

## Fire Alarm System Design Overview, Part Two.

### Selection of Equipment for the Design.

Having established the basic criteria for the design of the system, now is the time to start considering, with the aid of the building plan and measurements, the equipment you will select to meet the requirements on the system.

It is good practice to first cast an eye over the building plan for each floor, marking off zone boundaries. These will be principally one per floor, and then every 200sq. m unless the floor is an open plan warehouse.

Next, mark in any initial manual call points required – every exit point from the building. Once that's done, go over the building plan again, using measurement, to ensure that there is a maximum distance in any of the zones in any direction of travel of 60m to a manual call point. In any place that distance is exceeded, position an additional call point, so as to reduce the maximum distance of travel in any direction in the zone to 60m or less.

This distance measurement is reduced for call points on the escape route, to 45m, and further reduced if Disability Discrimination requirements come into play, to 25m.

There will be considerations to make in the positioning of manual call points, so as to avoid any possible confusion with light switches, or other switches which are wall mounted. For this reason, manual call points are often surface mounted, so as to protrude further from the walls than switches, and should always be fitted with luminescent signage to aid identification (*emergency lighting considerations here too, but that's the subject of another discussion*). A final consideration when selecting locations is that the standard requires manual call points to be mounted so as to have the centre of the call point at a height from the floor of 1.4m, plus or minus 200mm, again unless DDA applies in which case, that height may be reduced to 1.0m typically.

With the “**M**” part of the system covered, for the moment, it is time to look at automatic detection, as required by the category of the installation.

There are two primary types of automatic detection, with variants, as well as other types of detection device, which are suited to more specific applications, such as flame detectors, fire beams, heat sensing tapes or cables, and specialist high sensitivity smoke detection systems, as well as gaseous extinguishing systems (more on some of those another time).

Let's look at general automatic detection first, as this will, in almost all cases, be what is required to meet the design criteria, with warehousing and large “open” areas to be considered differently.

Simply, there is a choice between smoke detection, and heat detection. There are field devices on the market which offer both in one detector, but for now we will consider them separately.

## **Smoke Detectors.**

Smoke detection is broken down into two types of detector – ionisation, and optical. For the most part, optical smoke detectors will be fitted, for a number of reasons, such as general operating characteristics, and stability overall. Ionisation detectors, whilst often slightly cheaper, are susceptible to dust particles, and can be disturbed by draughts and wind.

The trade-off between ionisation and optical detectors is essentially that an ionisation detector will recognise and react slightly more quickly to fast burning fires – ones which generate a lot of smoke fast, whereas an optical detector will react better (again slightly) to smouldering, slower burning fires.

The industry, in general is leaning to optical detection as the way to go, and advances in optical technology have produced very reliable detectors in today's market with negligible differences across the range to ionisation devices.

## **Heat Detectors.**

Heat detection also comes in two basic forms, and will be described as either “fixed rate” or “rate of rise”.

The terminology used above, is in the strictest sense, a misnomer – the detectors that most people assume to be “fixed”, are in fact more usually rate of rise with a fixed ceiling. The principle here is that they will detect both a rapid rise in air temperature, and will also operate when a slower rise in temperature to the “static” ceiling is reached. Typical operating temperatures are 50 – 80 degrees rate of rise, and 65 – 100 degrees C static ceiling.

Fixed rate detection is literally that - a detector which will operate at a specific temperature, normally 100 degrees C.

## **Principles of Selection.**

In the majority of cases, heat detection will be utilised in preference to smoke detection where there is a risk, or likelihood, of combustion, or rapid changes of atmosphere on a routine basis. Such area may include kitchens, boiler rooms, some types of plant area, areas of strong natural or mechanised ventilation (forced ventilation).

Smoke detection will be utilised in a majority of other cases.

## **Detector Siting.**

There are several rules to observe when selecting and siting automatic detection. It seems irrelevant, but actually isn't for a number of reasons, to note that the “detector element” of either a smoke or heat detector should be a minimum of 25mm from the ceiling.

