Handbook for

Smoke Detection

in ventilation systems

Planning documentation: Bo Backvik/Tomas Fagergren

CALECTRO®

Gothenburg
Palmeblads Tryckeri AB

CALECTRO AB has a broad range of products for a large number of control and regulation functions in heating, ventilation and air conditioning systems.

We consider one of our most important fields to be our capacity to deliver reliable smoke detection components for ventilation systems.

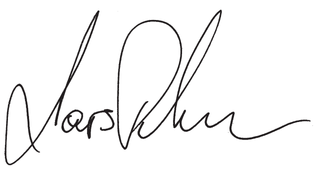
Rapid and reliable detection is an essential factor for simplifying evacuation and saving lives and property to the greatest extent possible.

But, even a good product is of little use unless it is used with knowledge and good judgement.

CALECTRO AB would therefore like to use this handbook to point out problem areas related to smoke detection in ventilation systems and help expand knowledge in order to develop systems better suited to their intended usage.

We would like to thank graduate engineer Bo Backvik, PBL Kontroll KB, and engineer Tomas Fagergren, Brandskyddslaget AB, for valuable contributions to the creation of this handbook.

Gothenburg, Sweden, April 2009
CALECTRO AB



Lars Petersson

Revised version April 2009

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SMOKE DETECTION INVENTILATION SYSTEMS

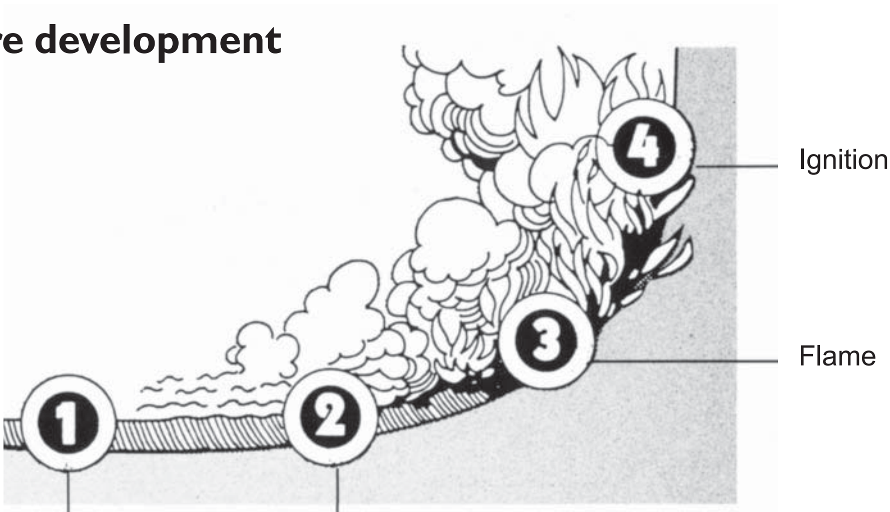
Current Swedish building regulations, BBR 15 (2008), set extensive requirements for evacuation safety. In a separate fire protection document, the building contractor must report the evacuation strategy and the function of the ventilation system during a fire. A ventilation system in operation provides good opportunities (with relatively low costs) to give clear signals about smoke from the start of a fire. This makes it possible to extend the amount of time available for evacuation.

The general objective of fire prevention measures in ventilation systems – to prevent the spread of fire and smoke – is to save lives and property. Measures taken in ventilation systems are only one part of the total technical fire protection installations.
In many cases, supplementation is required with measures geared towards rooms in fire cells.

The ventilation system (air handling system) of a building is considered a severe problem area. This is because by the very nature of the system the ventilation ducts more or less openly connect rooms in different fire cells and thereby give the smoke free passage. Many types of systems have large air flows, which means that openings and ducts are designed with large dimensions.

It is therefore particularly important to develop methods to prevent the spread of fire and smoke through or because of the building's ventilation system within the established technical fire time requirement.
An essential part of this development is improved knowledge of associated equipment required to initiate protection measures. One basic requirement is for fire to be detected at an early stage, for example via smoke detection.

Fire development



Invisible smoke and gas
No flame
No noticeable heat
The fire has started!

Smouldering phase
Visible smoke
No flame

Not later than here!

But the fire should preferably be detected in phase 1

As a rule, all buildings and building ventilation systems are fitted with a detector system intended to detect a fire as soon as possible and thereby help prevent other fire cells and evacuation routes from filling with smoke and toxic gases.

In structures fitted with a complete fire alarm system, this can be used to control required functions in the ventilation system.

This handbook describes detection, particularly in duct systems, by means of smoke detectors. The handbook reports the technical design of smoke detectors and presents viewpoints on usage to achieve the required functions at different requirement levels.

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BASIS OF FIRE PROTECTION MEASURES

According to the ACT ON TECHNICHAL REQUIREMENTS FOR CONSTRUCTION WORKS, (BVL), a building structure which is erected or modified must comply with important technical requirements with respect to matters such as safety in the event of fire.
In the attendant statute, BVF (SFS 1994:1215) it is stated in §4 that:

> Building structures shall be planned and erected in such a way that
>
> 1. the bearing capacity of the structure during a fire can be assumed to persist for a determined period of time.
> 2. the development and spread of fire and smoke within the structure is limited
> 3. the spread of fire to adjacent buildings is limited
> 4. individuals inside the building during a fire can leave it or be rescued in another manner
> 5. the safety of rescue workers during a fire is taken into consideration

Functional requirements are established in Boverket's building regulations BBR 15 (2008). Fire protection regulations (section 5 in BBR) are currently being reviewed, but this is not expected to be complete until 2010 at the earliest.

The great importance of fire protection measures in the initial phase of a fire (when evacuation should take place) can never be emphasised enough. But, the general objective of protection against the spread of fire and fumes (smoke) through the ventilation system is for the duration of the protection to equal the fire resistance of the structural parts that separate the fire zone.

If the fire reaches the later phase where the explosive gas mixtures have ignited, other rescue actions must also be taken.

The ambition level is based on the requirement of BBR 5:61:

> "Buildings must be divided into fire cells separated by structural parts that prevent the spread of fire and combustion gas."

There is no reason to have a lower ambition level for ventilation systems. They should therefore be designed with the objective of **preventing** the spread of fire and combustion gases. This is particularly important in order to make it possible for people to reach safety and to facilitate the work of rescue workers during the initial phase of a fire – which is often short and not infrequently a matter of only a few minutes.

It is well known that smoke is the dominant reason for personal injuries – usually the reason for about 80% of the injuries. Smoke also causes material damage, even outside the fire cell where the fire occurred – **if it spreads**.

With BBR, the method of achieving fire protection measures has been given a completely different focus than it had in old norms. Instead of using a "passive" approach with conventional solutions, the objective of BBR is to use calculations to plan different "active" and co-ordinated fire protection measures to achieve the desired requirement level.

Naturally, this combination of measures includes preventing the spread of fire and smoke via the ventilation system to the greatest possible extent. Active measures also include use of the ventilation system as a resource for early detection of fire. This requires that the system have an appropriate structure and has well conceived and refined smoke detection.

An active concept also includes creating a protection system that is tailored to the risk class of the building/structure and achieves the desired requirement level.

APPROPRIATE DETECTION

The objective of detection is based on the nature of the object, risk class and operating conditions to achieve appropriate detection with a system structure tailored to the building and its ventilation system.

The most important objective is to achieve early detection to ensure satisfactory evacuation safety and to limit the degree of damage. In the initial stage of a fire, the combustion gas temperatures are usually low, making smoke detectors a good choice.
In certain environments or if maintenance is not carried out properly, smoke detectors can give false alarms. Switching to heat detectors, however, could lead to no or seriously delayed alarms, which is even worse.

Greater knowledge concerning the characteristics of smoke detectors and their possibilities to ensure appropriate detection is one way to eliminate false alarms or at least limit them to an acceptable level.
The following should be taken into consideration in order to achieve appropriate detection:

- evaluate the nature of the object and the requirement level
- select the right type of smoke detector
- select the correct installation and positioning
- select the right number of smoke detectors
- evaluate the operating conditions of the ventilation system
- prepare monitoring and maintenance
- guidelines for functionality testing

Duct or room detection

What is “appropriate” detection?

The definition of this concept depends on the nature of the object, the set requirement level and operating conditions.

Duct detection, which means that detectors are placed inside ducts or in adapters outside of ducts, costs less but generally requires that the air treatment system is operating. It is not really possible to locate the seat of the fire, but it is possible to gain time.

Room detection, which means that detectors are placed in rooms or at representative positions for groups of rooms, provides a more direct connection to the seat of the fire and makes it possible to localise the fire provided that it is coupled with a more advanced alarm system.

As in many other cases, the issue is a matter of weighing technology against finances. Can an advanced detection system (= more expensive) help to limit damage to an extent that makes the cost justifiable? This does not apply to objects in which all technical measures to save lives and properties are considered a matter of course and where individual room detection and fire alarm systems are standard.
As previously mentioned, operating conditions must be taken into consideration – are fans running or not? In a system without operating fans, duct detection on its own is not enough. For more information, see the sections on installation, number and operating conditions.

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Duct detection, where appropriate supplemented with some room detection, should give most “standard” objects a satisfactory requirement level – both technically and financially.

An expansion of this leads to a technical solution that is beyond the ordinary. For a structure that requires monitoring with alarms in the event of a fire, a combination of fire alarm system with in-room detectors and duct detectors in the ventilation system is very practical. A structure often consists of large open rooms and groups of small rooms. Room detection for fire alarms for groups of small rooms can be unnecessarily expensive, while a duct detector can monitor 10-20 rooms, depending on their layout. Larger rooms are best monitored with room detectors.

NATURE OF THE OBJECT – REQUIREMENT LEVEL

Detection in ventilation systems focuses greatly on stopping or starting fans and closing or opening dampers with simple means and often without taking the time factor into consideration. At the same time, some form of alarm is triggered.

It is important to analyse the object and provide detailed instructions for the design of the detection system as early as the planning stage. Unfortunately, this is seldom or never the case.

In a broader sense, detection must be tailored to the object's risk class and the type of protection desired – the requirement level.

The protection of human lives under difficult circumstances and the protection of material or cultural values naturally set different detection requirements than those for systems geared towards a lower, more "normal" risk class.

A structure with many fire cells and many rooms in each cell naturally has different design requirements than one with just a few, "open" fire cells.

An office building is not protected in the same manner as a hospital. The fire risks are not the same, the rooms are different and they are used in different ways.

Different requirement levels could be:

higher

- to detect and localise the start of smoke (fire)
  to initiate active protection measures
  to notify the fire brigade
- to detect smoke
  to initiate active protection measures
  to notify the fire brigade
- to detect smoke
  to initiate active protection measures
  to trigger an alarm
- to detect smoke
  to initiate passive protection measures
  to trigger an alarm

lower

The design and component parts of the system vary depending on what requirement level* is set.

*) Refer to pages 7 and 8 for more information on "active" and "passive" protection measures.

