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Guidance on Video Smoke Detection Technology (VSD)

FIA Guidance for the Fire Protection Industry

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Contents

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1. Scope

This FIA Guidance Document provides an overview of video smoke detection technology (VSD) based on the analysis of video signals from CCTV cameras and gives some basic guidelines as to its application in fire detection and alarm systems.

This document does not cover video flame detectors which may employ a similar method but are designed specifically for the detection of highly flammable substances such as hydrocarbon fuels in high risk applications.

2. Introduction

VSD has been used for a number of years, during which time it has rapidly developed from an emerging technology to becoming a recognized solution in a growing number of applications where more conventional technologies might not have provided a satisfactory solution. VSD is used with other fire detection technologies to provide a fire detection solution in specific areas inside or outside a building.

Video image fire detection is still an active area of research and there are only a few systems that are commercially available. The capabilities of these systems vary from being able to only detect smoke to also being able to detect flame, as well as providing motion detection and other surveillance/security features.

3. What is VSD?

a. Basics of video smoke detection

Typically, VSD systems consist of video-based analytical smoke recognition algorithms that integrate cameras into fire detection systems. The video image from an analogue or digital camera is processed by proprietary software to determine if smoke from a fire can be identified in the image. The detection algorithms use different techniques to identify the smoke characteristics and can be based on spectral, spatial or temporal properties. These include assessing changes in brightness, contrast, shape, edge content, motion, and colour matching.

b. Factors affecting the operation of VSD

VSD systems require a minimum amount of light for effective detection performance. Capabilities vary between systems and it is important to select the correct camera for the application. Low-light cameras can enhance performance and some systems have been developed to operate in the dark using infrared (IR) illuminators and IR sensitive cameras.

Since the image from a video camera is being analyzed to detect a fire, the quality of the image is critical to the performance of the VSD. The selection of a suitable camera lens for the light conditions and desired field of view is extremely important and may require a site survey.

c. Types of VSD systems/configuration

There are two basic architectures utilized by VSD systems. Due to limitations of video processing technologies, the initial systems consisted of multiple cameras each with an analogue cable connection back to a central processing unit that executes all video capture, image processing and alarm decision algorithms. The processing unit typically has relay contact outputs and the ability to send various alarm signals to standard fire alarm control units. Depending on the manufacturer, systems can also record still shots or video clips associated with alarm events and can provide instantaneous video display to a monitor.

Advancement in technologies has allowed a second type of architecture where the video capture, image processing and alarm decision algorithms are performed at the camera in a single device. These fire detectors can have onboard storage of video and can be integrated on a closed-circuit system with an additional central processing unit, or it can be integrated as a point detector on a standard fire alarm system. These devices can also be monitored remotely via network or internet connections. Video events of alarm conditions can be archived for each device and can be displayed automatically to video monitors for instantaneous viewing.

d. The key benefits of VSD

VSD systems can provide unique advantages in a wide range of applications. These include the following:

- The ability to protect a large area, and/or areas with excessive ceiling heights, while still achieving fast detection. With VSD, smoke in the camera field of view can be detected whereas with other detector types, smoke has to migrate to, and be present in, the sensing area e.g. the sensing beam of a beam detector or the sensing chamber of a point smoke detector.
- VSD systems can be used for outdoor applications, such as train stations and off-shore oil platforms.
- The ability to have live video immediately available upon detecting a pre-alarm or an alarm condition. This immediate situational awareness allows monitoring personnel to easily view the protected area to determine the extent of the fire and to more accurately identify the location.
- Archiving of still and video images associated with alarm conditions also provides a means of assessing the cause of incidents and provides a basis for changes in the detection system if the event was a false/nuisance alarm.
- The ability to sub-divide the image into different areas for separately identifying fire risks or programming out (masking) known sources of potential false alarms.

e. The main applications of VSD

Because of some of the benefits which we have described, Video Smoke Detection technology has found applications in many areas where other detection systems could not provide a practical solution. These, for example, include:

- Commercial buildings, or parts of them, with high lobbies, open areas or interconnecting wells between storeys;
- Large aircraft hangars or similar structures;
- Oil and gas installations;
- Road and rail tunnels;
- Forests or other open area, long distance risks.

f. False alarm and other environmental factors

Video Smoke detectors use video camera chip technology. Although these are now able to form images at low illumination levels, there is still a possibility that in low lighting, smoke events may not be recognized or will require a much longer time to be processed before they can be recognized. Some detectors offer an add-on option for lighting the surveyed scene.

At the opposite end of the lighting scale, a very intensive light source, such as sunlight or flood lighting may partially or totally blind the detector's camera.

If VSDs are set too sensitive, in order to achieve very early detection, there is a risk that the detector could respond to environmental phenomena that simulate a smoke event.

In general, VSD systems do not have fixed settings. They have many parameters that need to be adjusted to provide the optimum response to a specific fire risk. Therefore, it is very important that the manufacturer should be fully consulted in matters of product application and system design. The manufacturer's installation, commissioning and service and maintenance instructions should also be followed.

4. Standards

There are currently no product performance standards for VSD. Therefore, at present, it is not possible to source products of assessed/quantified performance to a recognized VSD standard in respect of both sensitivity to fires and resilience to potential false alarm sources.

A number of organisations in the UK and abroad are currently in the process of investigating conceptual characteristic fires, smoke and nuisance scenarios for given applications. The FIA will monitor this process and provide further information as it becomes available.

BS 5839-1:2002 recognises the existence of VSD. Clause 21 j) recommends that:

"Video smoke detection systems should be capable of detecting smoke reliably in the absence of the normal lighting in the building and the absence of the mains power supply to any lighting provided specifically to aid the detection of smoke."

