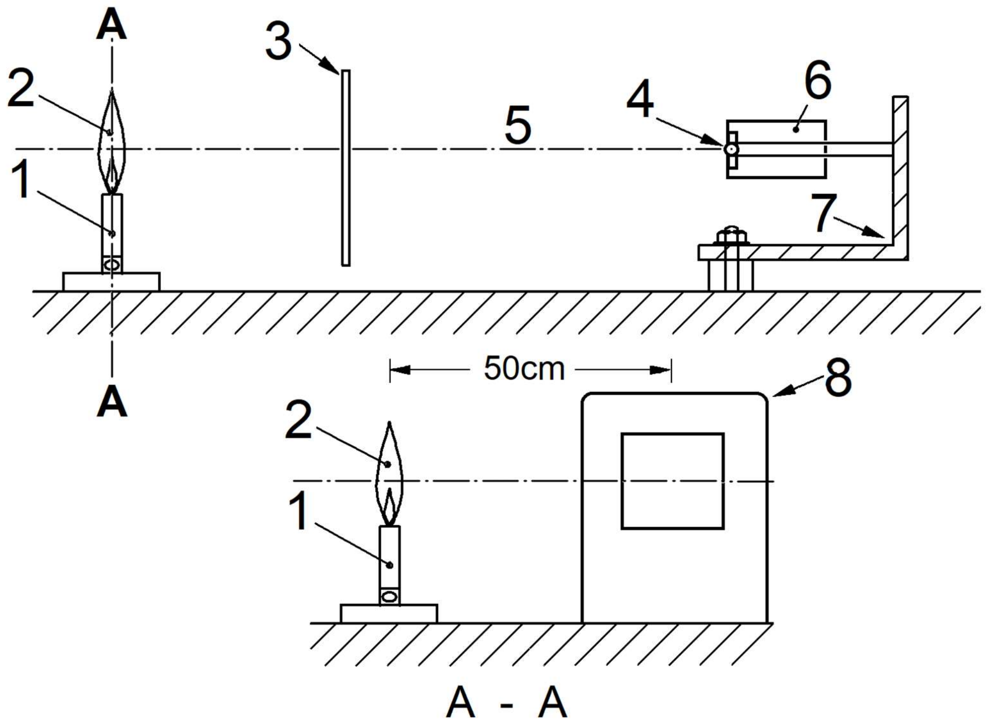
3.2.2.2 Static IR test

3.2.2.2.1 Object

To demonstrate that the VFD or VFDS is able to reject common sources of static IR yet respond to a flickering flame.

3.2.2.2.2 Test procedure

Mount a 300W Infrared Heat Lamp (IR source), or equivalent, facing the sensing device ensuring it is mounted on the flame bench in the same plane as the flickering flame source and spaced 50cm from it.



Key

1	Methane gas burner	5	Optical axis
2	Flame	6	Sensing device
3	Shield	7	Stand for sensing device
4	Sensing element(s)	8	IR source

Figure 1 - Set-up for static IR test

The IR source shall remain within the field of view of the sensing device during the test. The lamp shall be switched on for a period of 5 minutes with the gas burner shielded. A response measurement shall then be taken by bringing the sensing device closer to the flame source with the IR source in the same position and remaining switched on.

The maximum response point shall be designated D_{max} and the minimum value designated D_{min}.

3.2.2.2.3 Requirements

No false alarms should be observed during the entire test.

The ratio of the response points D_{max}:D_{min} shall not be greater than 1.14.

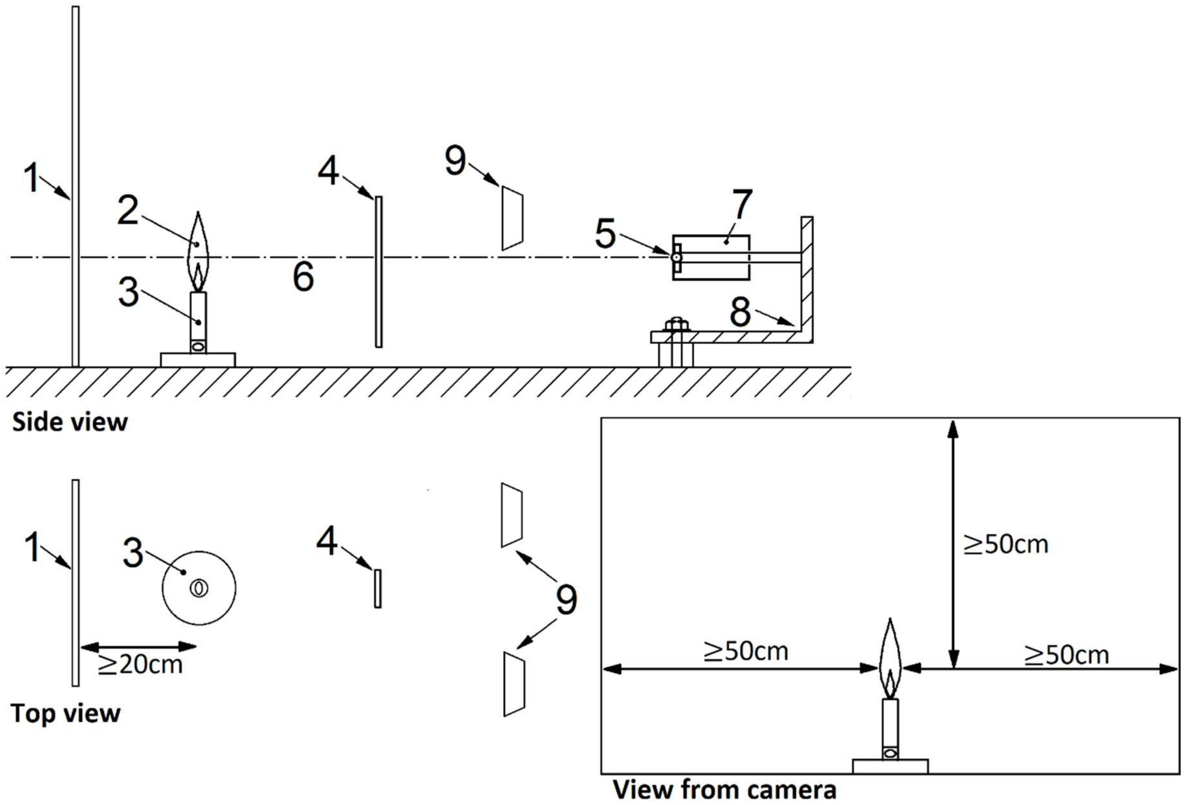
3.2.2.3 Light saturation test

3.2.2.3.1 Object

To demonstrate that the VFD or VFDS is able to respond in high ambient illumination levels.

3.2.2.3.2 Test procedure

A matt white background screen shall be illuminated using two suitable light sources, as shown in Figure 2, to produce the illumination levels, as shown in Table 3. The illumination levels should be measured from the flame location with the flame off and with the lux meter pointing directly at the white surface. The distance between the flame and the white surface should be at least 20cm for safety reasons. The distance between the light sources and the white surface should be varied to achieve the required illumination levels.



Key

1	White background screen	6	Optical axis
2	Flame	7	Sensing device
3	Methane gas burner	8	Stand for sensing device
4	Shield	9	Light sources
5	Sensing element(s)		

Figure 2 - Set-up for light saturation test

A light source with an equivalent colour temperature within the range 3000-4000K and, depending on the type, one of the following shall be applied:

Table 3 — Conditions for light saturation test

Type	Illumination (lux)	Tolerance (lux)	Duration (min)
A	1,000	±100	10
B	10,000	±1,000	10

Note: If a manufacturer additionally requires evidence of the product performance at higher illumination level/s, this can be agreed with the test body to conduct the additional test/s and report it under this clause.

After the exposure period, with the lights still on, a response measurement should be taken. The maximum response point shall be designated D_{max} and the minimum value designated D_{min}.

3.2.2.3.3 Requirements

The ratio of the response points D_{max}:D_{min} shall not be greater than 1.14.

3.2.2.4 Water reflection test

3.2.2.4.1 Object

To demonstrate that the VFD or VFDS is able to reject 3 different patterns of reflected light off an oscillating liquid surface. Applicable for Type B only.