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ACTIVE SMOKE CONTROL

Background

The contribution of the ventilation system to the spread of smoke is and has long been a favourite topic of discussion. Now, practically no one questions the fact that a ventilation system that is shared by several fire cells brings with it a risk of spreading both fire and combustion gas (smoke). The risk comes from the ventilation system often more or less openly connecting different fire cells, enabling smoke to spread via the duct system.

Passive systems

It was not so long ago that the standard method to deal with a fire was to stop the fans and open a bypass to "vent" the system and let smoke pass out to the open air. The method had many flaws and is now only used in special cases and then based on analytical dimensioning.

Another example of a passive system is stopped fans and a system of smoke-separating dampers (combustion gas dampers) between fire cells. This type of system can be expensive if there is a large number of fire cells.

Active systems

In active systems, an extraction system or the like is used to "gather" smoke and quickly transport it to a duct detector installed in a suitable location (see section on correct installation and positioning). With both extract and supply air systems, there is also a risk of smoke penetrating back into the supply air duct system at an early stage of the fire and at low fire pressure in the fire room. This penetration can be actively fought in different ways. In some cases, the extract and supply air system can be converted and smoke from the fire room can be transported to the open air via both duct systems.

With fans operating, the inlet temperature to the fan must not be higher than the fan can handle. Calculate the inlet temperature and check with the fan manufacturer to find the max. temperature level of the selected fan.

Provide a secured power supply if the fan(s) should continue operating during a fire.

Scope

The fundamental concept behind active protection against the spread of smoke can be developed in different ways.

Active smoke control can include the following:

- early detection
- localisation of the fire
- activation of protection measures
- smoke evacuation
- keeping evacuation routes free from smoke
- "pressurisation" (mechanical pressure increase in adjacent rooms to prevent the spread of smoke)
- warning and alerting

This can be achieved by designing the ventilation and detection systems to meet specific objectives.

Measures

The protection level that can be achieved with active measures is related to the degree to which one is prepared to supplement and make additions to the ventilation system.

Compared to normal operation, operating conditions are completely different when there is a fire. The following are examples of measures to supplement the ventilation system:

- install temperature-resistant fans (combustion gas fans if necessary) that strengthen the extraction fans or ensure extraction flow if the ordinary fans collapse.
- subdivide the building's fire cells into smoke cells for more effective monitoring of the smoke spread protection
- install dampers that can be used to control the supply and extraction air system for different fire and smoke cells
- install auxiliary fans for the outside air supply that can be used for pressurisation of e.g. evacuation routes to keep them smoke-free.

  Do not pressurise more than approx. 50-75 Pa; otherwise it can be difficult to open the doors. Calculation required.

The objective of active protection measures is to prevent smoke from leaving the room or fire cell in which the fire started to the greatest extent possible.

RIGHT TYPE OF SMOKE DETECTOR

Different types of detectors work differently depending on the nature of the "medium" – the smoke/air mixture – they are triggered by. Consider the following before deciding on a detector type:

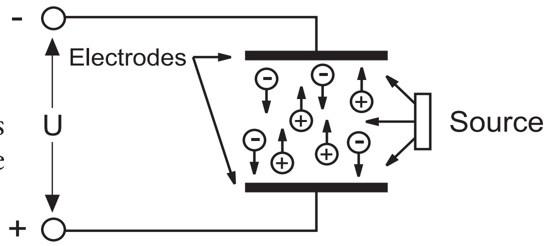
- what sort of fire can be expected – sleeper fire with a long development time – smouldering fire – flaming fire – etc.
- what kind of smoke does the fire produce – light smoke with small particles and slight density – black smoke with large particles and high density – something in between?
- temperature – smoke volume – dilution

Smoke consists of gases – more than 90% air and pyrolysis gases, carbon monoxide (CO), carbon dioxide (CO_2) and particles (soot). During plastic fires, other toxic and/or harmful gases are also produced.

The colour of the smoke and the size of the particles are important factors to the detector's function.
There are different types of detectors, including:

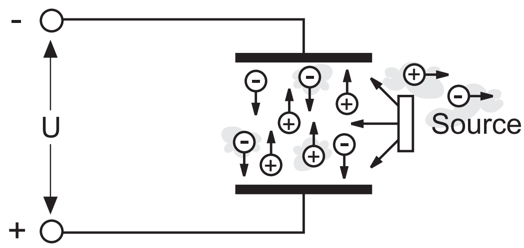
- ionising detectors
- optical (light scattering) detectors
- line optical (obscuring) detectors

Ionising detectors



Normal operation:
A weak, radioactive source ionises the air molecules so that an electric current is generated between the electrodes.

During a fire:
If smoke particles pass through the detector, the current changes and the detector emits an alarm signal

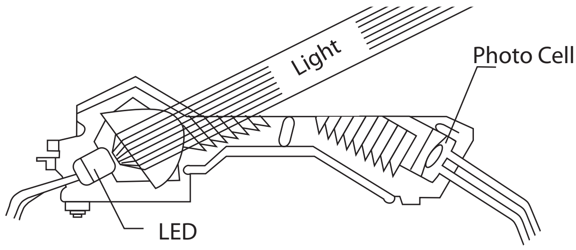


Advantage: The quickest one for fires with small particles (0.01–1 microns), even those that are invisible and are formed at the early stage of a fire.

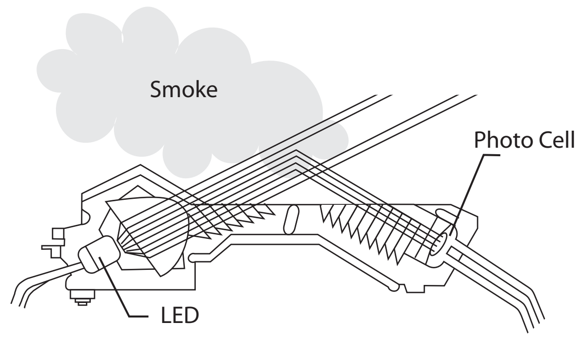
Disadvantage: Interference can be caused by invisible combustion gases, e.g. exhaust fumes from vehicles (garage), frying fumes (kitchen), welding, etc.
From an environmental perspective, the optical smoke detector is preferred to the ionised detector because the ionised smoke detector contains radioactive matter.

Optical (light scattering) detectors

Normal operation:
An LED emits light in a dark labyrinth in the detector housing. Light does not reach the photo cell.



During a fire:
When smoke particles enter the detector labyrinth, the light beam is refracted by the smoke particles and light is reflected to the photo cell so that the detector generates an alarm signal.

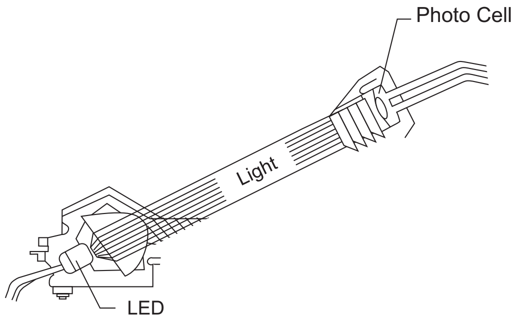


Advantage: Quick for white smoke from very slow (smouldering) fires.

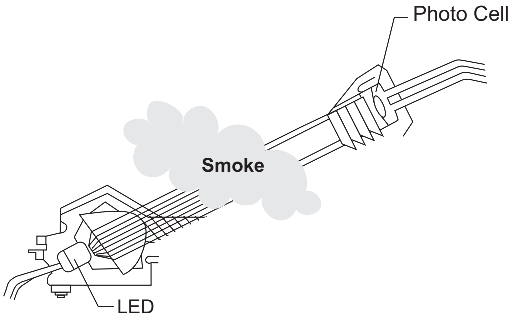
Disadvantage: Must be visible smoke.

Line optical (obscuring) detectors

Normal operation:
A transmitter emits a light beam to a recipient.



During a fire:
When the smoke particles pass through the detector, the light beam is obscured and the detector generates an alarm signal.



Advantage: Quick with <u>large</u> particles, including plastic fires at low temperature (approx. 300°C), e.g. cable ducts, computer rooms,etc.

Disadvantage: Must be visible (preferably dark) smoke. Hard to get stable in environmental tests. Sensitive to condensation in ducts.

Ionising detectors work best when there are a large number of small (0.01-1 micron) particles, while optical (light scattering) detectors are considered better for a smaller number of large (0.1-10 microns) particles.

It is difficult to determine the type of particles smoke will have. This depends on factors such as the type of material on fire and how the fire starts (rapid or slow ignition).

However, a guideline for this determination can be found internationally. Established test fires have been used for decades in detector tests. In order to be approved, each detector must be able to withstand these defined test fires.

The table below provides information on the nature of various types of fire and smoke.

Test fires in accordance with European standard EN 54-7 for point smoke detectors/ ceiling-mounted smoke detectors:

Test fire	Type of fire	Characteristics				
		Heat development	Updraft	Smoke	Aerosol spectrum	Visible part
TF2	Smouldering fire (wood)	Negligible	Weak	Yes	Most visible	Light, highly reflective
TF3	Smouldering fire (textile)	Negligible	Very weak	Yes	Most invisible	Light, highly reflective
TF4	Open, plastic (polyurethane)	Strong	Strong	Yes	Partially invisible	Very dark
TF5	Liquid fire (n-Heptane)	Strong	Strong	Yes	Most invisible	Very dark

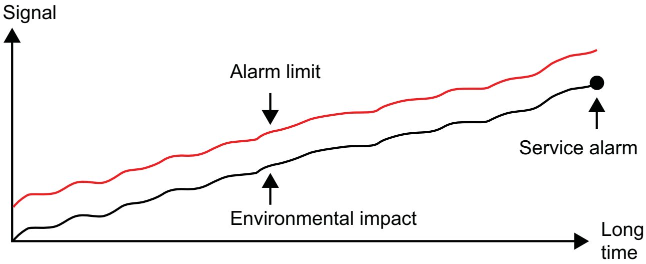
Remarks:

1. In order to be approved, smoke detectors must also pass the European environmental tests in accordance with EN 54-7, which for example include high wind speeds, temperature variations, relative humidity, vibrations, shock, high frequencies and electrical transients.

2. Both optical and ionising smoke detectors comply with the detection requirements specified above.

3. With the new generation of optical smoke detectors of the type EVC-PY-DA, the development of microprocessor-based electronics has levelled the playing field between ionising and optical detectors. With a new wavelength for the light source and optimised measuring angle in the detector chamber, detection of dark and low-reflecting smoke types has been greatly improved. From an environmental aspect as well, optical smoke detectors are preferable to ionising ones.

The detector also has an "intelligent" alarm level sensitivity adjustment as depicted in the sketch below.



Stable alarm level. The alarm level of the detector is continually adjusted so it is always optimal, regardless of the impact the environment has on the detector, e.g. dust, soot and other particles.

Each detector stores and updates information on the self-adjusted level.

