Recommendations

RC28

# for spark detection and suppression systems on pneumatic conveying installations

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Printed by Modern Colour Solutions 1.0/02.06

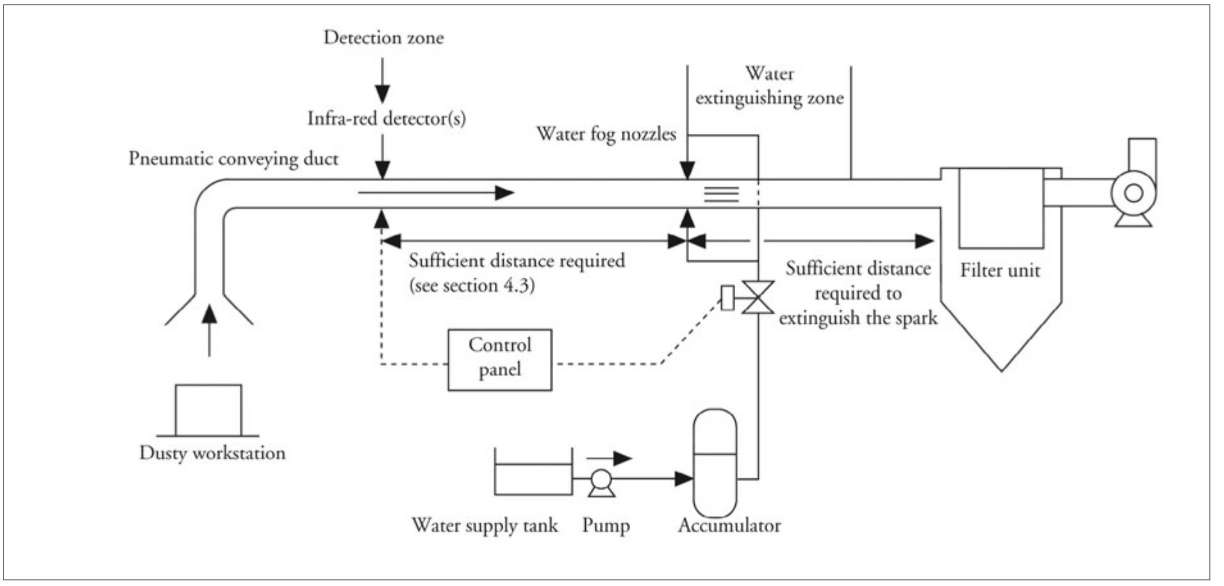


**Fig. 1. Typical example of use of spark detection and suppression system.**

## DEFINITION

*Spark:* is used throughout this document to indicate small potential sources of ignition that may include glowing particles.

## RECOMMENDATIONS

## 1. INTRODUCTION

Pneumatic conveying systems are employed in many process industries, for example:

- wood processing (particle board manufacturing)
- textiles
- metals (foundries, metal reclamation, polishing and grinding)
- tyre re-treading
- foodstuffs (spices and coffee)
- tobacco industry.

Other industries use conveying ducts, hoppers, filters and other vessels that may contain finely divided combustible material. In these systems there are a number of possible sources of ignition and the consequent risk of a dust fire or explosion.

The principal hazard arises from the pneumatic conveyance of materials from one area to another, on some occasions through fire compartment walls. Thus a source of ignition in one area has the ability to cause a fire in another, remote area.

Sparks or glowing particles may arise from foreign bodies, including tramp metal (especially in milling or grinding machinery), hot bearings, drying processes or self ignition of a build-up of material and subsequent smouldering. In many instances multiple detection and suppression systems will be necessary to protect a facility adequately.

In exceptional circumstances there may be a need for manual intervention. Where this is the case there should be a documented procedure in place and this should be agreed in advance by the insurer.