3.2.2.4.2 Test procedure

A 400W halogen floodlight shall be angled at around 30° to the horizontal and facing a tray containing water. The tray of water shall be a suitable size so that such that the sensing device can be mounted in a way that the area of the tray accounts for 3 ± 2% of the viewable area of the sensing device. The sensing device position shall be adjusted to achieve this. The ambient light level illuminating the tray of water (not from the floodlight) should be 650±50 lux (facing the ceiling).

A reference camera shall be positioned such that the tray of water takes up 70±10% of the total field of view.

In the start position, without vibration, the sensing device and reference camera should see the reflected light from the floodlight in the centre of the tray, wholly within the field of view.

A vibration motor, mounted onto the tray, shall be capable of providing a range of frequencies. The frequency shall be changed to produce 3 different water reflection characteristics with RMSE levels of 15.0 ± 3.0, 12.5 ± 3.0 and 8.0 ± 3.0.

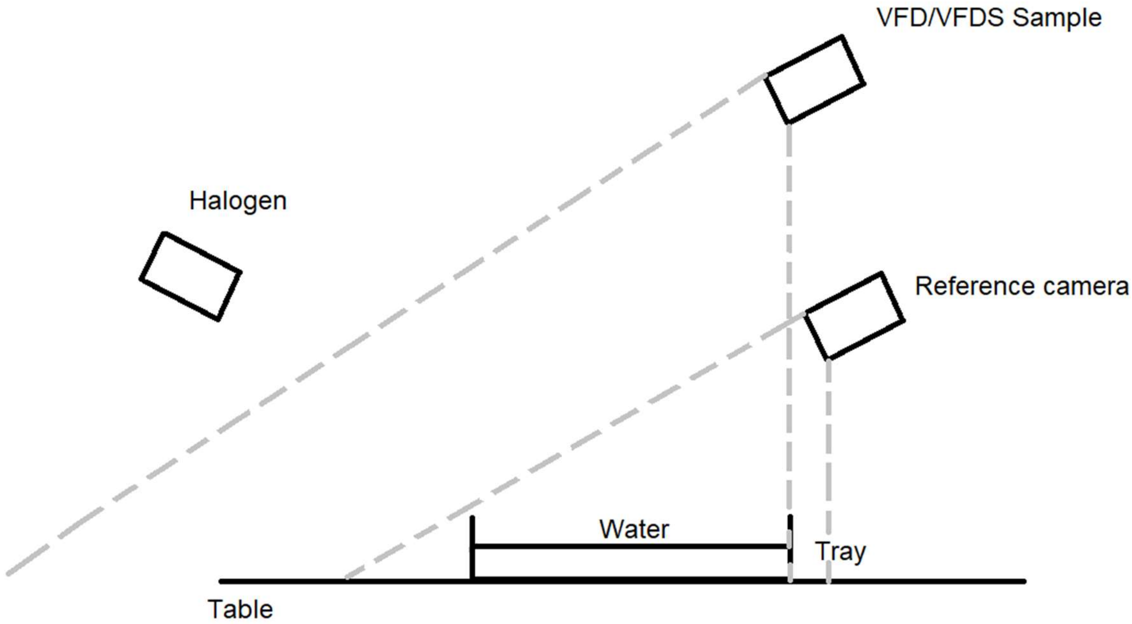


Figure 3 - Set-up for water reflection test

The reference camera shall record the footage from the tests. The first test will be with the setting that produces an RMSE of 15%, the second test at 12.5% and the final test at 8%. The sensing device should be on for the duration of the test.

For each test the motor will be switched on, left to run for 330 seconds after which power to the motor will be switched off. After waiting for 60 seconds the next test will be run in the same way for the same duration until all the three tests have been performed.

Without disconnecting the VFD or VFDS an RTV measurement shall then be taken on the flame bench. For the 3 video sequences generated, the RMSE will be determined (as described in Annex D) for the period between 30 and 330 seconds. These should be within the tolerances shown above.

3.2.2.4.3 Requirements

No false alarms should be observed during the entire test.

The ratio of the response points D_{max}:D_{min} shall not be greater than 1.14.

3.2.2.5 Window monitoring facility (option with requirements)

3.2.2.5.1 Object

To demonstrate that the VFD or VFDS has the facility to signal a fault when contaminants on the window(s) inhibit the transmission of the characteristic properties of flames to the sensor(s).

3.2.2.5.2 Test procedure

The optical signal through the window monitoring system shall all be mechanically attenuated by using a method specified by the manufacturer.

Where there are multiple optical signals and/or windows these shall be tested individually.

NOTE: A 100 % attenuation of the optical signal is acceptable.

3.2.2.5.3 Requirements

A fault signal shall be given within 300 s of the window being blocked.

3.2.3 Nominal activation conditions/sensitivity

3.2.3.1 Reproducibility

3.2.3.1.1 Object

To demonstrate that the response point of the VFD or VFDS does not vary unduly from specimen to specimen.

3.2.3.1.2 Test procedure

The response point of each of the test specimens shall be measured in accordance with 6.1.5 and each value of *D* shall be recorded.

For VFDS of VFDs having adjustable sensitivity settings, the measurement shall be repeated for each sensitivity.

For each setting, the highest value of D shall be designated D_{max}, the lowest value of D shall be designated D_{min}, and the mean value of D designated D_{mean}.

3.2.3.1.3 Requirements

For each sensitivity setting, the ratio $D_{max}:D_{mean}$ shall not be greater than 1.15 and the ratio $D_{mean}:D_{min}$ shall not be greater than 1.22.

3.2.3.2 Repeatability

3.2.3.2.1 Object

To demonstrate that the VFD or VFDS has a stable behaviour with respect to its response point even after a number of alarm conditions.

3.2.3.2.2 Test procedure

The response point of the specimen shall be measured in accordance with 3.2.1.5, six times. The maximum response point shall be designated D_{max} and the minimum value designated D_{min}.

3.2.3.2.3 Requirements

The ratio of the response points D_{max}:D_{min} shall not be greater than 1.14.

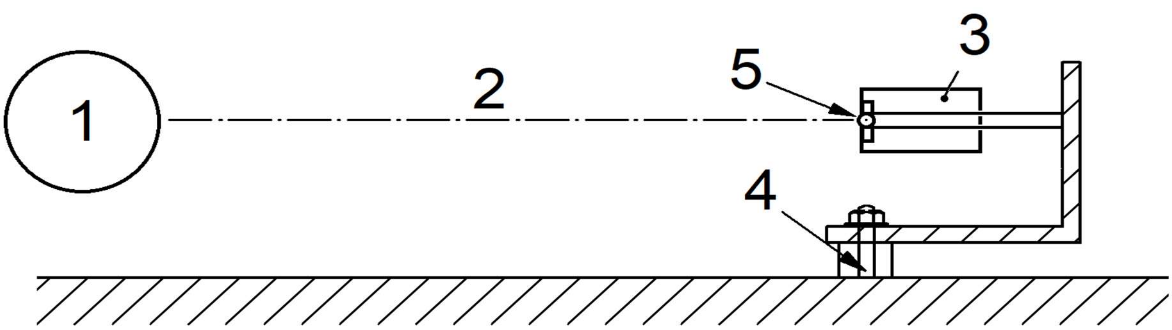
3.2.3.3 Directional dependence

3.2.3.3.1 Object

To demonstrate that the sensitivity of the VFD or VFDS is not unduly dependent on the direction of the stimuli incident on it.

3.2.3.3.2 Test procedure

The VFD or VFDS shall be mounted on the optical bench with its optical axis coincident with the source optical axis as shown in Figure 1 equating to a FoV of position 5 as shown in Figure 2. The VFD or VFDS shall then be rotated left and right and passing through the point of intersection of the optical axis and the plane of the sensing element(s). The response point of the sensing device shall be measured at the extreme left (position 4) and extreme right (position 6) of the Active FoV. The sensing device will be returned to its initial start position and the response point of the sensing device shall then be rotated up and down with measurements taken at the extreme top (position 2) and extreme bottom (position 8) of the Active FoV. The up/down rotations must take place at the intersection of the optical axis (2) with the plane of the sensing element of the sensing device (3). Measurements will also be taken at positions 1, 3, 7 and 9 by rotating the unit up/down and left/right as required.