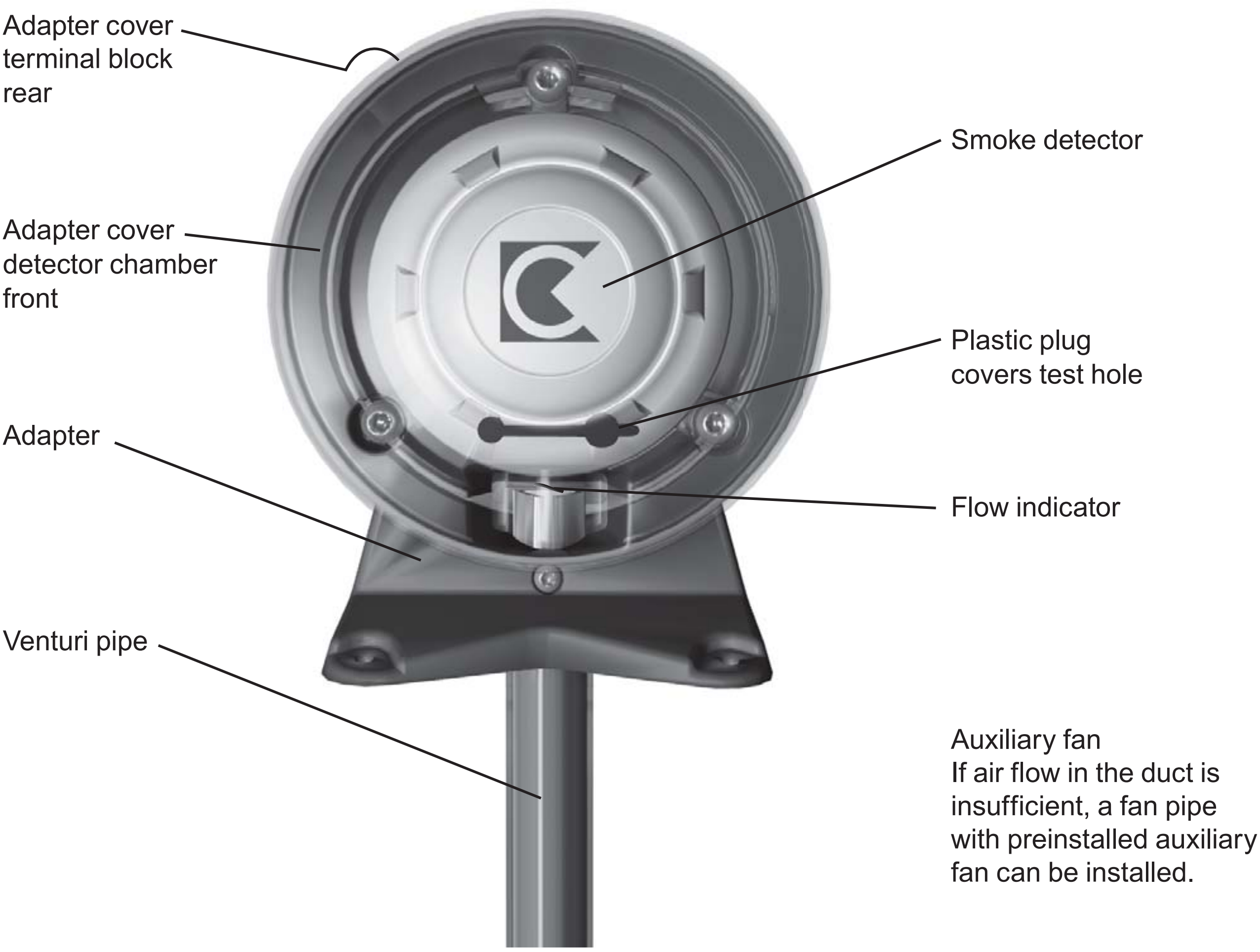
CORRECT INSTALLATION AND POSITIONING

In order to ensure proper functioning of a duct detector*1, it is essential for it to be installed correctly in the duct and correctly in relation to sources of interference. It is also important to install a sufficient number for appropriate detection. More on this is found under the heading “Number”.

The installation instructions primarily apply to ionising detectors and optical (light scattering) detectors, but certain sections also apply to line optical (obscuring) detectors.

Ionising and optical (light scattering) detectors must not be installed inside ducts. They should be placed in an adapter with transparent cover positioned outside of the duct. Air (or a mixture of air and smoke) is directed across the detector in the adapter via a 2-channel venturi pipe positioned inside the duct. The venturi pipe is adapted to the size of the duct and is fitted in the middle of the duct, where the flow is stable.

UG-3 Uniguard Superflow *2



Older types of smoke detectors have two venturi pipes – one with inlet and one with outlet – to obtain flow through the adapter.

*1) A detector positioned inside the duct or in an adapter outside the duct.
*2) The adapter and venturi pipe are patented.

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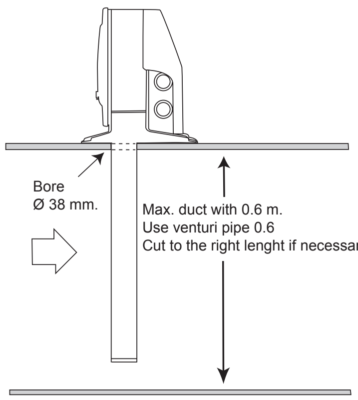
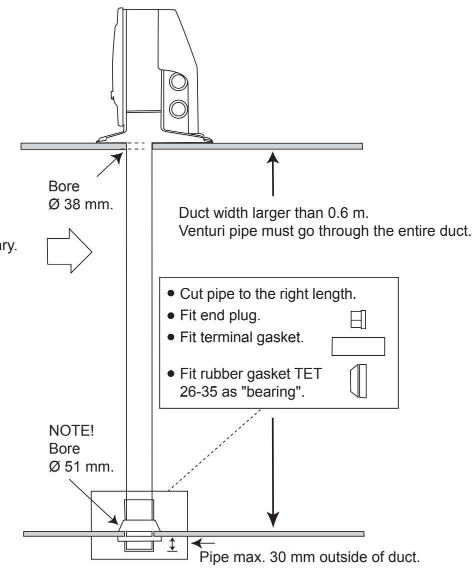
Duct detector

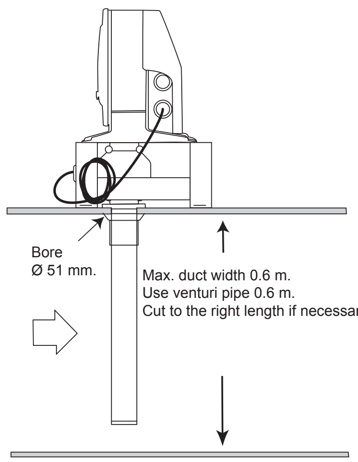
Position the detector in the centre of the duct where the flow is stable and the adapter in the middle of the duct wall.

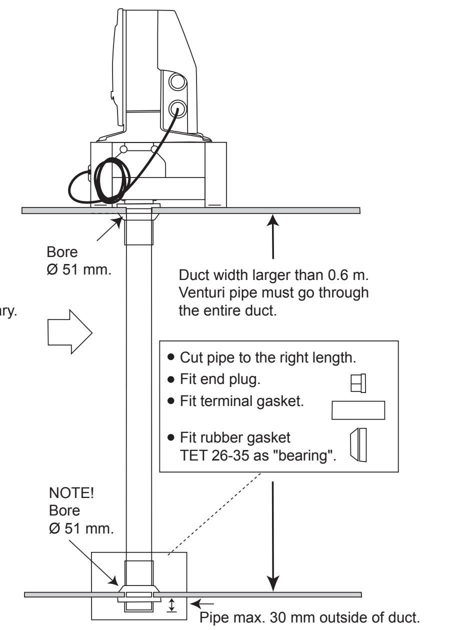




Standard venturi pipe lengths,
which can be cut to the required length:

VR-0.6M	Length=0.6 m	Ducts up to 0.6 m
VR-1.5M	Length=1.5 m	Ducts from 0.6 to 1.4 m
VR-2.8M	Length=2.8 m	Ducts larger then 1.4 m





Venturi pipe with auxiliary fan
which can be cut to the required length:

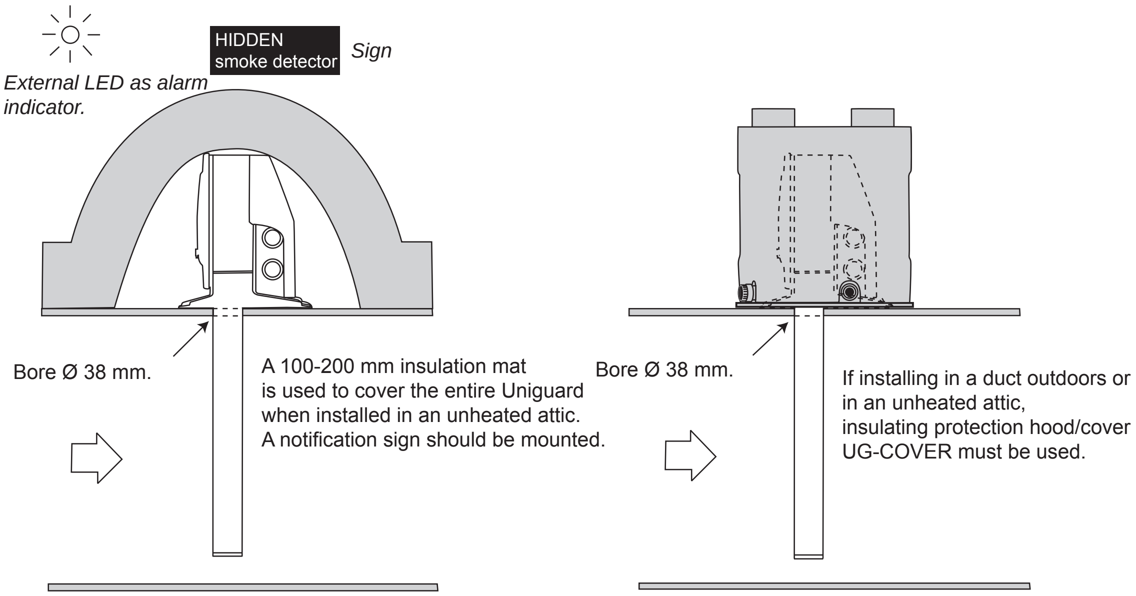
VRF-0.6M	Length=0.6 m	Ducts up to 0.6 m
VRF-1.5M	Length=1.5 m	Ducts from 0.6 to 1.4 m
VRF-2.8M	Length=2.8 m	Ducts larger then 1.4 m

When venturi pipes with a length of 1.5 m or 2.8 m are used, the pipe must go through and be fixed in the opposite duct wall with the rubber gasket included in the delivery (TET 26-35).
NOTE: The terminal gasket and end plug should always be fitted onto the pipe end. The pipe may protrude from the duct maximum 3 cm.

