Fact File 90

Fire Industry Association

Video Fire Detectors and Detection Systems

1. SCOPE

This FIA Fact File introduces ISO/TS 7240-29, the new ISO Technical Specification (TS) published in June 2017. It gives information as to the nature and content of the standard to assist manufacturers of video fire detectors (VFDs) in achieving design compliance.

The Fact File also discusses the recent BRE/FIA collaborative research project aimed at developing repeatable test methods for testing video fire detectors. It also gives a preliminary insight into the current work being undertaken in ISO to develop installation guidelines for systems using such detectors.

This fact file is to be used in conjunction with the FIA Guidance for VFD (Version 1 December 2009) which remains relevant.

2. INTRODUCTION

ISO/TS 7240-29 is essentially a product standard intended to allow for the type testing and verification of VFDs as stand-alone products. During the development of the standard it became increasingly evident to the experts involved that the ultimate performance of any VFD is intrinsically dependent on the environments in which it is installed. A consideration which was paramount in the thinking and deliberation of the ISO working group.

The ISO working group (ISO/TC21/SC3/WG24) was originally tasked to prepare a full ISO standard giving the general requirements and text methods for assessing the performance of VFDs. However, it was recognised that further work was needed to verify the test methods and techniques intended to be included in the standard before the text could be accepted and published as an ISO standard. ISO/TC21/SC3 therefore decided (in 2016) to publish the work to date as a Technical Specification (TS).

There are major challenges with writing a product standard for VFD which is sufficiently robust without incurring inappropriate costs. This is because, unlike other discreet detection technologies such as point-type smoke, ASD, beam and flame detectors, the performance of a VFD system is inherently dependant on the environment in which it is installed. The environment forms an integral part of the detector and it is therefore very difficult to measure and assess the performance of a VFD when separated from its environment in a reliable and repeatable manner.

This conundrum has tested the working group experts tasked with preparing the ISO product standard for VFD in the absence of any established installation guidance. Hence, while the appropriateness of the product tests (defined in TS 7240-29) is being considered by test houses and manufacturers alike, the ISO working group has been tasked to prepare installation guidance (ISO TS 7240-30). It is anticipated that the two documents will converge into a coherent solution to ensure the robustness of the VFD approach and an increased confidence in the advantages it can offer over other detection techniques.

3. BACKGROUND

ISO/TC21/SC3 decided to develop a VFD standard in 2011 with a US convenor (decision 263 adopted in Chicago). A new working group, ISO/TC21/SC3/WG24 was formed. WG24 spent many hours drafting ISO/TS 7240-29, taking input from existing content and recommendations in the FM (3232) and UL (268b) standards for VFD while adopting the approach and structure of EN and ISO 7240 series of product standards.

In general, product standards define a minimum performance expectation (e.g. a point type smoke detector should detect four standard test fires; TF2,3,4 & 5) and tests the consistency of this response when exposed to environmental trials. The latter requires a convenient technique for assessing the sensitivity of the device (e.g. point type detectors are exposed to a controlled smoke ramp in a smoke tunnel).

In this respect, the main challenges for testing VFD are:

- the definition of an RTV (Response Threshold Value) method – how does one measure the “smokiness” of the video image when the complex algorithms used in the various products submitted for testing can vary significantly. Moreover, these algorithms are most often kept confidential.
- the provision of meaningful fire performance tests that reflect the expectations of existing VFD products/techniques while also providing a degree of equivalence to the performance of more traditional techniques as defined by existing test fires.

These two issues relate separately to smoke detection and flame detection – so there were effectively four issues to address. These four issues eventually became the focus of the FIA sponsored research programme undertaken by BRE (further information below). Unfortunately, the final results of the BRE/FIA research project were not available to the ISO WG24 before publication of ISO/TS 7240-29 but, despite this, some of the early principles of this BRE/FIA research have been adopted by ISO.