Key

1	Test stimuli	4	Rotating in x-axis (pan)
2	Source optical axis (centre)	5	Rotations in y-axis (tilt)
3	Sensing device		

Figure 4 - Arrangement for the directional dependence test

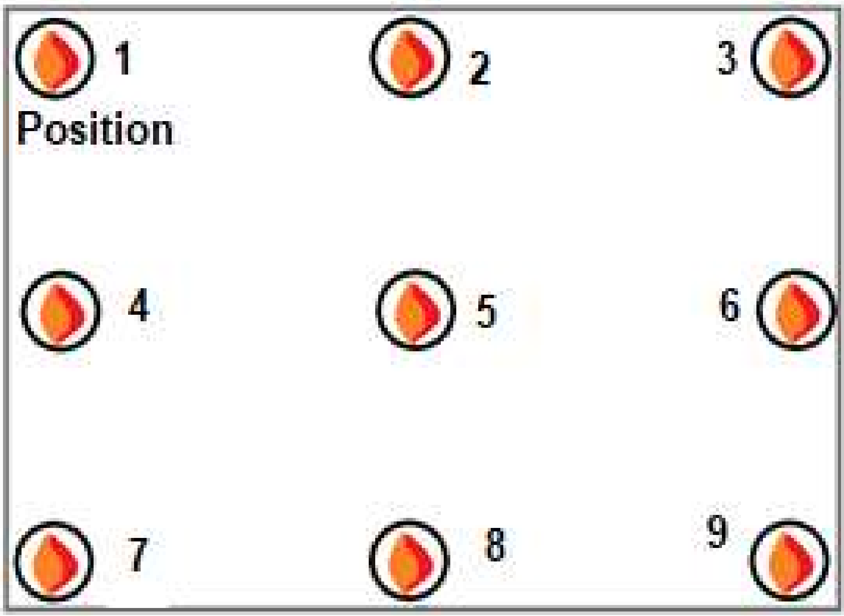


Figure 5 - Nine positions to be measured in the active field of view

The maximum value of response point recorded at any angle in this test and measured for the same specimen in the reproducibility test shall be designated D_{max} and the minimum value designated D_{min}.

3.2.3.3.3 Test procedure

The radio of the response points D_{max}:D_{min} shall not be greater than 1.41.

3.2.4 Tolerance to supply voltage

3.2.4.1 Variation in supply parameters

3.2.4.1.1 Object

To demonstrate that, within the specified range(s) of the supply parameters (e.g. voltage), the response point of the sensing device is not unduly dependent on these parameters.

3.2.4.1.2 Test procedure – VFD

The response point of the VFD shall be measured in accordance with 3.2.1.5 at the upper and lower limits of the supply parameters (e.g. voltage) range specified by the manufacturer.

The greatest of the two response points measured in this test and the response points for any parameter variation measured for the same specimen in the reproducibility test shall be designated D_{max} and the least shall be designated D_{min}.

3.2.4.1.3 Test procedure – VFDS

The processing hub and sensors shall be configured together to represent the worst case e.g. longest cable length (or simulated) as agreed with the manufacturer.

The response point of the VFDS shall be measured in accordance with 3.2.1.5 at the upper and lower limits of the supply parameters (e.g. voltage) range for the processing hub specified by the manufacturer.

The greatest of the four response points measured in this test and the response points for any parameter variation measured for the same specimen in the reproducibility test shall be designated D_{max} and the least shall be designated D_{min}.

3.2.4.1.4 Requirements

The ratio D_{max}:D_{min} shall not be greater than 1.26.

3.2.5 Performance parameters under fire conditions

3.2.5.1 Fire sensitivity

3.2.5.1.1 Object

To demonstrate that the VFD/VFDS has adequate sensitivity to fire as required for general application in fire detection systems, and to determine the detection distance capabilities.

3.2.5.1.2 Test procedure

The test consists of exposing four sensing devices to the radiation from two types of test fires at known distances, *d1 (minimum separation) and d2 (maximum separation)*, to determine if the VFD/VFDS are capable of producing an alarm signal within 30 s.

All VFD/VFDS shall be connected to supply and monitoring equipment as described in 3.2.1.2. The distances to the sensing devices shall be measured from the plane of the sensing elements to the centre of the fire.

The two least sensitive sensing device shall be tested at the maximum distance specified by the manufacturer. These shall be mounted on a support with their optical axes in the horizontal plane and at a height of (1,5 ± 0,2) m. The two most sensitive sensing devices shall be tested at the minimum distance specified by the manufacturer. These shall be mounted on a support with their optical axes in the horizontal plane and at a height of (1,0 ± 0,2) m. These two sensing devices should be placed as close to each other as possible (with the sensors no further than 300mm apart) and positioned to face the fire.

The test fire trays in accordance with C.1 shall be placed at the maximum distance from the least sensitive samples and the minimum distance from the most sensitive samples as shown in Figure 3. The sensing devices shall be shielded from radiation and shall be allowed to stabilize for at least 15 minutes or for a period specified by the manufacturer. The fire tray, containing n-heptane, shall be ignited and allowed to burn for at least 1 min. The shutter shall then be removed and all four sensing devices exposed to the radiation from the fire for a period of 30 s. At the end of the 30 s period the sensing devices shall again be shielded from the fire radiation and the status of each one recorded.

This procedure shall then be repeated for the other test fire using methylated spirits.

If all 4 VFD/VFDS are in the alarm condition at the end of each fire test, then they shall have passed the test fire. If one or more VFD/VFDS has failed to respond, then the VFD/VFDS shall have failed the test fire.

This test may be performed outside if this is considered a worse case, however measures will need to be in place to ensure that the movement of air around the test fires remains below 5m/sec. This may be achieved by shielding the test fires from any wind and radiation sources which may affect the response of the VFD/VFDS. With the agreement of the manufacturer, the atmospheric conditions may fall outside of the ranges specified in 3.2.1.1.

The VFD or VFDS should be configured in such a way that is representative of installation with no masking either physically or through software. If there are configurations that can affect the performance of the VFD/VFDS response, then those shall be selected which are considered to be most onerous.

For VFDS or VFDs with multiple sensitivity settings, it will be necessary to determine the response to the fire tests at the specified maximum and minimum distances for each sensitivity.

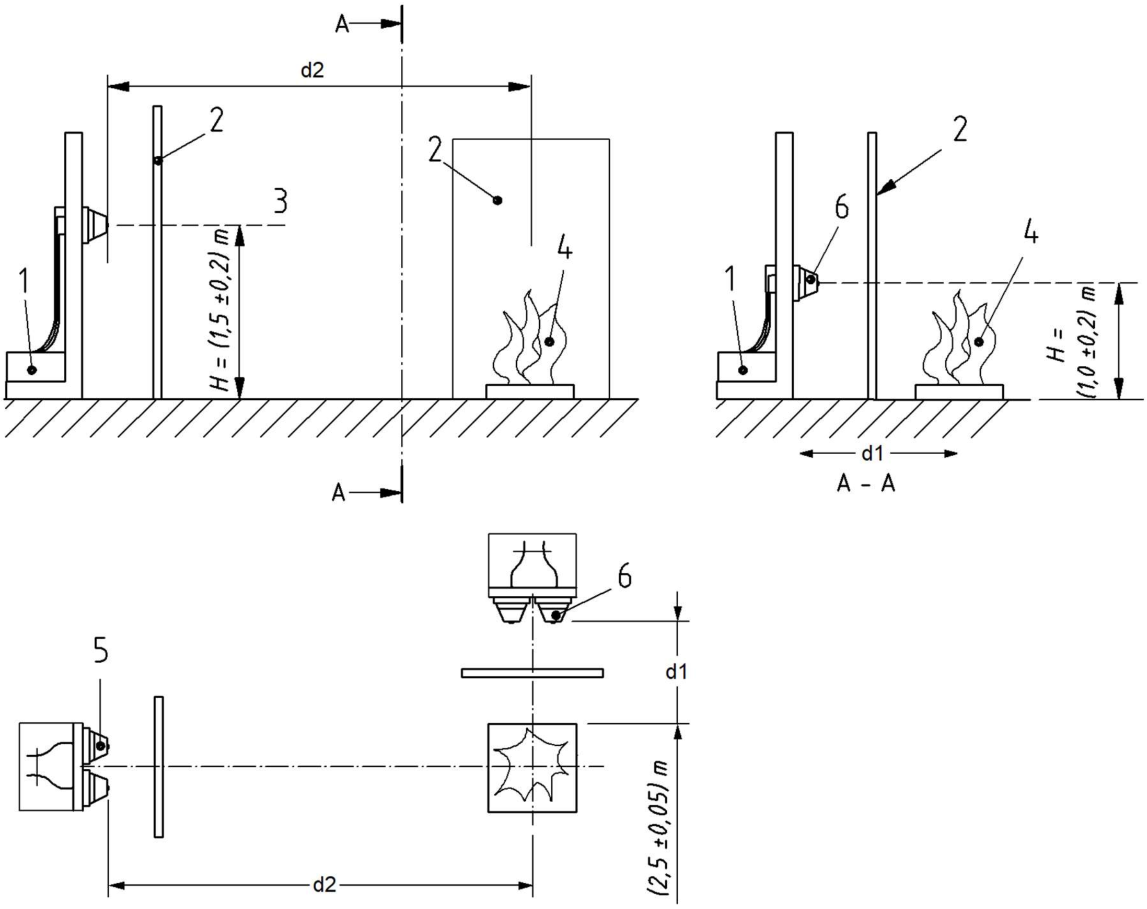


Figure 6 - Fire sensitivity test

Key

d1	Detection distance (minimum)
d2	Detection distance (maximum)
1	Supply and monitoring equipment
2	Shield to be removed during test
3	Horizontal optical axis of sensing devices
4	Test fire
5	Least sensitive sensing devices
6	Most sensitive sensing devices