The detector is positioned and marked so that operating and maintenance personnel can find it easily.
If the detector has a hidden position, e.g. in a shaft or above a false ceiling, inspection hatches must be installed and signs posted.

The detector should not be installed where condensation problems could arise, e.g. outdoors, in unheated attics, etc. If such cases, the detector must be insulated from the ambient air and marked with an extra indicator lamp, LED-03, and the sign "HIDDEN SMOKE DETECTOR".
Insulating hoods/covers, indicators and signs can be ordered from Calectro.

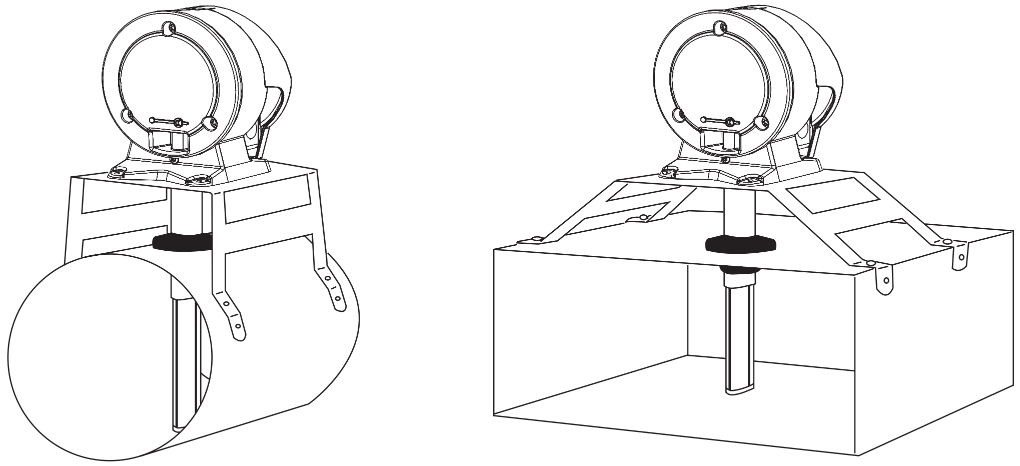
Installation in unheated attic.



Adapter on outside of insulated duct wall

If the duct is insulated on the outside, the adapter must be installed in a manner that does not disturb the thickness of the insulation.

A bracket – Calectro installation bracket UG-MB – is used if space is required between the smoke detector and duct. On round ducts, the bracket is suitable (even without insulation) to facilitate installation.



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Another operating condition worth noting is the speed in the duct at the adapter. Speed must be minimum 0.2 m/s and maximum 20 m/s.

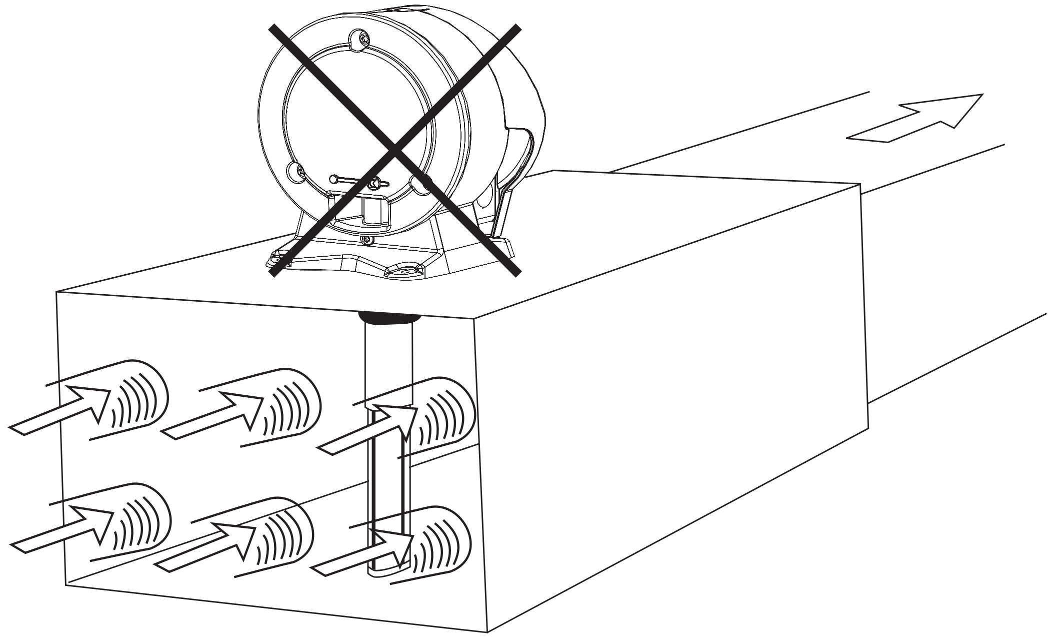
Within this range, detector sensitivity should remain basically unchanged.
The detector with adapter must also be stable, i.e. there must be no false alarms at speeds up to 20 m/s.

At speeds below 0.2 m/s, boosting the effect of the venturi pipe with an auxiliary fan via a special venturi pipe with preinstalled fan (see page 13) can be considered.

Ventilation branch box

Do not position the smoke detector in a ventilation branch box. Smoke from the connection ducts can bypass the smoke detector (regardless of type), and the alarm will fail to trigger due to air swirls and air pockets.

Example of <u>incorrect</u> installation!



Final check of installed detector

- Check that the duct detector is properly installed in relation to the direction of air flow – the arrow on the adapter should point in the direction of flow.
- Check that the venturi pipe is securely attached as indicated in the installation instructions – particularly if an extra long venturi pipe is used.
- Check that the duct detector is fitted with a flow indicator.
- Check that the adapter cover and its gasket seals properly.
- Check that the cable inlets are well sealed.
- Check that the flow indicator shows that air flows through the detector adapter when the unit is started.
- Check the test hole plug.

See also the information under "Functionality testing and inspection" on page 30!

Sources of interference

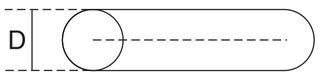
Another important rule is to select an appropriate distance from all bends, dampers and dimensional changes in the duct system that could cause flow interference as the result of air pocket formation. Such changes can in turn affect the air/smoke mixture, resulting in failed or delayed detection.

The duct detector should not be positioned:
- near inlets to or outlets from fans or air handling units
- near duct bends
- near branches/connections
- near dimensional changes
- near batteries, dampers or the like

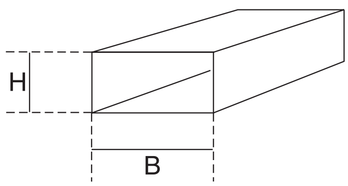
In order to achieve the required function, a duct detector must be positioned with the same degree of precision as when selecting the location of a flow meter.

The hydraulic diameter d_h is the unit of measure used when determining distance to a source of interference.

Circular duct



Rectangular duct



$d_h = D$

$$d_h = \frac{2 \times H \times W}{H+W}$$

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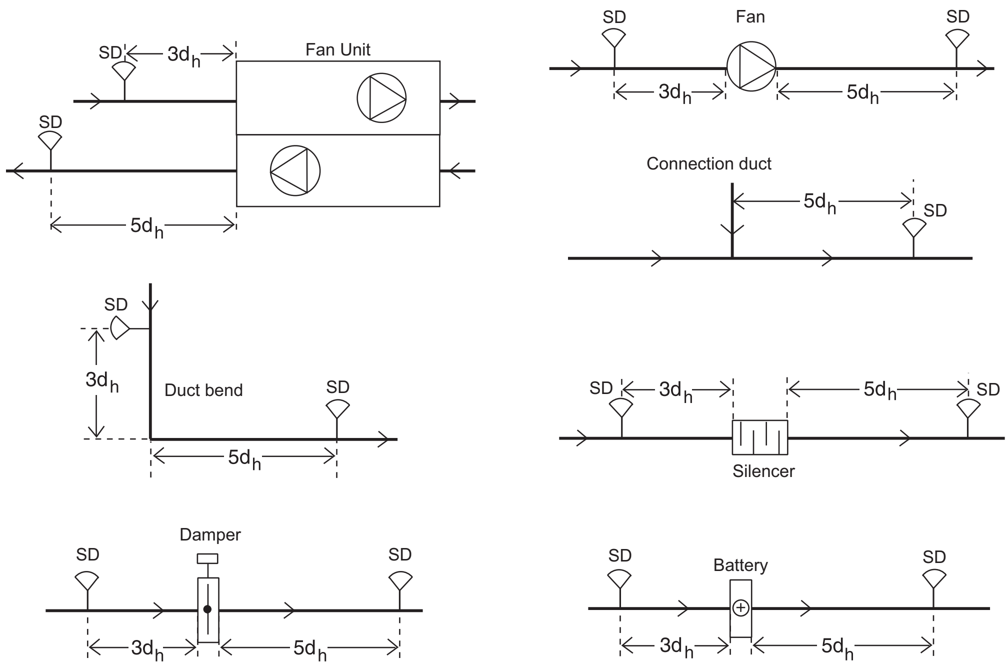
The distance before a source of interference should not be less than 3 x d_h and the distance after a source of interference should not be less than 5 x d_h. If it is very difficult to achieve these distances, the following can be accepted as an exception: 2 x d_h before and 3 x d_h after the source of interference. A smoke test can be used to test functionality and must be done if the shorter distances must be used.

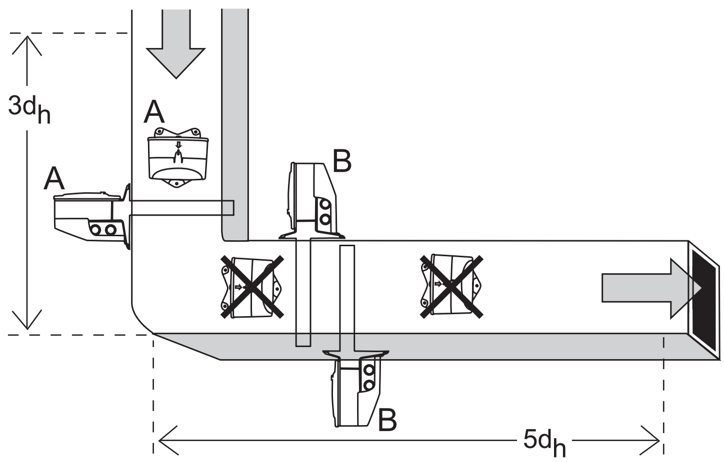
Smoke tests should be performed with a smoke generator (with paraffin as the aerosol material). This is used for test fires in laboratories. Smoke bombs or other chemical smoke should be avoided as these do not develop particles like an actual fire would. In addition, chemical smoke can damage the smoke detectors.

Examples of installation at sources of interference
SD = smoke detector



If it is **not** possible to install the smoke detector as specified above, you may be forced to disregard these regulations. The illustration below shows the best positioning for such cases. Try to position the detector at the position marked with an A (before the source of interference). If this is not possible, use position B and as close to the recommended distance as possible. Smoke tests should be performed with a smoke generator. Do not install the detector at the positions in the illustration marked with an X because in these positions the detector may miss the air flow.