In the case of a smoke detector, the detection element also requires to be within 600mm of the ceiling. For heat detection, that distance is 150mm.

There is also a need to be careful when considering partitions which do not extend all the way to the ceiling, or when obtrusions from the ceiling extend down into the room (beams, joists, etc).

Where a partition extends to within 300mm of ceiling, the areas either side will be treated as a partition. This also applies when a protrusion from the ceiling extends down into an area by more than 10% of floor to ceiling height.

- No detector should be sited within 500mm of an obstruction, of compartment edge.
- Do not site detectors within 1m of an air conditioning or heating vent.
- Do not site detectors closer than 1.2m radius to lift doors.
- Do not site detection closer to a light fitting than a distance of twice the depth of the light fitting.

### **Corridors.**

Corridors can only be considered as corridors up to 2m in width – beyond this, they are treated as rooms. This can skew the detection spacing, whichever type is used, as under 2m in width, there need be no overlap – i.e. smoke detection can be spaced 7.5m apart, and heat detection 5.3m. Over this width, coverage needs to be overlapped.

### **Voids.**

A void may be ignored for the purposes of fire detection if it is less than 800mm in height. However, if the void also permits fire to travel from one area to another, then it must be protected, irrespective of height, unless it is less than the minimum and maximum detector head depths.

Depending upon what the purpose of the void is, you may select to use either heat or smoke detection, though in the majority of cases, optical smoke detection is likely to be the most suitable solution.

### **Enclosed Stairwells.**

Where an enclosed stairwell is encountered, detection should be fitted at the head of each set of stairs, and on each landing off the stairs, taking account of distances from the door between the two.

### **Coverage – Smoke detection.**

A single smoke detector will provide detection within a 7.5m radius, and where more than one detector is required to cover an area, that radius must overlap by a certain amount, generally worked out on a basis of a 10.6 by 10.6m grid pattern - each detector will provide coverage of 112m<sup>3</sup>. This calculation is for use only on flat ceilings.

Apex ceilings and roofs are treated differently, in that so long as the peak of the apex is less than 600mm higher than the rest of the ceiling, it may be treated as a flat ceiling. Over this figure, detection is placed at the highest point of the apex, firstly, and then the calculation distances given above can be increased by 1% per degree of angle, up to a maximum of 25% - i.e. a 30 degree pitch, or a 60 degree pitch will still see detectors spaced a maximum of 9.3m apart.

### **Coverage – Heat Detection.**

The rules for spacing of heat detection broadly follow the above. However, the maximum coverage of each heat detector is a radius of 5.3m, or formed in a grid of 7.5m squares.

The same rules apply too for spacing in apex roofs, up to a maximum of 6.6m apart at steep pitch.

### **Coverage - Multi-Detectors.**

It is worth mentioning here that where multi-detectors, or combined heat and smoke detectors are used, the spacing rules to be followed are those of HEAT detection, and not smoke – even if at the time of installation, they are biased toward smoke. That may change in the future for any reason, and spacing would then be insufficient.

### **Design Considerations.**

It is now time to work through your building plan, selecting appropriate detection, and marking it on the plans, in accordance with the category specification for the system under design.

There may be areas in which neither heat, or smoke work suitably – and for those areas, specialist detection is likely to be required. I will cover these off in another part of the guide.

### **Sounders and Warning.**

Whichever warning device is selected, the tone must be the same everywhere within the protected area. You cannot select to use, say, a 6" bell in some areas, and then an electronic sounder in others, unless it can reproduce perfectly the tone of the 6" bell.

In today's systems, it is more and more rare to see electro-mechanical bells used, though they are still a viable option in some cases.

Generally speaking, sounder devices shall be placed so as to produce an alarm tone at a volume of a minimum of 5bB(A) above ambient noise levels in any part of the protected area. The alarm tone should not exceed 120dB(A) at any part of the protected premises, and should not be less than 65dB(A).