3.2.5.1.3 Requirements

The tested VFDs or VFDSs shall respond to both test fires at the maximum and minimum distances for all specified sensitivity settings.

3.2.6 Environmental conditions

For all environmental conditions tests the following apply:

- For VFDs the units shall be subjected to the Type test
- For VFDSs the sensing device shall be subjected to the Type test and the processing hub shall only be tested to Type A conditions. If two Type tests are required they do not need to be performed at the same time.

3.2.6.1 Temperature resistance

3.2.6.1.1 Dry heat (operational)

***3.2.6.1.1.1* Object**

To demonstrate the ability of the VFD or VFDS to withstand a high ambient temperature appropriate to its application.

***3.2.6.1.1.2* Test procedure and apparatus**

3.2.6.1.1.2.1 General

The test procedure and apparatus shall be as required by EN 60068-2-2:2007 as amended by EN 60068-2-2:2007 Test Bb, and by 3.2.6.1.1.2.2 to 3.2.6.1.1.2.4.

3.2.6.1.1.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 3.2.1.3 and shall be connected to supply and monitoring equipment as described in 3.2.1.2.

3.2.6.1.1.2.3 Conditioning

The following conditioning shall be applied:

Table 4 — Conditions for dry heat (operational) test

Type	Temperature (°C)	Duration (h)
A	55 ± 2	16
B	70 ± 2	16

3.2.6.1.1.2.4 Measurements during conditioning

The specimen shall be monitored during the conditioning period to detect any alarm or fault signals. During the last thirty minutes of the conditioning the specimen shall be subjected to the reduced functional test in accordance with 3.2.1.6.

3.2.6.1.1.2.5 Final measurements

No alarm or fault signals shall be given during the transition to the conditioning temperature, or during the conditioning. After the recovery period of at least 1 hour at standard laboratory conditions the response point of the specimen shall be measured in accordance with 3.2.1.5. The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.1.1.3 **Requirements**

No alarm or fault signals shall be given during the transition to the conditioning temperature or during the conditioning.

The specimen shall give an alarm signal in response to the reduced functional test.

The ratio $D_{max}:D_{min}$ shall be not greater than 1.26.

3.2.6.1.2 Dry heat (endurance)

3.2.6.1.2.1 **Object of the test**

To demonstrate the ability of the VFDs or VFDSs to withstand long-term ageing effects.

3.2.6.1.2.2 **Test procedure**

3.2.6.1.2.2.1 Reference

The tests apparatus and procedure shall be described in test Bb of EN 60068-2-2:2007 as amended by EN 60068-2-2:2007.

3.2.6.1.2.2.2 State of the specimen during conditioning

The specimen shall not be supplied with power during the conditioning.

3.2.6.1.2.2.3 Conditioning

The test conditions in Table 5 shall be applied.

Table 5 — Conditions for dry heat (endurance) test

Type	Temperature (°C)	Duration (days)
A	No test	No test
B	70 ± 2	21

3.2.6.1.2.2.4 Measurements during conditioning

No measurements are required during the conditioning.

3.2.6.1.2.2.5 Final measurements

After the recovery period of at least 1 hour at standard laboratory conditions the response point of the specimen shall be measured in accordance with 3.2.1.5.

The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

***3.2.6.1.2.3* Test requirements**

The ratio D_{max}:D_{min} shall be not greater than 1.26.

3.2.6.1.3 Cold (operational)

***3.2.6.1.3.1* Object**

To demonstrate the ability of the VFDs or VFDSs to function correctly at low ambient temperatures appropriate to the anticipated service temperature.

***3.2.6.1.3.2* Test procedure and apparatus**

3.2.6.1.3.2.1 General

The test apparatus and procedure shall be as required by EN 60068-2-1:2007 as amended by EN 60068-2-1:2007, Test Ab, and by 3.2.6.1.3.2.2 to 3.2.6.1.3.2.4.

3.2.6.1.3.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 3.2.1.3 and shall be connected to supply and monitoring equipment as described in 3.2.1.2.

3.2.6.1.3.2.3 Conditioning

The following conditioning shall be applied:

Table 6 — Conditions for cold (operational) test

Type	Temperature (°C)	Duration (h)
A	-10 ± 3	16
B	-25 ± 3	16

3.2.6.1.3.2.4 Measurements during conditioning

The specimen shall be monitored during the conditioning period to detect any alarm or fault signals. During the last thirty minutes of the conditioning the specimen shall be subjected to the reduced functional test in accordance with 3.2.1.6.

After the recovery period of at least 1 hour at standard laboratory conditions the response point of the specimen shall be measured in accordance with 3.2.1.5.

The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.1.3.3 **Requirements**

No alarm or fault signals shall be given during the transition to the conditioning temperature, or during the conditioning.

The specimen shall give an alarm signal in response to the reduced functional test.

The ratio D_{max}:D_{min} shall be not greater than 1.26.

3.2.6.1.4 Operational extreme temperature test (option)

3.2.6.1.4.1 **Object**

To demonstrate the ability of the VFDs or VFDSs to function correctly at extreme temperatures appropriate to the anticipated service temperature and outside of those covered in the Clause 3.2.6.1.1 Dry Heat (operational) and 3.2.6.1.3 Cold (operational) tests.

3.2.6.1.4.2 **Test procedure and apparatus**

3.2.6.1.4.2.1 General

Extreme cold test

The test apparatus and procedure shall be as required by EN 60068-2-1:2007 as amended by EN 60068-2-1:1993/A1:1993 and EN 60068-2-1:1993/A2:1994, Test Ab, and by 3.2.6.1.3.2.2 to 3.2.6.1.3.2.4. This test shall be carried out at the minimum temperature, C, requested by the manufacturer, down to a minimum of -40°C

Extreme heat test

The test procedure and apparatus shall be as required by EN 60068-2-2:2007 as amended by EN 60068-2-2:1993/A1:1993 Test Ba or Bb, and by 3.2.6.1.1.2.2 to 3.2.6.1.1.2.4. This test shall be carried out at the maximum temperature, H, requested by the manufacturer up to a maximum of 80°C.

3.2.6.1.4.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 3.2.1.3 and shall be connected to supply and monitoring equipment as described in 3.2.1.2.

3.2.6.1.4.2.3 Conditioning

The following conditioning shall be applied:

Table 7 — Conditions for cold (operational) test

Extreme test	Temperature °C	Duration h
Heat	H ± 3	16
Cold	C ± 3	16

3.2.6.1.4.2.4 Measurements during conditioning

The specimen shall be monitored during the conditioning period to detect any alarm or fault signals. During the last thirty minutes of the conditioning the specimen shall be subjected to the reduced functional test in accordance with 3.2.1.6.

After the recovery period of at least 1 hour at standard laboratory conditions the response point of the specimen shall be measured in accordance with 3.2.1.5.

The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.1.4.3 **Requirements**

No alarm or fault signals shall be given during the transition to the conditioning temperature, or during the conditioning.

The specimen shall give an alarm signal in response to the reduced functional test.

The ratio D_{max}:D_{min} shall be not greater than 1.26.

3.2.6.2 Humidity resistance

3.2.6.2.1 Damp heat, cyclic (operational)

3.2.6.2.1.1 Object

To demonstrate the immunity of the VFDs or VFDSs to an environment with high relative humidity where condensation may occur on the equipment.