Example of installation as an exception in space that is extremely difficult to access



CORRECT NUMBER OF SMOKE DETECTORS

The most common practice today is to place a smoke detector in the supply and extraction air ducts for each air handling unit and centrally in the air handling unit room. Whether this is sufficient or not depends on the scope and nature of the ventilation system as well as the set requirement level, e.g. what degree of delay can be accepted.

In principle, it does not matter whether the air handling unit room is located over, level with or below the ventilation installation.

For a big system with a large number of fire cells and perhaps many rooms in each cell, it is important to take into consideration the dilution ratio between smoke and air. Such evaluations are seldom or never performed for smoke detectors, even though the function of the detector depends on such an evaluation.

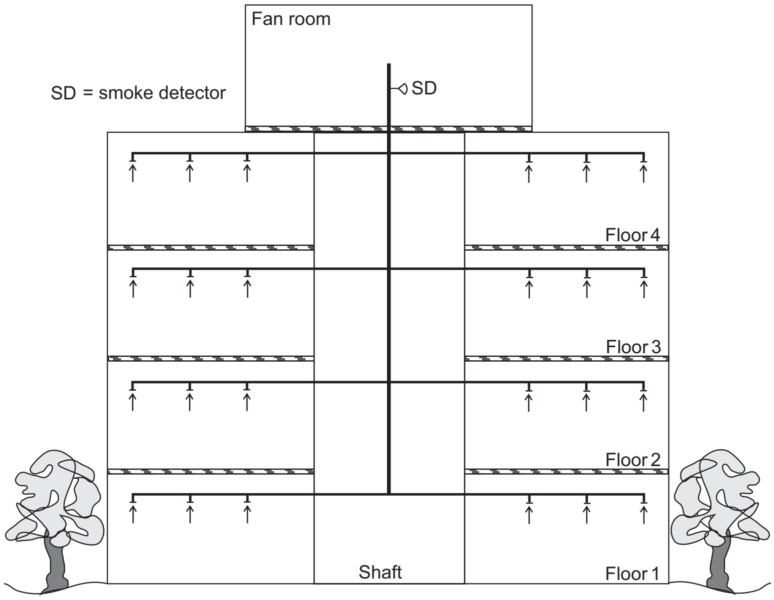
If dilution is too great, the concentration of particles will be so low that the smoke detector will not react. It is not until the fire has reached an advanced stage with increased combustion gas flow that there is detection – with an undesired delay and perhaps in a situation when it is too late to save lives and property.

There is limited practical experience on how much the smoke can be diluted. One rule of thumb is not to dilute the flow more than 10 times in order to obtain satisfactory protection.

Another rule of thumb is that the “duct route” (duct length/air speed) should not be longer than approx. 15-20 s. Soot particles can coagulate and become fewer in number and larger in size – and not pass the selected detector.

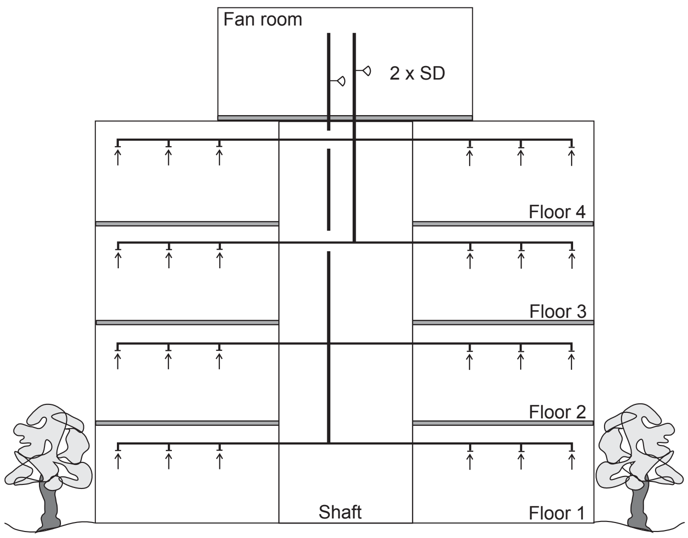
Duct detection generally requires that the ventilation system(s) is in operation. Viewpoints on detection in systems without operating fans are found in the section on operating conditions.

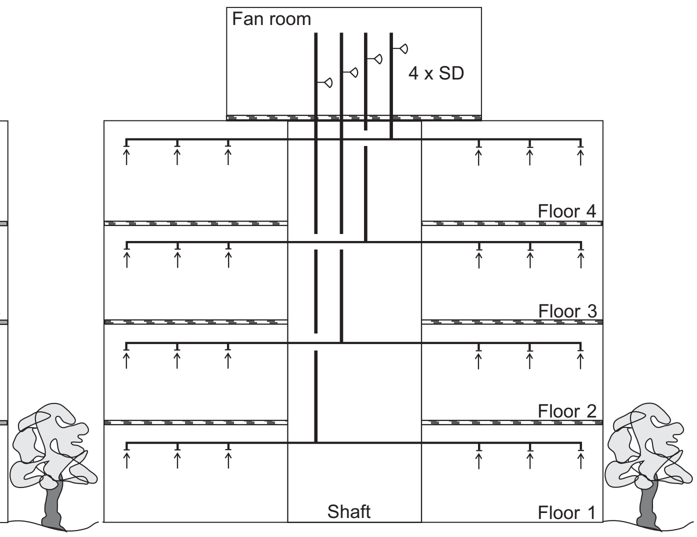
Detectors in air handling unit rooms



A smoke detector (SD) is positioned in front of the air handling unit and in a location common to the four floor levels.

Since the smoke is diluted a lot before it reaches the detector, the SD function is delayed.



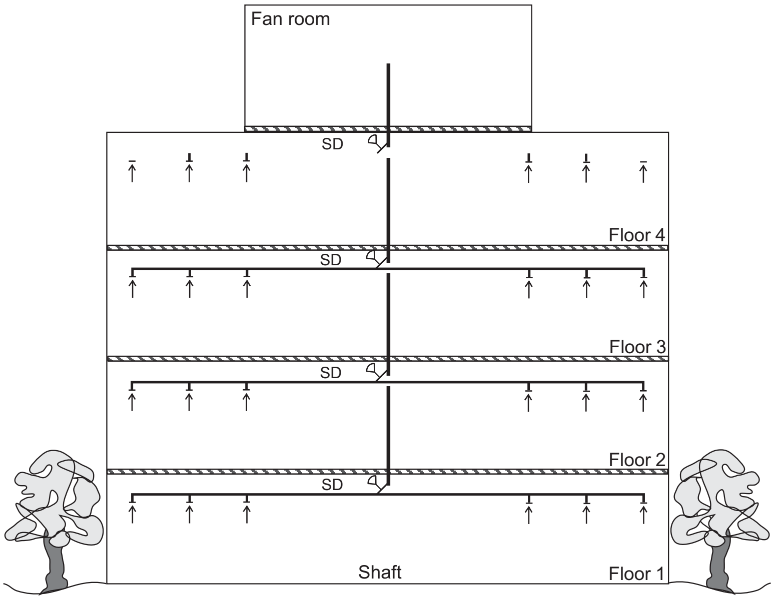


The number of main ducts is increased and one smoke detector (SD) is positioned in each main duct.

Having a greater number of main ducts can, to a reasonable extent, compensate for excessive dilution, but if a large number of rooms/smoke cells/fire cells are connected, this will not be enough.

Positioning detectors in air treatment unit rooms simplifies servicing and maintenance.

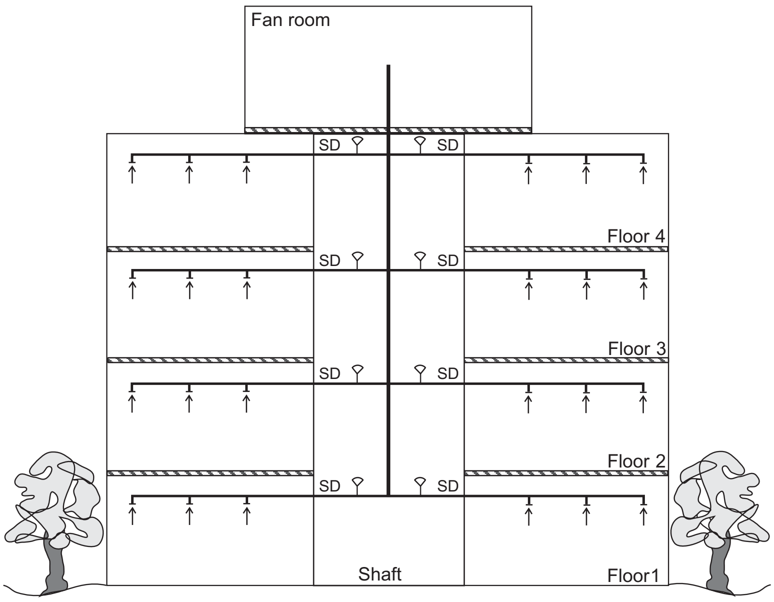
Detectors on floor levels



In this case, detectors can be placed on the floor levels – one detector (SD) for each level.

Decentralisation generates more rapid detection.

Positioning closer to the potential start of the fire increases the likelihood of obtaining detection even if the air treatment system is not in operation.



Detectors are placed in each connection duct.

Increasing the number of detectors in this manner can be justified as a means of preventing the degree of dilution from becoming too large due to the large number of connected rooms.

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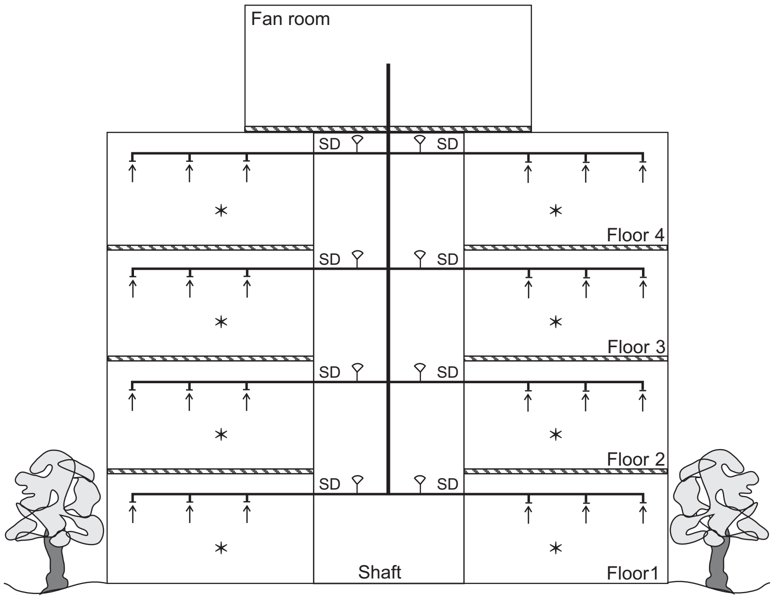
Duct and room detection



Duct detection in connection ducts is supplemented to some degree with room detection.
See also pages 4 and 23.