5. General guidance on the application of VSD

As with most types of detector, there are applications where VSD is appropriate and others where it is inappropriate. The following should be considered when specifying and designing VSD applications:

- Camera lenses should be selected to give the sensitivity and detection range required for the area to be protected;
- VSD cameras should be located so that they have a direct line-of-sight of the area to be protected. Cameras should be positioned taking into consideration temporary obstructions;
- The ability of VSDs cameras to provide identification of the location of a fire event. This may be by provision of signal outputs to a CIE. In some cases, this may be backed up with real time images sent to a video monitor;

- The possibility of smoke being diluted or affected by air movements due to the influx of fresh air supply in the monitored area. This could reduce the detection sensitivity of the VSD or, at least, delay the ensuing alarm event;
- In areas where temporary low levels of light are expected, e.g. during the night, or in permanently unlit underground facilities e.g. tunnels, supplementary lighting should be provided. For example, this may be infrared lamps, either integrated within, or bolted onto the VSD camera. In this case factors such as range, field of view and sensitivity may be affected;
- Wherever very high levels of light are expected, care should be taken to mount VSD cameras so that degradation in their performance is minimized. This may be either natural light e.g. direct or reflected sunlight, or artificial light e.g. flood lighting in marshalling areas or stadia. The use of appropriate hoods may be required;
- The possible presence of sources of false alarms in the area protected by the cameras and means provided by the VSD to reduce their effect e.g. software algorithms or masking;
- The integrity of VSD systems, particularly those that use stand-alone cameras connected to a central processing unit. This should include the reliability of data storage, the fire resistance and physical protection of video cables, the provision for adequate power supply and fault monitoring;
- The use of power supply equipment complying with EN 54-4 for all components of the VSD system;
- The manufacturer's recommendations for the acceptable environmental conditions applicable to the VSD and its accessories, including temperature range, humidity, vibration and EMC, for example.
- The potential adverse effect of contaminants, airborne or deposited on the camera viewing window/lens and/or associated lighting equipment.
- Regulations applying to the use of equipment with special protection such as flame proof or intrinsically safe equipment, when VSD systems are installed in potentially explosive environments, such as oil & gas facilities.

6. Situations where VSD can provide a means of early fire detection

A VSD may be more suited to detecting fires in certain large open areas and areas of special high risk as:

- VSD cameras are able to see the source of the fire and do not have to rely on convection to take the smoke plume to a detection point. This makes them particularly suitable for effectively detecting fires in spaces where stratification is likely to occur, where there is unpredictable air movement or rapid dispersion/dilution of the smoke, providing there is line of sight.
- The ability of VSD to be programmed to provide different sensitivity (range) by lens selection, and to adapt to difficult application environments (false alarm sources) by tuning software operational parameters, makes it an ideal detection tool in special applications where an engineered solution is likely to give the best answer.
- VSD, by providing visual verification of the event, will give operators information to facilitate a better and faster structured response of an incident and enable safer investigation by remote viewing.
- VSD, by providing accurate location of the incident, will benefit applications where targeted fire protection measures are required.
- VSD, by capturing video images of a monitored space, will enable the remote monitoring and recording of real time events.

7. Situations where VSDs are not recommended as the prime means of detection

VSD should NOT be used in the following situations:

- Where a deterministic response to known fires is required and can be achieved by the use of EN 54 approved detectors, i.e. most standard commercial and industrial applications.
- Where there are significant obstructions in the camera line-of-sight of the main identified risk or where such obstructions are temporary and of an unpredictable nature.
- Where there is a danger that the ambient lighting level is either too low or too high to obtain a satisfactory response from the VSD at the time it is required to monitor the risk, unless specific provisions are available to alleviate this danger. For example infrared illumination of the scene with back-up power supply, polarized lens filters, or where very intense light sources can blind the camera.
- Where certain processes are likely to produce smoke-like images which may be misunderstood by the video analysis software, unless it has been demonstrated through trial and, if required, tuning of the equipment so that the effect of these false alarm sources have been adequately established and eradicated. Examples include processes generating large amounts of steam and/or other gas plumes (exhaust fumes from forklift trucks) and/or environmental pollutants (vapour, dust, sprays). In outdoor or semi-outdoor situations this may also include insect swarms.
- Where likely environmental conditions present may have an adverse effect on the ability of the VSD to properly operate. For example this would include fog, mist, snow and rain.
- Where a particular equipment configuration, including installation cables, would not assure the integrity of the alarm transmission path through the system so as to provide the desired warnings to the occupants of a building or the desired response from the emergency services.
- Where the use of cameras is not appropriate due to data protection issues.

8. Siting VSDs

There are currently no established rules on the siting of VSDs and guidance should be sought from the manufacturer of the equipment or an approved (and trained) representative before finalising the design of any installations.

The effect of all the changeable parameters in the VSD, such as camera lenses, software parameters adjustment and lighting conditions should be taken into consideration following the consultation principle given in BS5839 Part 1: 2002, clause 6.

9. Installation of VSDs

Installation cables should be in accordance with the recommendations of BS 5839-1:2002.

10. Testing, servicing, maintenance and replacement

It is important to always follow the manufacturer's recommendations for testing, servicing, maintenance and replacement requirements.

It may be desirable that, in some installations where the effect of potential false alarm sources cannot be fully determined, a period of trial is undertaken before completing the commissioning of the system and handing it over to the client.

A method, appropriate to the risk, of testing the effectiveness of the VSD at both the commissioning stage and at subsequent service and maintenance visits should be agreed with the equipment manufacturers or system installer. Tests should be conducted and documented in accordance with this method.