For example, in terms of the RTV measurement of smoke, the technique of using a recording of a fire projected on an LCD screen and monitored by the VFD under test was shown to be feasible by the BRE/FIA research. This method is now included in the ISO standard as an alternative to performing repeated small-scale test fires to measure the sensitivity before and after each resilience environmental test, e.g. temperature, EMC, shock, etc.

Whichever the method, the ISO standard uses the time from ignition to be the measure of the fire sensitivity. This time is used to quantify any deviation in sensitivity for each resilience environmental test. By using time as the measure, it is assumed that the fire growth of test fires, (live or recorded) is gradual – ideally a smooth smoke ramp. However, the ISO/TS 7240-29 does not preclude the use of an RTV test fire which develops with a step change in whatever phenomena the VFD is responsive to (movement, contrast, colour etc) which would consistently cause an alarm to be triggered at the same time and, thus, obscure any sensitivity issues which could have been exposed by the environmental tests.

It does not define any particular characteristic of the small-scale test fire but the intention/assumption is that the fire grows steadily. As described below, the BRE/FIA research goes significantly further and proposes a measurement for the smokiness of the video image.

4. OVERVIEW OF ISO/TS 7240-29

ISO/TS 7240-29 specifies the requirements, test methods and performance criteria for video fire detectors (VFD), which operate in the visible spectrum.

As with similar standards there are 4 key elements:

1. A number of specific requirements are defined to ensure that the detector has adequate fault monitoring capability and is not unduly affected by the most likely failure modes (e.g. covered lens and low light)
2. Various environmental tests are undertaken, and the sensitivity checked to ensure that it has not changed significantly as a result of the particular conditioning applied (e.g. cold, vibration, SO2 and EMC).
3. The sensitivity assessment requires a reproducible test method – typically using a repeatable “smooth ramp” to see how much smoke (or flame) is needed to set it into alarm – known as the VFD’s “response threshold value”.
4. Finally, a set of fire tests are undertaken to ensure that the detector is responsive to the range of “typical” fires that it would be expected to detect.

These are described in more details below but first, the standard makes a clear distinction between smoke and flame detection - defining the former as Type A and the latter as Type B detectors. Importantly, it accommodates detectors which responds to either phenomena and defines a type AB detector (which may respond to smoke emitted during the flame tests or to the flames occurring during the smoke tests) as distinct from a combined VFD (Type A and Type B) which can respond to flame OR smoke and report and monitor for them separately. Note that a Type AB VFD may not signal an alarm for fires where only flame or only smoke are present but such a detector may be significantly less prone to false alarms.

Similar to other ISO 7240 (and EN 54) standards, part 29 does not specify false alarm tests but uniquely it includes a clause stating that “detectors shall be immune from phenomena that can cause unwanted alarms” and allows for optional, unspecified testing to demonstrate any such claims of immunity. Whether this clause will be retained or expanded on in the next revision remains to be seen.

However, the standard does address a number of critical lens faults which may prevent correct operation of the VFD. These include;

- a change of focus of the lens (clause 4.5 & 5.6)
- contamination of the lens (clause 4.6 & 5.4)
- complete obscuration of the lens (clause 4.6 & 5.5)

The focus and contamination are tested by defocusing or contaminating the lens to the point of fault then checking for excessive changes in sensitivity (<1.6 ratio) just before a fault is declared.

In terms of ambient light, clause 4.14 of ISO/TS 7240-29 requires operation in illumination levels 15-10,000 lux and tests the lower according to clause 5.8. The upper limit is only tested for outdoor applications in clause 5.9 at a contradictory level of 20,000 lux. Additionally, a test is incompletely described in clause 5.10 to investigate whether the VFD can operate when there are areas of high and low illumination within its Field of View (FoV). These anomalies were areas of prolonged discussion within the working group and should be addressed in the next revision.

Clause 5.11 investigates whether artificial light sources adversely affect the VFD including; fluorescent light, metal halide light, halogen light. LED beacon, rotating beacon, xenon beacon, high pressure sodium light, low pressure sodium, incandescent light, HID xenon light and laser light. Clause 5.12 extends this to arc welding. In all case the VFD must not signal fire or fault.