### 1.1 Principles of pneumatic conveyance

The principal component of pneumatic conveying systems is enclosed ductwork through which material is transported by an air stream with a velocity sufficient to keep the conveyed material in motion. There are two principal types of systems, pressure or suction, and they can be used in combination. Figure 1 shows the components of a pneumatic conveying system which is fitted with a spark detection and suppression system.

It is important to appreciate that the action of conveyance *transfers* the risk from one area – where the fire starts – to another, remote area where the fuel for the fire resides.

### 1.2 Sparks and fire and explosion hazard

Unless a suitable automatic detection and suppression system is in place, sparks or glowing particles may be conveyed into a dust filter or other plant unit, where ignition of the fine powder can occur. Expensive, disruptive fires or explosions are often the result.

Hot metal dust, even where it is not itself a material susceptible to fire and explosion, may cause heat or abrasive damage to filtration plant.

The best solution is to detect and eliminate the ignition hazard at an early stage so that it cannot cause an explosion or fire. This can be achieved with a spark detection and suppression system. Although the most common application of such a system is on process extraction ducts leading to a dust filter, there are also applications suitable for other enclosed plant configurations where fibres, chips and dust are transported and have the potential to cause or spread fire.

A spark detection and suppression system does not, however, eliminate the need for complementary protection methods such as screening for foreign bodies, explosion relief panels, fire detection systems and sprinkler protection of plant vessels. In some industries, conveying with inert gas may be the only safe option.

Thus a key recommendation is that, in circumstances where pneumatic conveying may be chosen as part of a production process, a suitable and sufficient fire risk assessment must be carried out to identify the hazards of the process as a whole and to decide on the adoption of suitable precautionary measures, which are likely to include a system for the detection and suppression of sparks. This assessment should be part of the fire risk assessment that is carried out for the workplace as a whole, in accordance with the requirements of current fire safety legislation. An explosion risk assessment should also be undertaken to comply with the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002.

## 2. THE SPARK DETECTION AND SUPPRESSION SYSTEM

A spark detection and suppression system comprises a combination of two sub-systems:

- a spark detector (usually infra-red) located in a pneumatic conveying duct and linked to a control panel to ensure that all signals from spark detectors are accumulated and processed;
- an extinguishing device or other means of fire and explosion prevention located farther along the duct, together with ancillary equipment (see Fig. 1).

The extinguishant is commonly water mist but if this is incompatible or there is a risk of contamination then an alternative, such as carbon dioxide, may be used.

Within this general arrangement a spark detection and suppression system may take many forms, utilising a variety of equipment. In most installations the method of operation will not be designed to shut down the protected equipment after a single activation of the extinguishing system, as the sparks will be extinguished, allowing material conveyance to continue uninterrupted.

## 3. SYSTEM SUITABILITY FOR MATERIAL BEING CONVEYED

Where the conveyed material is combustible and occurs in a finely divided state anywhere in the process (especially in a filter), there may be a dust fire or explosion hazard. If the minimum ignition energy of the finest powder in the plant, determined by laboratory flammability/explosibility testing, is below approximately 25mJ, the powder will be readily susceptible to ignition by a small spark (including that from electrostatic sources).

The spark detection and suppression system is especially appropriate for material of this type, where ignition sources may exist and where a fire or explosion in the plant could have serious consequences in terms of life safety, property damage and business interruption.

Most spark detection and suppression systems are installed in pneumatic plant which incorporates ducting, although the principle can be applied to other enclosed machinery, where early detection and extinguishment is desirable.

## 4. EQUIPMENT

4.1 Detection and detectors

The detectors commonly used in spark detection systems are infra-red radiation detection devices, fitted in the walls of the pneumatic conveying duct. Two main types of detectors are used; light sensitive detectors suitable for use in dark and enclosed systems and detectors insensitive to daylight. The latter type does not need to be in a dark environment since its sensitivity is adapted to ambient conditions.