3.2.6.2.1.2 Test procedure and apparatus

3.2.6.2.1.2.1 General

The test apparatus and procedure shall be as described in EN 60068-2-30:2005, using the Variant 1 test cycle and controlled recovery conditions, and as described by 3.2.6.2.1.2.2 to 3.2.6.2.1.2.4.

3.2.6.2.1.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 3.2.1.3 and shall be connected to supply and monitoring equipment as described in 3.2.1.2.

NOTE: Any feature intended to monitor the transmission of the sensing device window may be disabled during this test.

3.2.6.2.1.2.3 Conditioning

The following severity of conditioning shall be applied:

Table 8 — Conditions for Damp heat, cyclic (operational) test

Type	Lower temperature (°C)	Relative humidity (lower temperature) (%)	Upper temperature (°C)	Relative humidity (upper temperature) (%)	Number of cycles
A	25 ± 3	> 95	40 ± 2	93 ± 3	2
B	25 ± 3	> 95	55 ± 2	93 ± 3	2

3.2.6.2.1.2.4 Measurements during conditioning

The specimen shall be monitored to detect any alarm or fault signal during the conditioning.

During the last thirty minutes of the high temperature phase of the last cycle the VFD or VFDS shall be subjected to the reduced functional test described in 3.2.1.6.

After the recovery period of at least 1 hour at standard laboratory conditions the response point of the specimen shall be measured in accordance with 3.2.1.5.

The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.2.1.2.5 Requirements

No alarm or fault signals shall be given during the transition to the conditioning temperature or during the conditioning. The specimen shall give an alarm signal in response to the reduced functional test.

The ratio D_{max}:D_{min} shall be not greater than 1.26.

3.2.6.2.2 Damp heat, cyclic (endurance)

3.2.6.2.2.1 Object of the test

To demonstrate the ability of the VFDs or VFDSs to withstand the longer-term effects of high humidity and condensation.

3.2.6.2.2.2 Test procedure

3.2.6.2.2.2.1 Reference

The test apparatus and procedure shall be as described in EN 60068-2-30:2005, using the Variant 1 test cycle and controlled recovery conditions.

3.2.6.2.2.2.2 State of the specimen during conditioning

The specimen shall not be supplied with power during the conditioning.

3.2.6.2.2.2.3 Conditioning

The test conditionings in Table 9 shall be applied.

Table 9 — Conditions for Damp heat, cyclic (endurance) test

Type	Temperature (°C)	Number of cycles
A	No test	No test
B	55 ± 2	6

3.2.6.2.2.2.4 Measurements during conditioning

No measurements are required during the conditioning.

3.2.6.2.2.2.5 Final measurements

After the recovery period of at least 1 hour at standard laboratory conditions the response point of the specimen shall be measured in accordance with 3.2.1.5. The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.2.2.3 Test requirements

The ratio D_{max}:D_{min} shall be not greater than 1.26.

3.2.6.2.3 Damp heat, steady state (endurance)

3.2.6.2.3.1 Object

To demonstrate the ability of the VFDs or VFDSs to withstand the long term effects of humidity in the service environment (examples include changes in electrical properties of materials, chemical reactions involving moisture, galvanic corrosion etc.).

3.2.6.2.3.2 Test procedure and apparatus

3.2.6.2.3.2.1 General

The test apparatus and procedure shall be described in EN 60068-2-78:2013, test Cab as described below.

3.2.6.2.3.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 3.2.1.3 but shall not be supplied with power during the conditioning.

3.2.6.2.3.2.3 Conditioning

The following conditioning shall be applied:

Table 10 — Conditions for Damp heat, steady state (endurance) test

Type	**Temperature (°C)**	**Relative humidity (%)**	**Duration (days)**
A & B	40 ± 2	93 ± 3	21

3.2.6.2.3.2.4 Final measurements

After the recovery period of at least 1 hour at standard laboratory conditions the response point of the specimen shall be measured in accordance with 3.2.1.5.

The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.2.3.3 Requirements

The ratio D_{max}:D_{min} shall be not greater than 1.26.

3.2.6.3 Corrosion resistance

3.2.6.3.1 Sulphur dioxide (SO_2) corrosion (endurance)

3.2.6.3.1.1 Object

To demonstrate the ability of the VFDs or VFDSs to withstand the corrosive effects of sulphur dioxide as an atmospheric pollutant. For VFDSs the sensing device shall be subjected to this test but is not required for the processing hub.

3.2.6.3.1.2 Test procedure and apparatus

3.2.6.3.1.2.1 General

The test apparatus and procedure shall be as described in EN 60068 2-42:2003, Test Kc, except for the relative humidity of the test atmosphere, which shall be maintained (93 ± 3) % instead of (75 ± 5) %.

3.2.6.3.1.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 3.2.1.3. It shall not be supplied with power during the conditioning, but it shall have untinned copper wires, of the appropriate diameter, connected to sufficient terminals to allow the final measurement to be made, without making further connections to the specimen.

3.2.6.3.1.2.3 Conditioning

The following conditioning shall be applied;

Temperature	(25 ± 2) °C
Relative humidity	(93 ± 3) %
SO_2 concentration	(25 ± 5) ppm
Duration	21 days

3.2.6.3.1.2.4 Final measurements

Immediately after conditioning, the specimen shall be subjected to a drying period of 16 h at 40 °C and not more than 50 % relative humidity, followed by a recovery period of at least 1 hour at standard laboratory conditions. After this recovery period the response point of the specimen shall be measured in accordance with 3.2.1.5.

The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.3.1.3 Requirements

The ratio D_{max}:D_{min} shall be not greater than 1.26.

3.2.6.4 Shock and vibration resistance

3.2.6.4.1 Shock (operational)

3.2.6.4.1.1 Object

To demonstrate the immunity of the sensing device only to mechanical shocks, which are likely to occur, albeit infrequently, in the anticipated service environment.

3.2.6.4.1.2 Test procedure and apparatus

3.2.6.4.1.2.1 General

The test apparatus and procedure shall be generally as described in Test Ea of EN 60068-2-27:2009 expect that the conditioning shall be described in 3.2.6.3.2.1.2.2 to 3.2.6.3.2.1.2.5.

3.2.6.4.1.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 3.2.1.3 to a rigid fixture, and shall be connected to its supply and monitoring equipment as described in 3.2.1.2.

3.2.6.4.1.2.3 Conditioning

No test is applied to specimens with a mass > 4.75 kg. For specimens with a mass ≤ 4.75 kg the following conditioning shall be applied:

Shock pulse type:	Half sine
Pulse duration:	6 ms
Peak acceleration:	$10 \times (100 - 20\boldsymbol{M})$ m s^{-2} (Where $\boldsymbol{M}$ (kg) is the specimen's mass)
Number of directions:	6
Pulses per direction:	3

3.2.6.4.1.2.4 Measurements during conditioning

The specimen shall be monitored during the conditioning period and for a further 2 minutes to detect any alarm or fault signals.

3.2.6.4.1.2.5 Final measurements

The response point of the specimen shall be measured in accordance with 3.2.1.5.

The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.4.1.3 Requirements

No alarm or fault signal shall be given during the conditioning period or further 2 minutes.

The ratio D_{max}:D_{min} shall be not greater than 1.26.

3.2.6.4.2 Impact (operational)

3.2.6.4.2.1 Object

The sensing device only is tested to demonstrate its immunity to mechanical impacts upon its surface, which it may sustain in the normal service environment and which it can reasonably be expected to withstand.

3.2.6.4.2.2 Test procedure and apparatus

3.2.6.4.2.2.1 General

The test shall be conducted in accordance with EN 60068-2-75:2014 and 3.2.6.4.2.2.2 to 3.2.6.4.2.2.5.

3.2.6.4.2.2.2 State of the specimen during conditioning

Adjust the specimen to the maximum sensitivity, and mount and connect in accordance with 3.2.1.5.

3.2.6.4.2.2.3 Conditioning

The following conditioning shall be applied:

Impact energy:	(0,5 ± 0.04) J;
Number of impacts per point:	3.

For each component of the sensing device in turn, apply impacts to each point on the component which is deemed to be susceptible to mechanical damage that would impair it's correct operation, up to a maximum of 20 points on each component (lenses, windows etc. that may be deemed susceptible to damage). No two points at which the impacts are applied shall be less than 20 mm apart. Care shall be taken to ensure that the results from one series of three blows do not influence subsequent series. In case of doubt with regard to the influence of preceding blows, the defect shall be disregarded and a further three blows shall be applied to the same position on a new specimen.