Increased detection reliability is achieved (regardless of whether the system is operating) by supplementing duct detection with a certain degree of room detection, such as in corridors or other representative positions (to protect a group of rooms).

*) Position of SD in e.g. corridor; see page 23.

SENSITIVITY

Conventional smoke detectors – (decentralised intelligence)

A conventional smoke detector has built-in functionality for determining whether an alarm should be triggered. This means that the smoke detector already has a set limit value for service and smoke alarms.

Effect of dirt.
When a conventional smoke detector is exposed to dirt, both its sensitivity and the risk of a false alarm increase.

Analogue smoke detectors in fire alarm system – (centralised intelligence)

Analogue smoke detectors are connected to an advanced central unit. The analogue smoke detector provides information on current "smoke indication level" (analogue value) and address to the central unit, which can be programmed with a different sensitivity level for each smoke detector if necessary.

Effect of dirt.
When an analogue smoke detector is exposed to dirt, its analogue value increases. In order to prevent an increase in smoke detector sensitivity, the central unit compensates/increases the alarm limit value. This serves to maintain the sensitivity level and reduces the risk of false alarm.

New optical smoke detector with automatic sensitivity adjustment

EVC-PY-DA is a conventional optical smoke detector that combines the benefits of decentralised intelligence with automatic sensitivity adjustment. This means that technology previously only available in advanced fire alarm systems is now available in Calectro smoke detectors for ventilation ducts (UG-3-O) and ceiling installation (EVC-PY-DA). Since the alarm level is adjusted automatically, sensitivity is maintained and the service life of the smoke detector increases. The service alarm is triggered when the smoke detector has reached maximum adjustment (compensation) + 60% remaining sensitivity.

Approval in accordance with EN 54-7

A smoke detector should be tested in order to be provided a "trade description". The basis of this is laboratory testing in accordance with European standards, a test which shows that the detector has the correct sensitivity in relation to established test fires and which shows that the detector has the correct ratio between sensitivity and stability (environmental test); see page 11 EN 54-7.

For this reason, detectors tested in accordance with EN 54-7 should always be used.

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OPERATING CONDITIONS

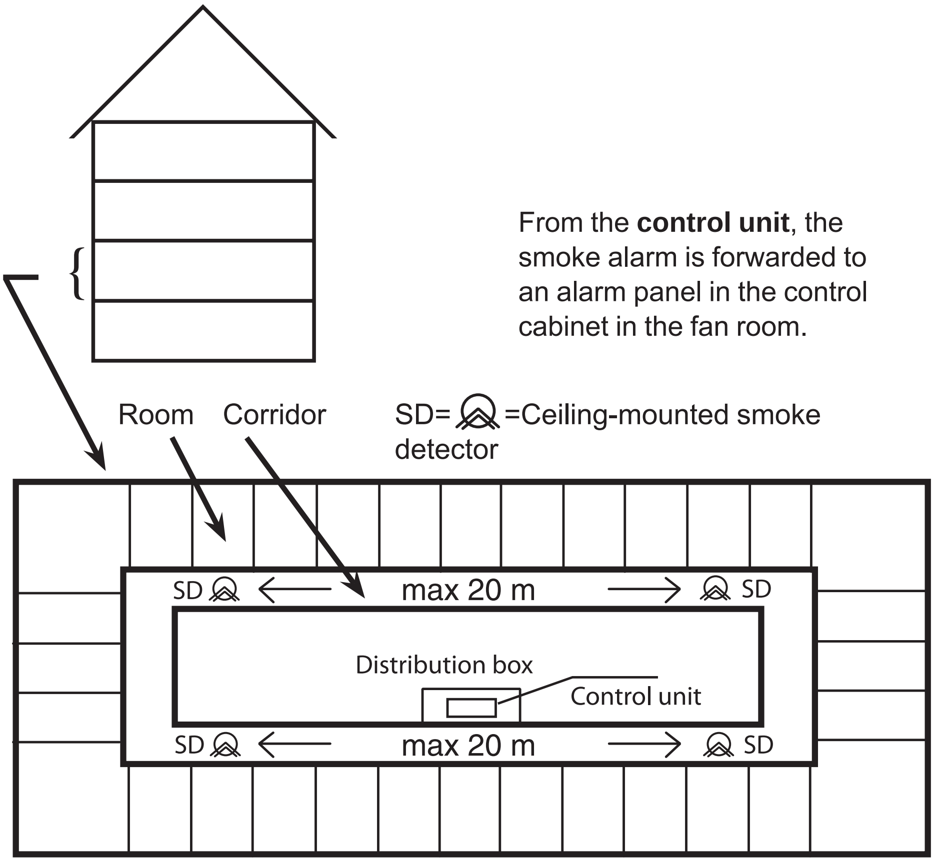
When designing an appropriate smoke detection system, consideration must be given to whether the air handling unit is in operation.

Completely different conditions apply if you want to maintain the requirement level set for an operating system in a system that does not have fans operating.

When the fans are not operating, the associated duct system can be considered "closed" and there is no noticeable flow in the ducts. Consequently, it takes a long time for the smoke to reach the detectors – regardless of whether they are installed in the duct or in an adapter – so that they can produce a signal. With such a delay, the alarm does not have the same value as if it had been triggered at an earlier stage.

> **A general rule is that duct detection requires the air handling unit to be operating. The system can be supplemented to provide protection when the unit is stopped.**

Example:



Examples of different positioning alternatives are found under the heading "Correct number" on pages 18-21.

Positioning in the air handling unit room as described on page 19 can never be considered to provide good protection when the system is not operating. Installing a detector inside a duct or fitting the adapter with an auxiliary fan in the form of a so-called fan pipe can hardly be considered sufficient since there is no smoke in the duct (during the initial stage of the fire). If conditions are just right, smoke could spread in the main ducts and cause detection – with a considerable time delay. In such cases, each main duct is fitted with a smoke detector.

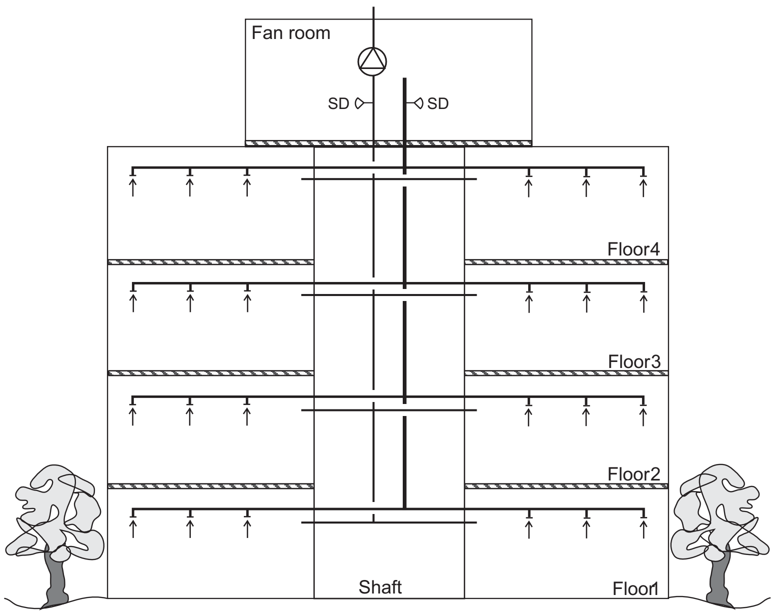
On page 20, it was noted that if a duct detector is positioned quite close to the potential start of a fire, the likelihood of detection increases, even if the system is not operating. If a fire breaks out, the smoke will also spread in the duct system, albeit slowly. When the smoke reaches the duct detector, it is initially at a low speed. In such cases, an auxiliary fan in the form of a so-called fan pipe can enhance the effect of the venturi pipe and reduce detection time.

Supplementation of the detector system, e.g. as described on page 21, is a solution that is recommended for reliable detection, regardless of whether the air handling unit is operating.

"Regulations for automatic fire alarm systems" – SBF 110:6 – e.g. items 3.4.1 and 3.4.3 apply to in-room detectors.

SBF 110:6 item 3.1.4 applies to ventilation systems in general.

Another form of detection can be illustrated with the following example:



When the fans are off, detection is handled with a separate system. A small-sized duct system is connected to the rooms. The small fan starts when the main system stops. If smoke is detected, the protection measures of the main system are triggered.

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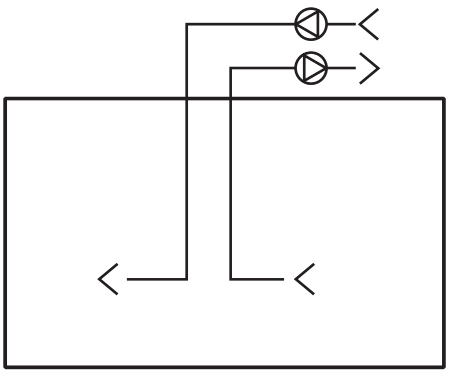
DETECTION IN SUPPLY AIR

In older standards and practice, the general rule was that a ventilation system servicing several fire cells should be stopped in the event of a fire upon a signal from a triggered smoke detector in the supply air duct immediately after the supply air fan.

Below are some updated views on detection in supply air.

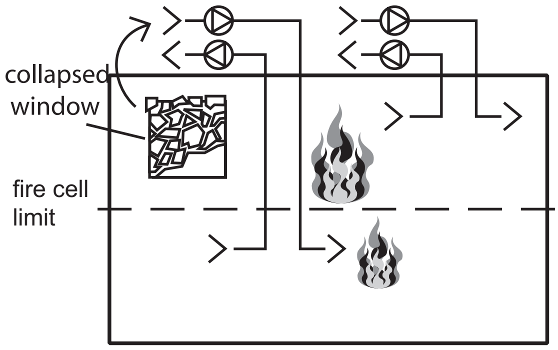
Building made up of one fire cell – one extract and supply air system



If the building is made up of one fire cell, the consequences are not greater if the fire starts in the fan motor or if combustion gas is sucked in via the outdoor air inlet compared to if the fire starts in the building.

A smoke detector in the supply air duct directly after the supply air unit can thus be a good idea to protect property, but is not required by Swedish building regulations, BBR 15 (2008).

Building made up of several fire cells – one extract and supply air system per fire cell



Here, there is no risk of combustion gas spreading between the building's fire cells.
However, there is a risk of short circuit so that smoke is sucked in via the outdoor air inlet to

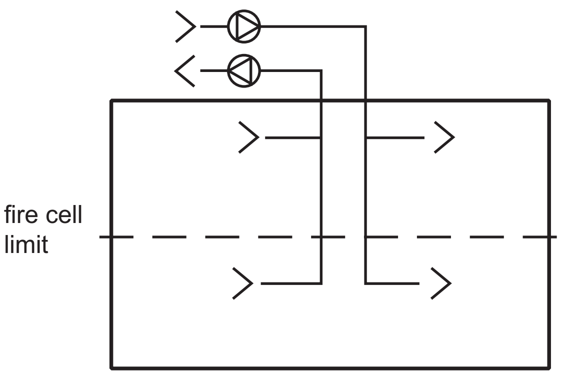
a unit serving another fire cell. This leads to indirect spread between fire cells via the ventilation system.