The number of detectors is determined by the geometry and size of the duct. Circular ducts may only require two detectors, one being mounted on each side. Detectors should be mounted opposite each other in the same vertical plane in order to perform effectively. Detectors should never be mounted on the bottom of a duct where deposits may accumulate.

The detector must be able to cover the full cross-sectional area of the duct and the following features are important:

4.1.1 It should be able to detect the smallest spark considered to be an ignition source for the conveyed material, as described in section 3.

4.1.2 It should be capable of indicating the level of energy of the spark and thus the nature of the hazard in the relation to the environment.

4.1.3 It should be stable in performance, so that it does not activate unless there is a spark present, and does not allow sparks to pass undetected.

4.1.4 All sparks should be indicated (and suppression implemented) in proportion to the risk they present. By analysing the data in response to paragraph 4.1.2 above it may be permissible to set the system to allow low-volume, low-energy sparks to pass without activating the extinguishing system. However, even a single spark can present a risk and this adjusted mode of operation should only be implemented after careful review of data from the system records and in consultation with the equipment suppliers.

4.1.5 It is important that the detector and signalling system selected (i.e. conventional or optic cabling) is suitable for the operating temperature of the duct, which may vary from 66°C to 1016°C.

4.1.6 It may be useful to record the number of detected sparks for future analysis.

4.1.7 The number of detectors must be sufficient to ensure full coverage of the duct and any envisaged variations in duct diameter, material density, particle shape and air velocity.

4.1.8 Additional detectors may be required if confirmation of the presence of a spark (i.e a 'double-knock' system) is necessary before extinguishment is activated.

4.1.9 The detector should be resistant to fouling by material conveyed in the duct. It will be necessary to institute a programme of inspection and/or cleaning of the detector eyepiece, if automatic testing is not a function of the system. All cleaning, servicing and maintenance of the system should be recorded.

4.1.10 A means should be provided of electronically simulating the presence of a spark in the duct to test the functionality of the detector.

4.1.11 The airflow speed in the duct is important. If the speed of air flow is set faster than that for which the particular design of detector is suitable, the spark may not be detected. The control parameters thus need to be determined with care.

4.1.12 Because detection is by means of radiation, detectors in locations subject to incident light (for example, in ducts with translucent panels) should be of the solar blind type.

4.1.13 In some installations the conveying fan may be located on the inlet side of the filter. Fans can themselves produce sparks and, in such an installation, supplementary detection and suppression would be necessary.

## 4.2 Control and indicating equipment

The control and indicating equipment should be capable of controlling a number of zones where applicable and indicate by visual and/or audible means:

- alarm states
- readiness of the system
- power failure
- battery failure
- failure of the trace heating system (where fitted)
- faults (in the form of cable breaks or short circuits)
- spark counting (optical indication may also be desirable)
- extinguishant (water or gas) discharges
- failure of the air/gas flow in the duct.

The equipment should also provide a means of simulating an activation of both the detection and extinguishing functions, for test purposes.

## 4.3 The extinguishing system

The most commonly employed extinguishing system (and the one mainly referred to in this document) uses water, injected at a pressure of approximately 7bar into the conveying pipe to produce a water mist. Atomising the water in this way to produce a mist maximises the cooling effect and surface area that can be covered with a given volume of water.

The number of nozzles required is a function of the size of the duct and the air speed; for large ducts, multiple nozzles may be needed. These are located several metres downstream of the detector, the distance being calculated to allow for the response time of the system and the velocity of the material being conveyed. The water mist injection must commence before the spark reaches the injection nozzle(s) and the extinguishant injection needs to be of sufficient density and duration (normally lasting up to 10 seconds) to extinguish the spark.

At the planning stage the implications of injecting even small volumes of water into the equipment should be carefully assessed.

Components of a water mist spark extinguishing system should consist of the following:

- a suitable water or gas extinguishing supply
- a flow/pressure switch
- a booster pump (if necessary)
- a strainer screen to protect the system from contaminants in the water supply.
- extinguishing nozzle(s)
- solenoid valve
- pipes
- disable devices
- trace heating where necessary.