Functionally, the standard requires a red LED to indicate when an alarm has been detected. This is a standard feature of all detection devices in the ISO 7240 and EN 54 series. However, uniquely for VFD, the red ELD is not require if the "VFD displays an image of the FOV to the user". This concession was made on the assumption that the user display clearly indicates a fire condition, and its location (most usually with a bounding box of some sort) but it is not explicitly stated.

There are some standard requirements regarding connectivity within the system:

- open or short on connections to ancillary devices shall not prevent correct operation
- removal of a detachable camera shall give a fault
- faults in the transmission path shall not affect more than one VFD.

Another standard requirement is that "adjustments" must have appropriate access codes or special tools to be compliant with the standard.

With regard to declarations by the manufacturer there are some specific points:

1. The type (A/B/AB) must be stated (clause 4.2) – multiple types may be declared.
2. Detection ranges must be specified (clause 4.4).
3. The Ingress Protection (IP) must be declared according to Table 2 (see table below).
4. The operating temperature must be declared according to Table 3 (see table below).

APPLICATION	IP RATING (TABLE 2)	TEMPERATURE (TABLE 3)
Indoor controlled	IP30	0 °C to 40 °C
Indoor		−10 °C to 55 °C
Outdoor 1	IP54	−25 °C to 70 °C
Outdoor 2		−40 °C to 55 °C
Special	Nominated by the manufacturer	Nominated by the manufacturer

Note: *For distributed systems these ratings are declared for each sub-assembly/enclosure.*

Environmental tests:

ISO/TS 7240-29 follows the common theme of the ISO 7240 (and EN 54) series of inspecting and comparing the sensitivity of the detector when subjected to environmental conditioning. In summary the following conditioning is applied.

CLAUSE	DESCRIPTION	CONDITIONS	REQUIREMENT
5.13	Variation in supply parameters	Upper & lower limits of voltage supply	tmax : tmin ≤ 1.6
5.14	Dry heat (operational)	55°C for 2 hr	tmax : tmin ≤ 1.6
5.15	Dry heat (operational) - optional	70°C for 2 hr	tmax : tmin ≤ 1.6
5.16	Cold (operational)	-10°C for 16 hr	tmax : tmin ≤ 1.6
5.17	Cold (operational) - optional	-40°C for 16 hr	tmax : tmin ≤ 1.6
5.18	Damp heat, steady-state (operational)	40°C RH93% for 4 days	tmax : tmin ≤ 1.6
5.19	Damp heat, steady-state (endurance)	40°C RH93% for 21 days	tmax : tmin ≤ 1.6
5.20	Ingress protection	per IEC 60529	tmax : tmin ≤ 1.6
5.21	SO_2 corrosion (endurance)	25°C RH93% SO2 25ul/l for 21 days	tmax : tmin ≤ 1.6
5.22	Shock (operational)	10g 6ms 6x3 times	tmax : tmin ≤ 1.6
5.23	Impact cameras (operational)	1.9J swinging hammer	tmax : tmin ≤ 1.6
5.24	Impact controllers (operational)	0.5J impact tool	Functional
5.25	Vibration, sinusoidal, (operational)	10-150Hz 5m/s^{-2}	tmax : tmin ≤ 1.6
5.26	Vibration, sinusoidal (endurance)	10-150Hz 10m/s^{-2}	tmax : tmin ≤ 1.6
5.27	EMC immunity (operational)	per IEC 62599-2:	tmax : tmin ≤ 1.6

Note: *It is an anomaly in the standard that there is a performance test applied to ingress protection.*

Sensitivity assessment:

The environmental tests are built on the premise that it is possible to determine the sensitivity of a VFD – called its "response Threshold Value (RTV). This is addressed in Clause 5.1.7 and outlines two approaches, it being the manufacturers decision on which is most appropriate. However, very little specific detail is provided on how to perform the sensitivity test and clause 5.1.7.1 inexplicably requires that the TRTV is measured in the fire test room which may be unnecessary. The two approaches are:

- to repeat a small-scale test fire "specified by the manufacturer and agreed by the test house" or
- to record/film a suitable test fire and then use this high-resolution recording, played back on a large screen, to activate the VFD.