- Stop of the fans is controlled by the smoke detector in supply air.

or

- Stop of the fans is controlled by the building's fire detection system (supplemented if necessary).

Building made up of several fire cells – one extract and supply air system



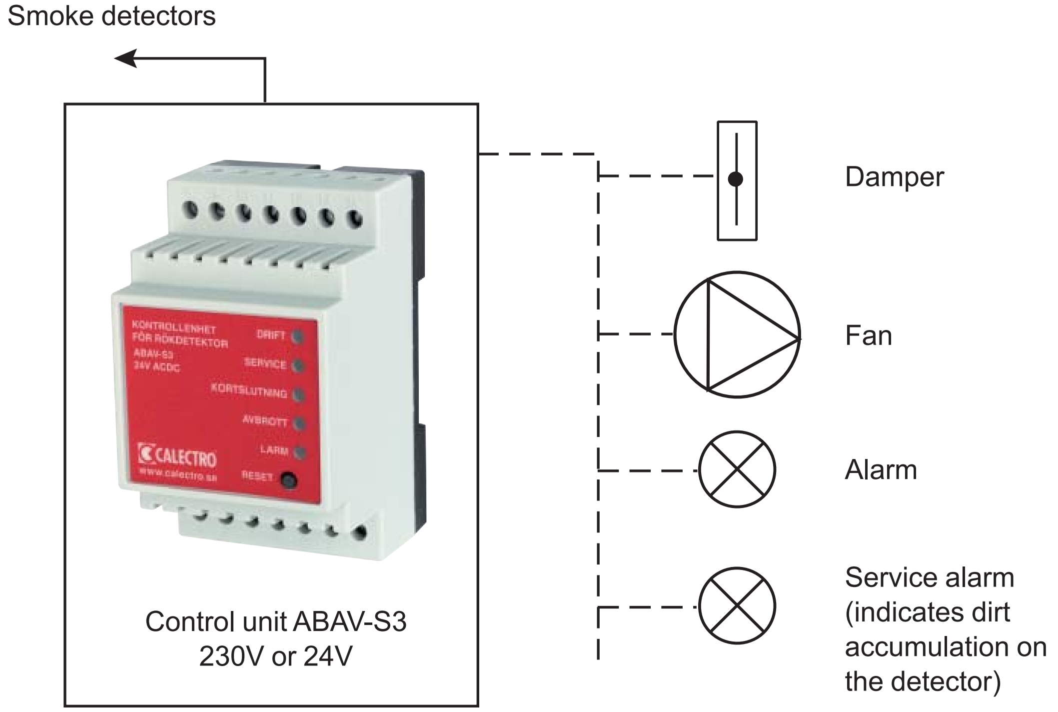
When several fire cells are served by a common extract and supply air system, there is a risk of combustion gas spreading between fire cells. There are several ways to resolve this. This always requires some form of fire detection in the building, either duct detector(s) in extract air duct(s) and/or via the building's fire detection system.

If a fire starts in the fan motor (supply air), all fire cells in the building will be affected. It is wise practice to install a smoke detector in the supply air duct directly after the supply air fan. Stop of the fan is controlled by the smoke detector.

Note that if the fans should continue running during a fire, this function must be blocked.

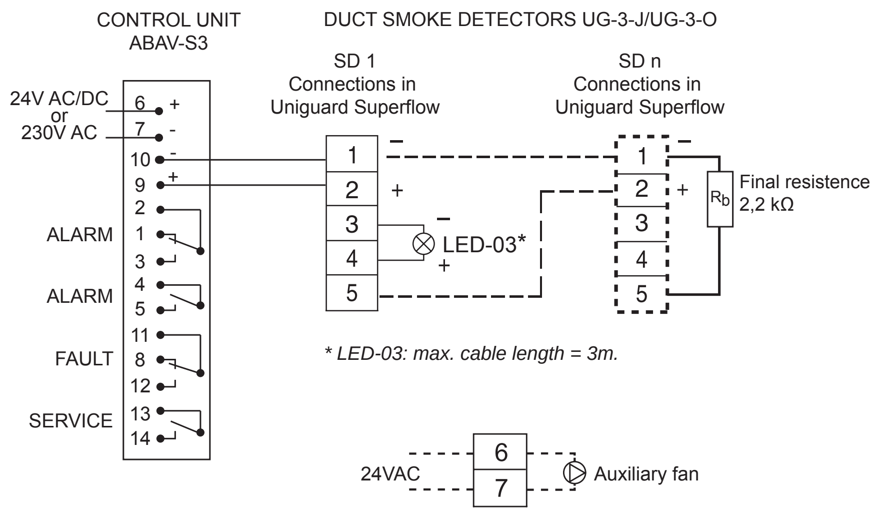
MONITORING AND MAINTENANCE

There are different types of control units to automatically close/open smoke dampers, fire dampers or smoke fire dampers and to stop/start fans.

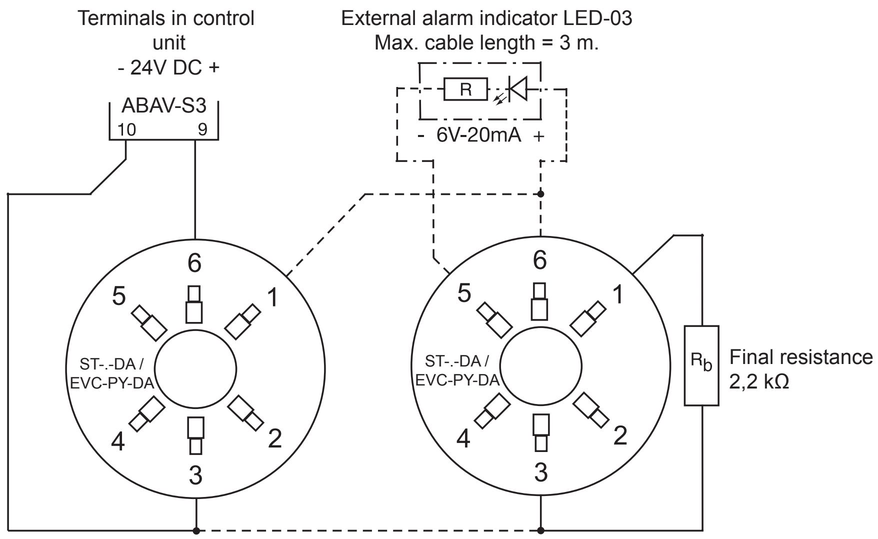


A control unit also serves as an alarm centre for the air handling unit. From the control unit, signals can be forwarded to e. g. the unit's control cabinet/alarm panel.

Wiring diagram – duct detector



Wiring diagram – ceiling detector



Theoretically, an unlimited number of smoke detectors can be connected. But, for functionality and maintenance reasons, the number should be limited to about 10.

Smoke detectors with the same function, i.e. will close/open the same damper or start/stop the same fans in the event of a fire alarm, are connected to one control unit.

If the detectors will actuate different dampers and fans, e.g. supply air side or extraction air side, one control unit is used for the smoke detectors installed for the supply air side and another control unit is used for the extraction air side.

Maintenance

To keep the detector insert from becoming too dirty, it should be cleaned at suitable intervals (at least once a year).

The following alternatives are available depending on the degree of dirt:

A. Dry particles can be vacuumed or carefully blown away.

B. Other dirt is removed with a damp cloth.

C. If the detector insert is so dirty that cleaning alternatives A and B are not enough, the detector insert must be replaced.

D. A reserve stock of detector inserts and control units should be kept to facilitate rapid module replacement during servicing.

The venturi pipe should also be removed and cleaned each time the detector is cleaned. After cleaning, the pipe is refitted in its original position. NOTE: Do not forget to refit the end plug.

NOTE: After cleaning, check that all connections are tight, the adapter cover forms a tight seal and that the flow indicator is oscillating. Also check that the sealing plug has been reinserted in the test hole after the detector has been tested with smoke or aerosol (RDP-300).

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Since dirt is the most common reason for false alarms, smoke detectors with built-in service alarm (maintenance alarm) should be used.
With the tough environment of duct systems, it is difficult to prescribe suitable maintenance intervals in advance.

The Calectro Uniguard Superflow duct detector comes with a service alarm as standard.
The system can be built based on 2 principles:

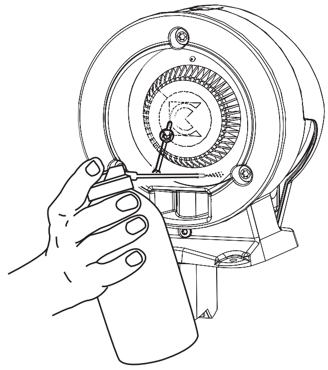
1. Service alarm indication on smoke detector with LED. Control unit ABAV-S3 should be used.
2. The same as point 1, but with an external signal for both service alarm and smoke alarm. Control unit ABAV-S3 must be used.

A service alarm is a requirement when using certain active solutions as protection against the spread of combustion gas.

TESTING SMOKE DETECTORS

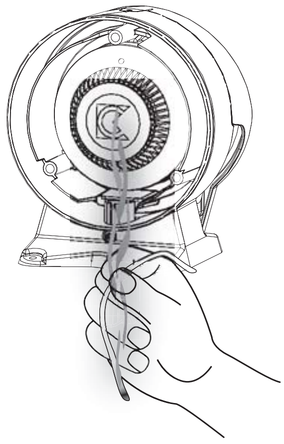
The following detectors are tested with smoke spray RDP-300.
Conventional smoke detectors.

Duct-mounted	Ceiling-mounted
UG-3-J	EVC-PY-DA
UG-3-O	ST-I
UG-3-A4I	ST-P
UG-3-A4O	ST-I-DA
UG-3-A5I	ST-P-DA
UG-3-A5O	



The following detectors are tested with smoke from a smouldering cotton thread.
Analogue, addressable smoke detectors.