Trace heating and insulation must be adequate to withstand the temperature extremes and environmental conditions of the area where the equipment is installed. Do not attempt to achieve frost protection by adding glycol mixtures to the extinguishing water.

Where water is incompatible with the product being handled or its use is inappropriate for other reasons, alternative extinguishing agents, such as carbon dioxide or other inert gases, should be considered. In those cases, the effectiveness and practicality of using the proposed extinguishant in the equipment to be protected should be tested and proved before use.

## 4.4 Response time

The response time of the system (in seconds), between detection and commencing suppression, is determined by the following factors:

- the electro-mechanics of the detector and extinguishant injector
- the availability of extinguishant at the injector at sufficient pressure and flow rate
- the unhindered operation of the extinguishant injector
- the operating systems of the dampers.

## 4.5 Supply of extinguishant

4.5.1 Water

For a water mist system, water under pressure should be immediately available at all times, preferably from a gas-pressurised water accumulator cylinder. Stored extinguishing water should be sufficient for at least 60s of continuous operation. Where there is more than one extinguishing zone, 50% additional water should be added. Calculations of the highest water demand should include all water-based extinguishing systems likely to come into operation simultaneously.

Water mist systems should be constructed of copper or galvanised iron pipes.

Pipework in external or unheated locations should be protected against frost by trace heating and lagging, with automatic thermostat control where necessary. An alarm should be fitted to warn of a failure of the trace heating to allow suitable remedial action to be taken. The alarm should be monitored.

4.5.2 Other extinguishants

For extinguishing media other than water, equivalent considerations apply. For example, in the case of gas systems:

- cylinders of suitable gas should be located in safe locations near the plant to be protected
- the volumes of gas available should be monitored regularly
- an adequate number of spare gas cylinders should be stored safely on site.

4.5.3 Multiple activations

Where the system is designed to provide multiple activations, it is important that, once the supply of extinguishant has reduced to that required for a full, single activation, an alarm is indicated and the protected equipment is shut down, preferably by automatic means, to permit replenishment of the extinguishant.

As a general guide, to allow for multiple activation, the supply of extinguishant available should be sufficient for at least 60s operation.

## 4.6 Alternative to extinguishing

In some situations it may be impracticable to extinguish the spark; as a result, the use of a spark diversion system ('abort gate') may be appropriate.

The purpose of spark diversion is to detect sparks and divert the material flow to a safe area to prevent fire and explosion. The diversion gate is typically located upstream of the product collection equipment. The unit has a shutter, which during normal operation is held up by an electromagnet. Releasing the power to the electromagnet causes the shutter to drop, sometimes with spring-assisted action, to divert the flow to safety.

Spark diversion systems thus consist of spark detection, control systems and quick action devices such as quick action dampers or vents to divert material flow.

Just as with spark extinguishing systems, spark detector and diversion components should be installed with sufficient spatial separation, determined by the velocity of the material being pneumatically conveyed and the total time delay of the system.

# 5. SYSTEM APPROVAL AND OPERATION

Properly installed spark detection and suppression systems operate to extinguish sparks in pneumatic conveying systems and thereby prevent dust fires and explosions. They are, however, complex systems and, unless operated correctly, have considerable potential for failure to function as intended.

The reliability of all components and a competent design is of utmost importance for a system to be effective. The use of products approved to an appropriate standard is essential. The Comité Européen des Assurances (CEA) document CEA 4044: June 2004: provides suitable guidelines for gas extinguishing installations (ref. 1).

It is also recommended that attention be given to the following features and items to ensure correct installation, operation, maintenance and checking.

## 5.1 Approved products

The principal components should be approved by a UKAS accredited third-party certification body to an appropriate product or performance-based standard. Certificatory evidence should exist for:

- detector units
- extinguishing units (nozzles, solenoid valves etc.)
- water supply equipment, comprising accumulator and pump unit
- control unit components.