Neither approach includes any recommendations on the nature of the test fire (smoke or flame) which is one of the shortcomings of the standard. There are some recommendations for the second approach with respect to the quality of the camera and playback device used to reproduce the test fire but these are arguable "pseudo prescriptive" and do not add much value when the nature of the fire test itself is undefined!

This lack of detail is because, at the time of writing, there was limited experience with defining a suitable test fire to measure sensitivity and, in the case of the second approach, re-projecting it. Clearly the second approach has the advantage of eliminating variances in the test fire itself because the VFD is exposed to a recording of just one test fire – thus better assessing the reproducibility of the VFD without the interference of the variance of the test fire itself.

The issues described above contributed to the decision by ISO/TC21/SC3 to publish Part 29 as a Technical Specification (TS) rather than as a full ISO product standard.

Fire tests:

In a nutshell, different performance tests are defined for each type whereby Type A detectors must respond to smoky fires and type B must respond to flaming fires.

These fires are based on the classic test fires as catalogued in ISO/TS 7240-9. For short range VFD the original tests fire may be performed in a Fire Test Room (FTR). However, as VFD typically have ranges in-excess-of the 9 meters, modified versions of the test fires are performed in more open areas. These use the same fuel source but omit the m & y measurements taken at the ceiling of the FTR to monitor and verify the characteristics of the fire. Instead, the amount of fuel (and how it is burned/overheated) is directly specified in anticipation that adequate reproducibility will be achieved. This approach has not been substantiated which is why the work has been published as a TS initially.

The following table summarises the fire tests to be applied. In order to provide some insight into the logic of why the fires are applied they have been separated into two columns with test fires where smoke is the dominant phenomena listed in column 3 and those where flames are the dominant phenomena in column 4.

TYPE	RANGE	TEST FIRES		CLAUSE	COMMENT/ COMPARISON
		PREDOMINATELY SMOKING FIRES	PREDOMINATELY FLAMING FIRES		
A (smoke)	≤9m	TF2, TF3 & TF8	TF4 & TF5	5.7.2.2	In the standard FTR as per part 15 for multi-sensors (less TF1)
	>9m	TF2c, TF3c & TF8a	TF4a & TF5c	5.7.2.3	Tests modified for open area
B (flame)	≤9m		TF1, TF4 & TF6	5.7.2.4	In the standard FTR as per part 10 for flame (plus TF1)
	>9m		TF1a, TF4a & TF6a	5.7.2.5	Tests modified for open area
AB	≤9m	TF2, TF3 & TF8	TF1, TF4, TF5 & TF6	5.7.2.6.1	May detect flame present in a smoky fire or visa-versa
	>9m	TF2c, TF3c & TF8a	TF1a, TF4a, TF5c & TF6a	5.7.2.6.2	
A and B		Apply fire tests for A and B above	Apply fire tests for A and B above		The detector signals flame and smoke alarms separately

***Note:** there is a typo in clause 5.7.2.5 of the standard which incorrectly calls up the unmodified TF4.*

It may appear confusing that a combined smoke and flame VFD designated as Type A and Type B should detect all the test fires – and so too should a Type AB detector. The difference is that a Type AB detector could respond to the small amounts of smoke emitted by the flaming fire tests or the radiation emitted by a fire intended to test for smoke response (e.g. the glowing wicks in TF3). In contrast a combined detector must activate the correct output for each fire type.

The test fires have been derived from those already existing (see ISO/TS 7240-9) to provide some confidence that the VFD has a similar/comparable performance to more traditional detection technologies. It is still under debate whether they are representative for VFD systems or, as discussed in the introduction to this paper, whether the environment/ background to the image (which is critical to the efficacy of the VFD) needs to be considered in relation to each fire test. For example, detecting white smoke against a white background is almost impossible. However, such potential limitations are very dependent on the details of how the VFD algorithms are designed. In view of these issues the standard was not ready to be published as a full ISO and was published as a TS in 2017.