3.2.6.4.2.2.4 Monitoring during conditioning

Where the application of the impact apparatus does not obscure the field of view of the sensing device, monitor the specimen to detect any alarm or fault signals.

3.2.6.4.2.2.5 Final measurements

After the conditioning, measure the response threshold in accordance with 3.2.1.5. The greater of the RTVs measured in this test and that measured for the same specimen in the reproducibility test, shall be designated D_{max} the lesser shall be designated D_{min}.

3.2.6.4.2.2.6 Requirements

No alarm or fault signals shall be given during the conditioning except when the sensing device is obstructed by the impact apparatus. The ratio of the response points D_{max}:D_{min} shall not be greater than 1.26.

3.2.6.4.3 Vibration, sinusoidal (operational)

3.2.6.4.3.1 Object

To demonstrate the immunity of the sensing device only to vibration levels considered appropriate to the normal service environment.

3.2.6.4.3.2 Test procedure and apparatus

3.2.6.4.3.2.1 General

The test apparatus and procedure shall be as described in Test Fc of EN 60068-2-6:2008 and as described in 3.2.6.4.3.2.2 to 3.2.6.4.3.2.5.

3.2.6.4.3.2.2 State of the specimen during conditioning

The specimen shall be mounted on a rigid fixture as described in 3.2.1.3 and shall be connected to its supply and monitoring equipment as described in 3.2.1.2. The field of view of the sensing device shall be of a uniform and plain background. The vibration shall be applied in each of three mutually perpendicular axes, in turn. The specimen shall be mounted so that one of the three axes is perpendicular to is normal mounting plane.

3.2.6.4.3.2.3 Conditioning

The following conditioning shall be applied:

Frequency range:	2 Hz to 10 Hz
Displacement amplitude:	1.24 mm
Frequency range:	10 Hz to 150 Hz
Acceleration amplitude:	5 m s^{-2} (≈0,5 g_n)
Number of axes:	3
Sweep rate:	1 octave min^{-1}
Number of sweep cycles per axis:	1

The vibration operational and endurance tests may be combined such that the specimen is subjected to the operational test conditioning followed by the endurance test conditioning in one axis before changing to the next axis. Only one final measurement needs to be made.

3.2.6.4.3.2.4 Measurements during conditioning

The specimen shall be monitored during the conditioning period for any alarm/fault signals.

3.2.6.4.3.2.5 Final measurements

The final measurements specified in 3.2.1.5 are normally made after the vibration endurance test and only need to be made here if the operational test is conducted in isolation.

3.2.6.4.3.2.6 Requirements

No alarm or fault signals shall be given during the conditioning. The ratio of the response points D_{max}:D_{min} shall not be greater than 1.26.

3.2.6.4.4 Vibration, sinusoidal (endurance)

3.2.6.4.4.1 Object

To demonstrate the ability of the sensing device only to withstand the long term effects of vibration at levels appropriate to the service environment.

3.2.6.4.4.2 Test procedure and apparatus

3.2.6.4.4.2.1 General

The test apparatus and procedure shall be described in Test Fc of EN 60068-2-6:2008, and as described in 3.2.6.4.4.2.2 to 3.2.6.4.4.2.4.

3.2.6.4.4.2.2 State of the specimen during conditioning

The specimen shall be mounted on a rigid fixture as described in 3.2.1.3, but shall not be supplied with power during conditioning. The vibration shall be applied in each of three mutually perpendicular axes, in turn. The specimen shall be mounted so that one of the three axes is perpendicular to its normal mounting axis.

3.2.6.4.4.2.3 Conditioning

The following conditioning shall be applied:

Frequency range:	10 Hz to 150 Hz
Acceleration amplitude:	10 m s^{-2} (≈1,0 g_n)
Number of axes:	3
Sweep rate:	1 octave min^{-1}
Number of sweep cycles per axis:	20

The vibration operational and endurance tests may be combined such that the specimen is subjected to the operational test conditioning followed by the endurance test conditioning in one axis before changing to the next axis. Only one final measurement needs to be made.

3.2.6.4.4.2.4 Final measurements

The response point of the specimen shall be measured in accordance with 3.2.1.5.

The greater of the response points measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.4.4.3 Requirements

The ratio of the response points D_{max}:D_{min} shall not be greater than 1.26.

3.2.6.5 Electrical stability

3.2.6.5.1 Electromagnetic Compatibility (EMC), Immunity tests (operational)

3.2.6.5.1.1 Object

To demonstrate the immunity of the VFD or VFDS to electromagnetic disturbances considered appropriate to the normal service environment.

3.2.6.5.1.2 Test procedure and apparatus

The following EMC immunity tests shall be carried out, using the apparatus and procedures as described in EN 50130-4:2011+A1:2014.

3.2.6.5.1.2.1 General – VFD only

a) Electrostatic discharge;
b) Radiated electromagnetic fields;
c) Conducted disturbances induced by electromagnetic fields;
d) Fast transient bursts;
e) Slow high energy voltage surges.

3.2.6.5.1.2.2 General – VFDs only

a) Electrostatic discharge (on both components);
b) Radiated electromagnetic fields (both components tested together as one system);
c) Conducted disturbances induced by electromagnetic fields (on all cables);
d) Fast transient bursts (on all cables);
e) Slow high energy voltage surges (on all cables).

3.2.6.5.1.2.3 State of the specimen during conditioning

The specimen shall be mounted as described in 3.2.1.3 and shall be connected to supply and monitoring equipment as described in 3.2.1.2.

3.2.6.5.1.2.4 Measurements during conditioning

The specimen shall be monitored during the conditioning period for alarm or fault signals.

3.2.6.5.1.2.5 Final measurements

After conditioning, the response point of the specimen shall be measured in accordance with 3.2.1.5. The greatest of the response points in each of the tests a) to e) measured in this test and that measured for the same specimen in the reproducibility test shall be designated D_{max} and the lesser shall be designated D_{min}.

3.2.6.5.1.3 Requirements

For each test a) to e) the criteria for compliance specified in EN 50130-4:2011+A1:2014 shall apply the ratio of the response values D_{max}:D_{min} shall not be greater than 1.26.

4 CLASSIFICATION AND DESIGNATION

In order to fulfil the performance requirements of this Standard, VFD or VFDS should meet the requirement(s) of this clause, which should then be verified by visual inspection or engineering assessment and tested as described in Clause 3.

In order to express their performance, the detection capabilities of VFD or VFDS are expressed as shown in Table 1) for each sensitivity setting.

Table 1 — Detection Capability

Capability	Distance (m)
Minimum	
Maximum	

5 MARKING, LABELLING AND PACKAGING

5.1 Marking

The VFD or active components of the VFDS shall be clearly marked with the following information, following the guidance in PN 103:

a) the number and date of this Loss Prevention Standard (i.e. LPS 1976:Issue 1);
b) the name or trademark of the manufacturer or supplier;
c) manufacturer or supplier model designation (type or number);
d) some mark(s) or code(s) (e.g. a serial number or batch code), by which the manufacturer can identify, at least, the date or batch and place of manufacture, and the version number(s) of any software, contained within the VFD or VFDS;
e) the detection capability of the VFD or VFDS;
f) environment type [i.e. Type A or B];
g) the wiring terminal designations;

Where any marking on the device uses symbols or abbreviations not in common use then these shall be explained in the data supplied with the device. The marking shall be visible during installation of the VFD or VFDS and shall be accessible during maintenance. The markings shall not be placed on screws or other easily removable parts.Each VFD or VFDS shall be supplied with a reference to the appropriate data in Clause 5.2.

5.2 Data

The information below shall be supplied with the device or shall be available online:

a) operating power source specifications (s);
b) IP Code to EN60529:1992 as amended by EN60529:1992+A2:2013;
c) field of view as determined in 3.2.3.3;
d) the ambient light level operating limits;
e) any other information necessary to allow correct installation, operation and maintenance of the device.

To enable correct operation of the VFD or VFDS, these data should describe the requirements for the correct processing of the signals from the device or system. This may be in the form of a full technical specification of these signals, a reference to the appropriate signalling protocol or a reference to suitable types of control and indicating equipment etc.