NS-AIS
NS-AOS
UG-3-NS-AIS
UG-3-NS-AOS

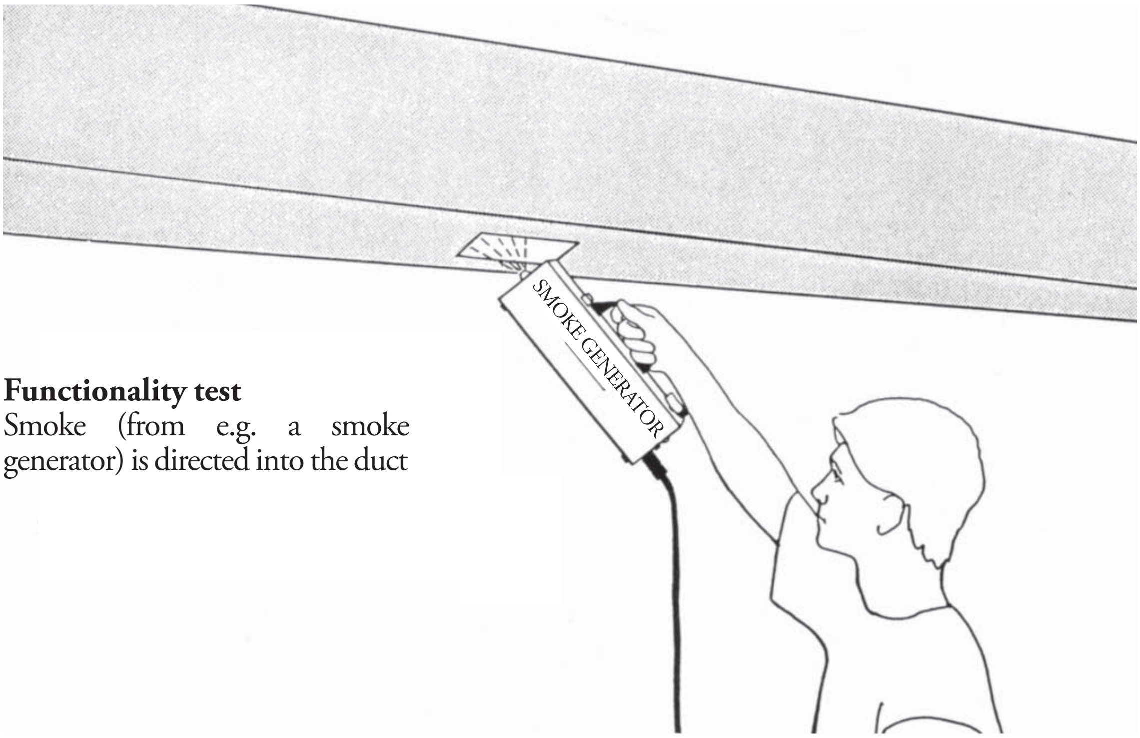


FUNCTIONALITY TESTING AND INSPECTION

After completing installation, it is easy to check that the electrical connection is correct. Smoke is applied to the detector with a smoke detector tester or by other means and the reaction of the detector is observed.
Also perform the final check of installed detector described on page 16.

This is not a functionality test in the strictest sense of the word. Conducting a functionality test which corresponds to the conditions that can occur during a real fire is in all practicality impossible.

However, a functionality test should always be conducted, preferably by applying smoke from a smoke generator at an appropriate point in the duct system. (Use paraffin or glycerine-based smoke generators as aerosol material. Smoke bombs or other chemical smoke could damage the detector and should be avoided.)



Functionality test
Smoke (from e.g. a smoke generator) is directed into the duct

A periodic functionality test is performed after the system has been put into operation.

At regular intervals – at least once a year – the system is checked to ensure that upon receiving an alarm from a triggered smoke detector the control unit actuates the right fans and closes/opens the right dampers.

At the same time, there is a check that the flow indicator is oscillating (that air really flows from the ventilation duct through the detector) and the detector insert is visually inspected to see if cleaning is necessary.

If the venturi pipes have been detached, check to ensure they were reinstalled in their original positions, that all connections are tight, that the cover forms a tight seal and that the end plug has been installed (see page 28).

PLANNING DOCUMENTATION

Bear in mind the following during planning work

A. Select a solution that optimises smoke detection for the object in question based on the information on pages 19 and 20. See also suggestions for improved fire protection on pages 21, 23 and 24.

B. Use the same degree of care when positioning the smoke detector's venturi pipe as when selecting a position for a flow meter in ducts, i.e. at least 3 d_h (duct widths) before and 5 d_h after a source of interference. (Source of interference = battery, filter, pipe bend, etc.) See page 17.

C. Establish the duct size and select an appropriate length for the venturi pipe. See page 13. The size is written in the description.

D. Installation bracket UG-MB is always used if the duct will be insulated. See page 14.

E. If the detector has an auxiliary fan, the auxiliary fan must be connected via the relay switch that controls the ventilation unit fans so that the auxiliary fan only runs when the regular fans are stopped.

F. Position the smoke detector so that it is accessible for servicing. The LED of the smoke detector should therefore be visible from the floor. If this is not possible, the detector should be marked with an extra indicator lamp, LED 03, and the sign “hidden smoke detector”.

G. Avoid installing ionising detectors where problems could occur, e.g. in ventilation ducts of restaurant kitchens (frying fumes), garages (exhaust fumes), workshops with welding and boiler rooms (non-combustible flue gases).

   Consult the supplier for alternative solutions.

H. Smoke tests should be performed on the smoke detectors after installation is complete to ensure that they are correctly positioned and installed.

   1. The electrical connection can be tested with smoke detector spray or matches to check that the right damper and fan are actuated during detection.

   2. Perform a smoke test with a smoke generator from a suitable space that is monitored by the detector.

I. For smoke detector models, see the table on page 32.

![CALECTRO]

OVERVIEW
DIFFERENT TYPES OF SMOKE DETECTORS

Conventional – for connection to a control unit

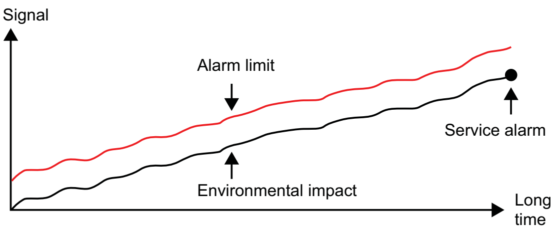
Type	Control unit input		Smoke alarm	Service alarm	Ceiling installation	Duct installation	Auxiliary fan	Ionising detector	Optical detector
	230V AC	24V AC/DC	Alarm pt. 1	Alarm pt. 2					
UG-3-J	ABAV-S3	ABAV-S3	X	X		X	*1	X	
UG-3-O	ABAV-S3	ABAV-S3	X	X		X	*1		X
EVC-PY-DA	ABAV-S3	ABAV-S3	X	X	X				X
ST-I	ABAV	ABV-3	X		X			X	
ST-P	ABAV	ABV-3	X		X				X
ST-I-DA	ABAV-S3	ABAV-S3	X	X	X			X	
ST-P-DA	ABAV-S3	ABAV-S3	X	X	X				X

Conventional – Standalone with built-in relay function (detector without control unit)

Type	Input		Smoke alarm	Service alarm	Ceiling installation	Duct installation	Auxiliary fan	Ionising detector	Optical detector
	230V AC	24V AC/DC	Alarm pt. 1	Alarm pt. 2					
UG-3-A4I		X	X	X		X	*1	X	
UG-3-A4O		X	X	X		X	*1		X
UG-3-A5I	X		X	X		X	*1	X	
UG-3-A5O	X		X	X		X	*1		X

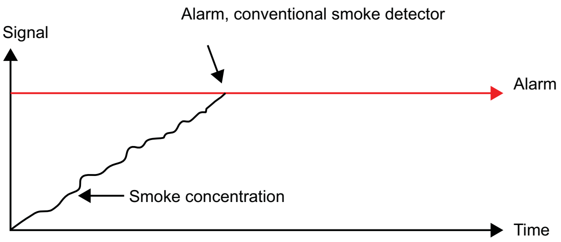
Alarm point 1: Smoke in duct.
Alarm point 2 (service alarm)**:** Dirty smoke detector.
*1: Can be combined with an auxiliary fan.

Alarm function for conventional optical smoke detectors



The conventional optical smoke detector EVC-PY-DA has an intelligent monitoring circuit that continuously checks and adjusts the sensitivity for optimum functionality during the entire life of the detector. When the detector can no longer compensate for environmental influences, a service alarm is indicated.

Alarm function for conventional ionising smoke detectors



The conventional ionising smoke detector generates an alarm as soon as the preset alarm limit has been exceeded.
Sources of interference, such as short-term electrical transients or dirt, could generate a false alarm.

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Analogue, addressable – for connection to a control unit

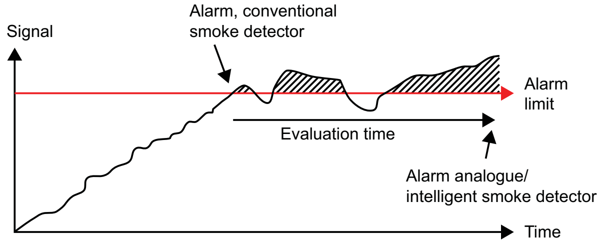
Type	Control unit input		Smoke alarm	Service alarm	Ceiling installation	Duct installation	Auxiliary fan	Ionising detector	Optical detector
	230V AC	24V AC/DC	Alarm pt. 1	Alarm pt. 2					
NS-AIS*1a		KE-1000	X	X	X			X	
UG-3-NS-AIS*1a		KE-1000	X	X		X	*2	X	
NS-AOS*1b		KE-1000	X	X	X				X
UG-3-NS-AOS*1a		KE-1000	X	X		X	*2		X

Alarm point 1: Smoke in duct.
Alarm point 2 (service alarm)**:** Dirty smoke detector.

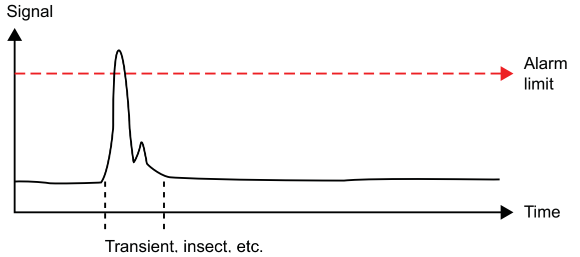
*1a: Analogue ionising detector that also indicates the address when a smoke alarm is triggered.
*1b: Analogue optical detector that also indicates the address when a smoke alarm is triggered.

*2: Can be combined with an auxiliary fan.

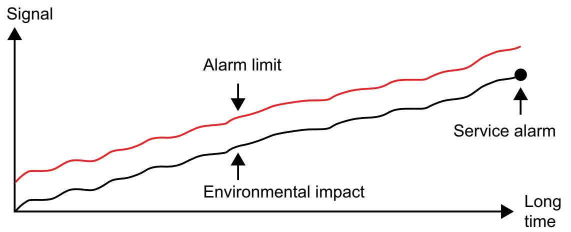
Function for analogue addressable smoke detectors



The analogue detector evaluates alarm signals by measuring time, signal height and signal propagation. The detector only generates an alarm if this check gives the preset values for a fire.



The analogue detector does not generate an alarm from short, strong signals from interference, such as insects and electrical transients.



Stable alarm level. The alarm level of the detector is continually adjusted so it is always optimal, regardless of the impact the environment has on the detector, e.g. dust, soot and other particles.

Important historical data:
Each detector stores and updates important data, such as when the detector was put into operation, number of operating hours, number of alarms and the self-adjustment level.

NOTES

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