**Table 1: Recommended periodic inspection and maintenance frequencies.**

| Frequency | Inspection/maintenance functions |
|---|---|
| *Daily* | • Operating conditions<br>• Water pressure<br>• Inspection of spark sensors<br>• Inspection of water mist nozzles |
| *Weekly* | • Operation of sensors<br>• Cleaning of sensors and extinguishing nozzles<br>• Water supply<br>• Spark counter device reading if fitted |
| *Monthly* | • Function of entire system<br>• Clean state of dirt catcher<br>• Function of trace heating, alarm devices and triggering of fire protection devices |
| *Six monthly* | • Cleaning of control console |
| *Annual* | • Removal, inspection and cleaning of strainer screen<br>• Full service of the other components of the water mist system<br>• Implementation of freeze prevention measures |

### 5.2 Competent installers

Installers should be third-party certified, by a nationally accredited inspection body, to install the specific product/system.

### 5.3 System manual

A system manual should be available for inspection, with full details of the principal operational features, including:

- maximum air velocity in the pneumatic conveying duct
- minimum distance between the detector and extinguishing nozzles
- minimum distance from the extinguishing nozzles to the dust filter (or other plant unit inlet)
- spark and time thresholds or detector sensitivity settings. The detector sensitivity should be factory-set and not easily adjustable on site
- design pressure of water (or alternative extinguishant)
- design flow rate of water (or alternative extinguishant), and length of time for which it should flow.

## 6. INSPECTION AND MAINTENANCE

Spark sensing devices can be rendered inoperative by moisture (resulting from leakage and resulting condensation) or vibration (from adjacent machinery) and so a regular inspection and maintenance regime is necessary to ensure the accurate, correct, working of the equipment and to minimise the occurrence of false alarms.

The lens of the sensor can become obscured by adhering materials or abrasion so that it does not detect a spark or produces false alarms. Sensors should thus be tested daily. Although this may be done automatically by self-testing, it should be backed up by manual testing, with recalibration being carried out if necessary.

The materials being conveyed in the duct may also build up on the extinguishing nozzles. These may also be affected by mineral deposits from releases of water mist. The nozzles should therefore be subject to inspection, including an examination for signs of wear, on a daily basis.

Where there is a high temperature duct, fibre optic cables that conduct infra-red energy to the sensor are likely to be used and these require regular inspection as dryer systems can cause a build-up of deposits on a cable sufficient to affect its efficiency. Regular checking is therefore required.

Any diversion systems should be subject to periodic testing and an appropriate freeze prevention maintenance programme should also be devised and implemented.

Routine inspections should be carried out by a suitably trained member of staff. Periodic maintenance should be carried out by an approved company which has third-party certification to perform such work.

The scope and frequency of the maintenance of the water injection system will depend to a large extent on the quality of the water supply. Annual maintenance, however, should include the removal, inspection and cleaning of the strainer screen that protects the water mist system from contaminants in this supply.

The control console should be cleaned every six months using low pressure air. If it is located in a dusty environment, vacuum cleaning is preferable.

Site control should include a log book of all system events such as:

- alarm activation
- routine inspections and maintenance
- annual servicing
- defects identified and remedial action taken
- all modifications to the installation.

Where spark diversion systems are fitted, these should also be subject to regular inspection and servicing as recommended by the manufacturer.

## REFERENCES


1. CEA 4044: June 2004: *Gas extinguishing installations - Specifications for spark detection, spark extinguishing and spark diversion systems - Planning and installation*, Comité Européen des Assurances.
2. CEA 4035: June 2001: *Specification for spark detection systems. Requirements and test methods for spark detectors,* Comité Européen des Assurances.
3. CEA 4033: May 2000: *Specifications for spark extinguishing systems. Requirements and test methods for waterbased spark extinguishing devices in ducts*, Comité Européen des Assurances.