6 PUBLICATIONS REFERRED TO:

EN 50130-4:2011, *Alarm systems — Part 4: Electromagnetic compatibility — Product family standard: Immunity requirements for components of fire, intruder and social alarm systems*

EN 54-1:2021, *Fire detection and fire alarm systems – Part 1: Introduction*

EN 54-10:2002 Fire detection and fire alarm systems – Part 10: Flame detectors – Point type detectors using an optical light beam.

EN 60529:1992, *Degrees of protection provided by enclosures (IP code) (IEC 60529:1989)* (including EN 60529:1992/A2:2013)

EN 60068-2-1:2007, *Environmental testing — Part 2-1: Tests — Tests A: Cold (IEC 60068-2-1:2007)* (including EN 60068-2-1:1993/A1:1993 and EN 60068-2-1:1993/A2:1994)

EN 60068-2-2:2007, Environmental testing — Part 2-2: Tests — Test B: Dry heat (IEC 60068-2-2:2007) (Including EN 60068-2-2:1993/A1:1993)

EN 60068-2-6:2008, *Environmental testing — Part 2-6: Tests — Tests Fc: Vibration, (sinusoidal)(IEC 60068-2-6:2007)*

EN 60068-2-27:2009, *Environmental testing — Part 2-27: Tests — Test Ea and guidance: Shock (IEC 60068-2-27:2008)*

EN 60068-2-30:2005, *Environmental testing — Part 2-30: Tests — Test Db: Damp heat, cyclic (12 h + 12 h cycle) (IEC 60068-2-30:2005)*

EN 60068 2-42:2003, *Environmental testing — Part 2-42: Tests; Test Kc: Sulphur dioxide test for contacts and connections (IEC 60068-2-42:2003)*

EN 60068-2-75:2014, *Environmental testing – Part 2-75:Tests; Test Eh: Hammer tests (IEC 60068-2-75:2014)*

EN 60068-2-78:2013, *Environmental testing — Part 2-78: Tests; Test Cab: Damp heat, steady state (IEC 60068-2-78:2012)*

FM 3260:2021 Radiant Energy-Sensing Fire Detectors for Automatic Fire Alarm Signaling

ISO 7240-10:2012 Fire detection and alarm systems – Part 10: Point-type flame detectors

PN103 Rev. 14.2, Rules and Guidance for use of the LPCB Certification Marks (2022)

Annex A
(normative)

Apparatus for response point determination

A.1 Optical bench

The apparatus uses an optical bench to allow the distance between the source and the reference point of the sensing device to be adjusted while maintaining the relative alignment of the optical axes of the source with the sensing device. In order to allow for variations in response point the bench shall have an effective working length of at least 5 m.

The mounting stands used for the specimen and for other parts of the test equipment shall be constrained to move in a direction parallel to the axis of the bench. Means shall be provided to measure the distances between the individual bench-mounted items to an accuracy of ± 10 mm.

The mounting stand shall allow adjustment of the height and orientation of the sensing device such that its optical axis can be made coincident with the source optical axis. The sensing device mounting stand shall also allow the sensing device to be rotated up and down (tilt) as well as left and right (pan), and passing through the point of intersection of the optical axis and the plane of the sensing device sensing element(s). Means shall be provided to measure the angular rotations with an accuracy of ±5°.

An example of a suitable optical bench arrangement is shown in Figure A.1.

The source to stimulate the sensing device into alarm shall be a gas burner.

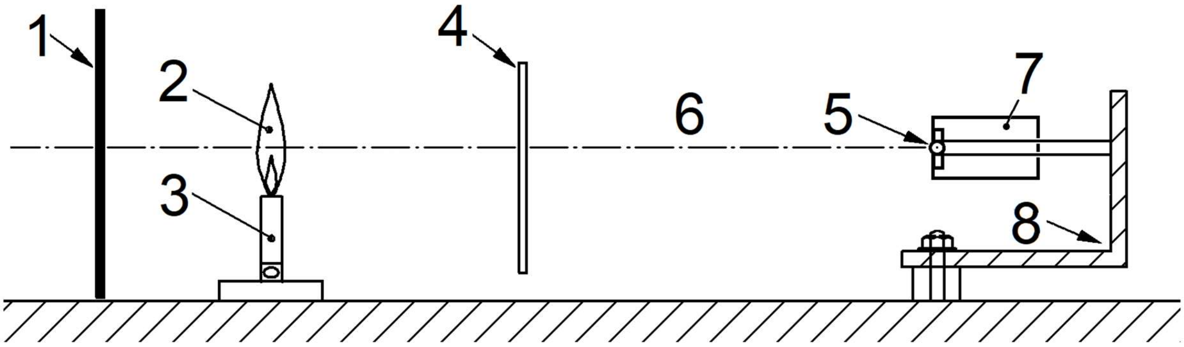
A.2 Radiation source

The radiation shall be produced by a gas burner, burning methane of not less than 98 % purity, whose flame radiation output is in the wavelength band in which the VFD/VFDS under test is intended to operate. The burner should be set with the air mixing slots fully closed so that the flame is visible with a naturally flickering flame. The gas flow should remain constant when the VFD/VFDS's are being tested.

The perpendicular axis through the centre of the flame height shall be considered to be the optical axis of the source.

A non-reflective, black screen shall be used directly behind the flame and should be at least 15 cm from the flame. The screen should be large enough to ensure that FoV of the reference camera does not see outside the screen. It is not necessary for the screen to be large enough to be fully within the FoV of the sensing device.

A gas burner suitable for use as a source is described in Annex B.



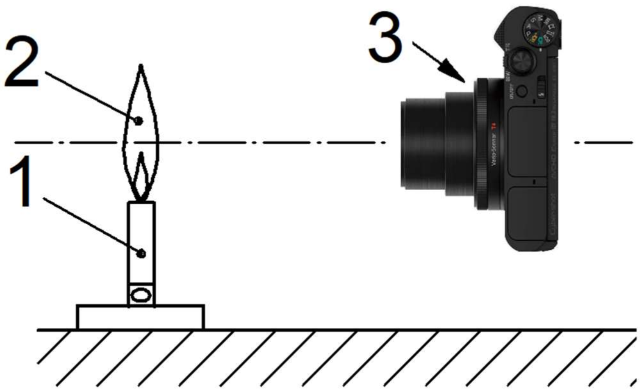
Key

1	Black background screen	5	Sensing element(s)
2	Flame	6	Optical axis
3	Methane gas burner	7	Sensing device
4	Shield	8	Stand for sensing device

Figure A.1 – Optical bench arrangement for tests

A.3 Source stability

A suitable reference camera shall be arranged as shown in Figure A.2 below.



Key

1	Methane gas burner	3	Reference camera
2	Flame		

Figure A.2 – Arrangement of reference camera

The distance of the camera from the flame and the settings of the camera shall be adjusted so that the requirements for source stability, detailed below, are met.

The flickering flame from a gas burner will tend to move around even when there is no significant air movement around the burner. As such the RMSE will sit at a mean level and random fluctuations will take place around the mean.

The video shall be taken with the flame against a black non-reflective background in an area with the average ambient light level of 250±50 lux when measured in the 5 orientations: left, right, up and down the flame bench and facing up. When checked throughout the test programme the variation of individual light measurements (in each of the 5 positions) should not change by more than 20 %.

In order to measure the source stability, the flame from the gas burner is recorded using the reference camera, suitably positioned and configured, such that the flame with the field of view is in the "portrait" orientation. This ensures that the signal:total area of the field of view is higher, leading to greater accuracy of the measurement/s. See Figure A.3 below.

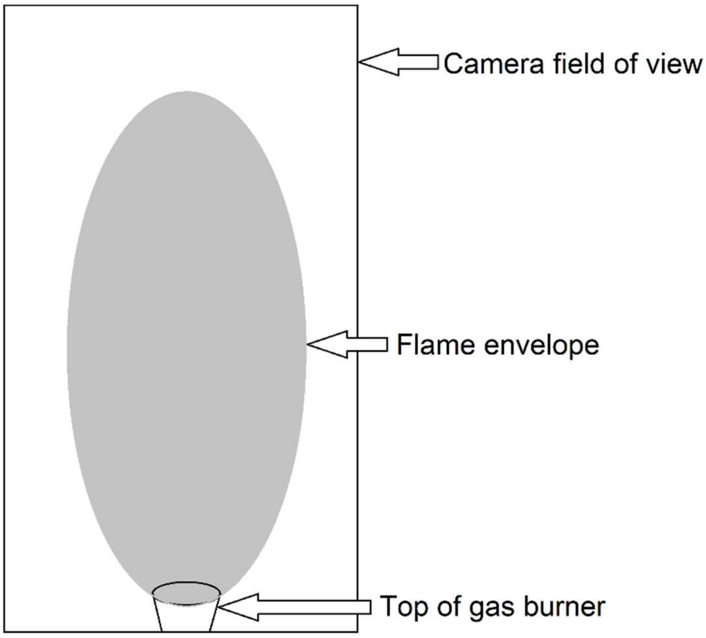


Figure A.3 – Arrangement of flame within field of view of reference camera

The flame envelope, which forms the limits of horizontal and vertical reach of the flame, shall remain wholly within the field of view of the reference camera. A recorded video of the flame should be taken for a period of 5 minutes and the RMSE of the sequence will be derived using the method described in Annex D Calculating the RMSE of a video sequence.