5. FURTHER RELEVANT PUBLICATIONS AND ONGOING WORK

While the principal objective of this fact file is to introduce ISO/TS 7240-29 it also provides an opportunity to outline some parallel work by BRE/FIA and subsequent work by ISO to draft an installation code.

6. BRE/FIA RESEARCH

In 2012 the FIA set up a VFD Task Group to review and contribute to the work of the ISO WG; nominating the experts to attend and organising site visits to some existing VFD installations. In 2014 this Task Group identified the need for research to support the developing code and initiated a research project with BRE. The project was undertaken in several phases and a briefing paper has been published which summarises the results and recommendations. The results focus on 4 areas; separating the assessment of flame and smoke detection in terms of "bench testing" (to establish the RTV) and full-scale fire tests (to establish performance).

Significantly, the project demonstrated that the RTV measurement technique used for standard flame detectors (as defined in ISO 7240-10 using apparatus to adjust the distance between the detector and a standard small flame) could be suitable for Type B VFD – though it had to be tailored differently for the two VFDs tested.

With regard to performance testing of Type B VFD, the project demonstrated that the existing tests used for flame detectors (see ISO 7240-10) are appropriate.

For Type A detectors, the technique of using a projected video (as adopted by the ISO standard) was successfully deployed to determine the RTV of several systems. In particular, a technique of using the Root Mean Square Error (RMSE) of contrast as a measure of how "smoky" a video image is (compared to an initial/reference image) was deemed to be acceptable as a reference measure for the RTV measurements of Type A VFD. By performing multiple RMSE calculations for each frame of a video sequence it was possible to observe; that the smoke ramp was suitably smooth and that the RMSE value at the point of alarm could be used for assessing any changes in detector sensitivity.

In contrast, work associated with performance testing of Type A VFD, following and adapting the methods outlined in ISO TC 7240-29, were less conclusive. In particular, the "visibility" of smoke to a VFD was observed to be highly dependent on the background and on the intensity (and angle) of the illumination. It was found that testing at night was necessary, and windy days had to be avoided. Another complication was the interference between the flame and smoke elements of the test fires – particularly the reflection of flames that danced on the background. To address this a 1.2m x 1.2m x 2.4m high box was constructed around the test fires with a smoke vent at the top to contain the fires. Early attempts at using a tarpaulin sheet to provide a consistent background were frustrated by movement which affected the RMSE measurement. A plasterboard background was subsequently constructed and provided more consistent results in terms of the smoke ramp as measured by the RMSE value. The response of the detectors included in the research were quite variable with VSD operating with an average 58% success rate for detecting the small volumes of rising smoke that contrasted with the background. While this may appear to be a poor result these fires were particularly challenging and it is unlikely that they would have been detected by traditional

detection techniques. It is also worth noting that these VSD tested also responded with ~52% success rate to the even more challenging condition of smoke against similar colour backgrounds.

The field is open for further research work.

7. OVERVIEW OF DRAFT ISO/TS 7240-30

During the development of ISO/TS 7240-29 it was recognized that, much more than with traditional forms of fire detection, the environment into which a VFD system (VDFS) is installed directly affects the ability to detect an incipient fire. These factors are outside of the scope of ISO/TS 7240-29, but it was felt that they were critical enough that a standard or test specification was required to cover the installation of VFDs.

In March 2018, ISO/TC21/SC3/WG24 started to work on ISO/TS 7240-30; Installation requirements for video fire detectors. It considers the factors that will affect the functionality of a VFD as installed; either as an independent fire detection system (VFDS) or used in conjunction with a fire detection and alarm system (FDAS). The following paragraphs provide a précis of the draft standard (with reference to the specific clauses where relevant) as it stands in Spring 2021 (Draft #21).

Equipment and material (Clause 4):

ISO/TS 7240-30 requires that all components of a VFDS should be approved to relevant standards and that they should be suitable for the environment into which it is to be installed.

Further, a VFDS should be assessed to ISO 7240-13 to ensure compatibility of the various components.