Once this is calculated the RMSE mean should be at 20±5 with a permitted standard deviation of 7.5.

A.4 Shield

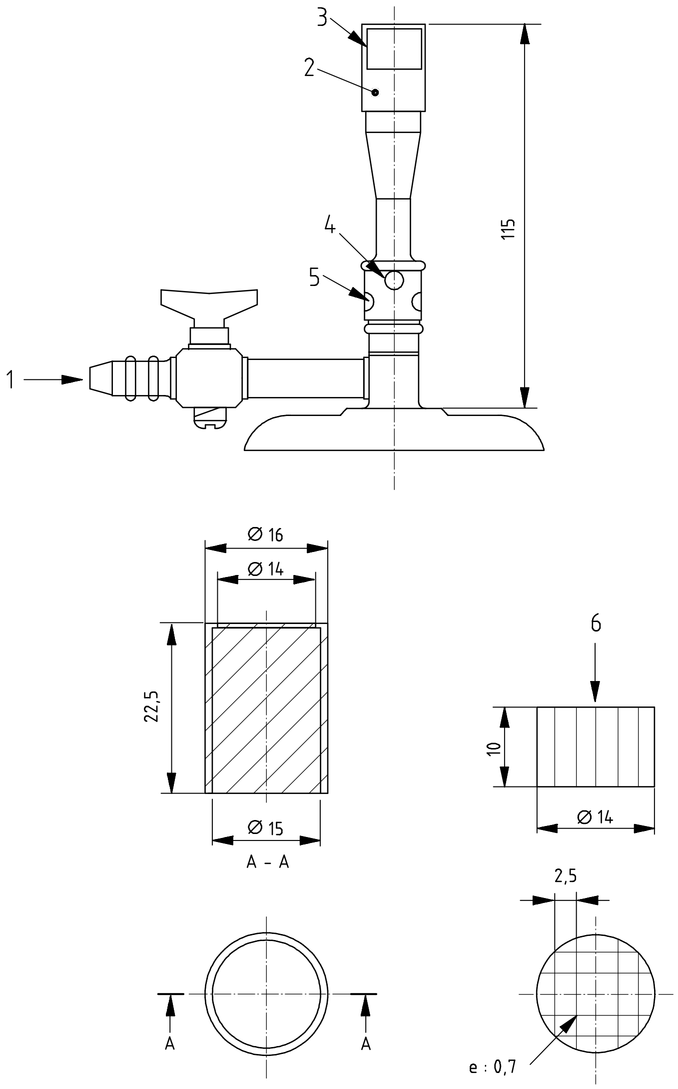
A shield shall be provided such that the specimen can be shielded from the radiation source. The shield shall allow the duration of the exposure of the sensing device to the source to be controlled with an accuracy of ± 0.5 s.

Annex B
(informative)

Example of a methane burner

Figure B.1 shows an example of a burner (Meker burner) which is suitable for the source in A.2. The burner should be supplied with gas at a constant pressure to maintain constant radiated output.

Dimensions in millimetres



Key

1 Gas
2 Piece A
3 Piece B
4 4 holes
5 4 holes

Figure B.1 – Example of methane burner

Annex C
(informative)

Test fires

C.1 n-heptane fire

This fire is intended to represent a fire burning with a yellow (sooty) flame.

a) Fuel:

Approximately 500 ml of n-heptane (pure) with approximately 3 % toluene (pure) by volume. The quantity of fuel used shall be sufficient to ensure that the complete base area of the tray is covered by fuel for the complete duration of the test(s).

b) Arrangement:

The heptane/toluene mixture shall be burned in a square tray made from 2 mm thick sheet steel, with dimensions 330 mm x 330 mm x 50 mm deep.

C.2 Methylated spirit fire

This fire is intended to represent a fire burning with a clear (invisible) flame.

a) Fuel:

Approximately 1500 ml of methylated spirit containing at least 90 % ethyl alcohol (C_2H_5OH) by volume. The quantity of fuel used shall be sufficient to ensure that the complete base area of the tray is covered by fuel for the complete duration of the test(s).

b) Arrangement:

The methylated spirit shall be burned in a square tray made from 2 mm thick sheet steel, with dimensions 500 mm x 500 mm x 50 mm deep.

C.3 Test conditions

For both fires the following apply:

a) Initial temperature:

The initial temperature of the fuel shall be (20 ± 10) °C

b) Ignition:

Ignition shall be by any convenient means which does not affect the initial temperature or composition of the fuel.

c) End of test:

30 s after exposure of sensing devices to fire.

Annex D
(normative)

Calculating the RMSE of a video sequence

D.1 Background

For the purpose of this product standard and utilising an appropriate test method, a simple metric is needed that reflects either the constant or changing levels of flame in a way that replicates VFD/VFDS response.

A method has previously been developed that utilises the image sequence taken from a video to quantify the amount of change.

Fundamentally VFD/VFDSs are looking at changes in pixels (between subsequent images) and their attributes to identify when the changes correspond to a growth of flame.

As other changes such as the ambient light levels and shadows cast by test personnel are also included these should be kept to a minimum and ideally not be present. If not, these changes, not related to the flame, would be included in any analysis of the video sequences generated. When the environment is controlled, the metric reflects the change solely due to the flame and can be used to:

• identify whether the changes within a sequence of images could be considered a linear growth and quantified;

• confirm that a “steady” condition remains within prescribed specifications.

The metric that corresponded to the amount of pixel change within a series of images was the root mean squared error (RMSE) deviation which is the most basic form of how VFDs work. Effectively for each pixel the colour difference (from the original image) is taken, squared and all the squared differences are averaged and the square root of this average is taken and reported as a percentage change. As more of the image changes throughout the dynamic range of the colours for each pixel the greater the reported change. For example, if a video sequence starts off with the first frame completely white which gradually gets darker until the final frame is completely black then this would correspond to a 100% RMSE change.

D.2 Generating a video sequence

The reference camera used for taking the reference video sequences shall be mounted on a tripod and the following should be controlled and minimised:

- Vibration that could cause the field of view of the reference camera to change;
- Light conditions that can change e.g. sunlight coming through a window and changing the ambient illumination;
- Movements within the test area that may directly cast shadows or indirectly lead to changes in the light level in the vicinity of the reference camera field of view;
- Settings on the camera should remain the same (e.g in manual mode with all “auto” functions turned off);
- Turbulence in the test area should be minimised;

- The background used should be the same throughout a test programme and should be kept clean and free of debris/dirt.

D.3 Deriving the RMSE of a video sequence

Once the video sequence has been taken the RMSE needs to be generated for that series of frames. To do this the video file needs to be split into a sequence of frames, an initial frame of this sequence is taken as a reference and each subsequent frame can then be compared to that initial reference frame.

The camera can be shaking for a while once the camera record button has been pressed or the image viewed needs to settle down prior to the first frame being taken. So the first frame could well be 60 seconds into a video sequence. At least an additional 300 seconds of video should be taken and frames for analysis should be taken every second.

Each frame is processed using a suitable algorithm to perform a RMSE comparison of image deviation between each subsequent frame with the initial frame. By noting the time between frames and the associated RMSE values the RMSE of that sequence can be generated. The RMSE is reported as the percentage change of subsequent images from the initial selected frame.

Note that as the RMSE signal can be quite turbulent, a running five second average is taken to smoothen out the peaks and troughs.

AMENDMENTS ISSUED SINCE PUBLICATION

DOCUMENT NO.	AMENDMENT DETAILS	SIGNATURE	DATE
1.3	Amendment to Participating Organisations to remove Governing Body and Expert Groups		Oct 2022

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