System Functionality (Clause 5):

The designer of the VFDS needs to consider factors that may affect the detection system.

- The detectors rely on visibility of smoke or flame, however some areas covered may be masked physically or digitally to avoid nuisance alarms. Where such masked areas exist, the designer will need to ensure that smoke propagating from them is detected, or that alternative detection covers those areas.
- External factors that could affect the ability of the VFD to detect a fire such as vibration of the camera, EMC disturbances should be taken into account.

Due to the nature of VFDS, ISO/TS 7240-30 specifies that field performance testing must be carried out on the system verify the functionality of the installation.

Design (Clause 6):

VFDS should only be designed by persons having suitable qualification and experience. The design should be carried out in a systematic fashion and should be correctly documented.

Design considerations:

- The power supply for the VFDS and for any artificial lighting critical to the operation of the fire system must be approved to ISO 7240-4 and should be suitable capacity.
- Illumination:
  - Where used as a primary detection method it is critical that necessary illumination is maintained at all times with faults given in the case of failure.
  - When used as supplementary detection lighting must meet the installation specification
- When protecting specific risks need to think about movement around, behind and in the area being protected and that the risk itself may actually be moving.
- Whether used for smoke or flame detection need to ensure the VFDS will detect smoke or flame anywhere in the protected area (even if not in line of sight)
- VFDS can be prone to nuisance alarms if not installed correctly to need to consider sources of nuisance alarms and how to mitigate.

Coverage:

A camera installation will have blind spots, hence multiple cameras looking at the area covered in different directions or alternate methods of detection may be necessary to ensure that the area is fully covered.

Cameras can cover huge volumes and hence need to consider zoning and use of multiple cameras to avoid a single point of failure losing protection in multiple zones.

VFDs can detect fires at the point of ignition, and from smoke propagating from the point ignition. Ideally the system should be designed such that all points of ignition are monitored but if this is not possible then consider smoke propagation into the protected volume.

Installation and Commissioning (Clauses 7&8)

To be carried out by a qualified person(s) in compliance with the design and/or commissioning plan. Any challenges or changes are to be verified with the system designer.

Servicing (Clause 11)

The system designer should prepare a service plan of routing tests and maintenance Servicing is to be carried out by a qualified person in compliance with the servicing plan.

8. SUMMARY

ISO/TS 7240-29 is a new standard which is a key milestone to enabling the application of a complex new technology to enhance the safety in case of fire in situations where more conventional fire detection may not offer an optimum solution.

It provides manufacturers with a means to assess VFD and to potentially apply a quality mark to their VFD. It also gives installers a means to ensure that the systems they install comply with the minimum performance requirement for the detection of certain type of fires.

One of the difficulties in drafting the new standard has been the way that the response of VFDs is modified by the surrounding environment into which they are installed and operating. Although the drafting team fully appreciated this issue it was felt that further work may well be required to refine requirements and the test methods employed. This need for on-going development to further refine the standard led to the decision by ISO TC21/SC3 to release the standard as a Technical Specification rather than a fully-fledged product standard. This is also likely to be the case for the complimentary document (draft ISO/TS 7240-30) providing guidance and recommendations for the design, installation, commissioning, and maintenance of systems using VFDs.

9. BIBLIOGRAPHY

ISO/TS 7240-9, Test fires for fire detectors

ISO 7240-10, Point-type, resettable flame detectors that operate using radiation from a flame

ISO 7240-13, Compatibility assessment of system components

ISO 7240-15, Point-type fire detectors using smoke and heat sensors

ISO/TS 7240-29, Video fire detectors

ISO/WD TS 7240-30, Installation requirements for video fire detectors

FIA guidance document on video fire detection technology (VFD) - Version 1 (December 2009)

BRE Briefing paper: The development of test methods to assess video flame and video smoke detectors

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Fire Industry Association

Tudor House, Kingsway Business Park, Oldfield Road, Hampton, Middlesex TW12 2HD
Tel: +44 (0)20 3166 5002 • www.fia.uk.com