Where sleeping is a feature of the premises, special allowance must be made to ensure that at each bedhead the alarm tone is a minimum of 75dB(A). Special rules may apply if the DDA applies.

Clearly, there are situations where it will not be possible to comply with these requirements – for example in an area where the ambient noise level is already over a hundred dB, or where DDA requirements indicate noise is not a suitable alarm method.

In these cases, sounders should still be installed in compliance with the standard – to the specification given above, but with the addition of alternative alarm devices also installed.

Flashing sounder beacons are a suitable alternative, as they offer a Xenon flashing beacon in addition to the alarm tone, giving a visual means of alarm identification too. The colour of the



beacon typically will be red, although it should be distinct from any other flashing beacons already on the site.

In the case of DDA applying, for sleeping arrangements, it is possible to specify vibrating devices, such as pillows, though care must be taken if such a device is already in use for other purposes as to vibration pattern, and in this case, should also be supplemented by a sounder and a flashing beacon. Vibrating devices should never be the sole means of raising an alarm.

Having digested this, you can now begin to mark off your building plan with sounder devices, taking care to note that fire doors, walls, and other obstructions are also likely to reduce sounder levels by between 20 and 30dB.

### **Control Panel Specification.**

At this point, you have a field device count, broken down into zones, and a sounder count. You need to add 25% of the detection or zone figure to allow for BS calculations, and room for additional devices which may become necessary to meet final compliance.

Let's assume, for a moment that you have counted 40 devices, broken down into 3 zones. You would then specify a four zone control panel.

As an alternative, at the other end of the scale, let's say you've counted 2500 field devices, broken down into 18 zones. In this case, a clear advantage would be gained by using an analogue addressable system, with software assignable zones.

### **Conventional V. Analogue Systems.**

Before any discussion of "protocols", and manufacturer choice, we are well to discuss the differences between systems termed "conventional" and those considered "analogue" or "addressable".

Each has its own merits in a given situation. There are cost v labour trade offs, and a clear fulcrum where one becomes a better choice of system over another.

Analogue installations will almost always offer more information at the control panel, and offer more configuration options than a conventional system will.

However, conventional systems may well offer all that is needed, and have clear advantages in terms of redundancy and resilience in the case of fire – because each zone and each sounder circuit are separately hard wired, any fire has to do a corresponding greater amount of damage before the system fails.

Analogue systems compensate for this by using a combination of conventional wiring technology in part, and very sophisticated fault monitoring in another part.

In realistic terms, the choice really comes down to preference, and cost. For very small systems, typically under eight zones, there is no overall advantage to using analogue technology – the odds are that each zone is small enough to be observed from one point, and that there are an insufficient number of devices in the installation to need point descriptions.

Over this number, the advantages of analogue systems begin to show merit. Features such as point description allow the omission of zoning the installation (unless needed for other reasons), devices are much more closely monitored, and can indicate upcoming faults, circuits similarly are closely monitored.

One primary advantage of analogue technology lies in the areas of something called cause and effect. This alone, even on a small system, may sway your choice of system type in favour of analogue, over conventional.

### **Cause and Effect.**

In even the simplest systems, cause and effect is present, though with most conventional systems, it is pre-set, and little can be done to change that.

In essence, a fire alarm system is always governed by one simple cause and effect rule.

The fire CAUSES the EFFECT of alarm sounders to activate.

In small systems that is desirable. The objective, at some level is to detect a fire, and make enough noise, or other warning, to allow everyone notice to evacuate safely.

However, that effect in a larger system – say a hotel set out over ten floors – could well end in a stampede, and nobody, save a lucky few on the ground floor get out alive, because of crushing, people tripping, or some similar reason.

In this case, we would want to design in a tidal effect – allowing people to evacuate in a safe manner, in a staged way, perhaps one floor at a time.

To do this successfully, we need to consider where the fire breaks out, how people are going to escape, and what the consequences of any given escape pattern may be on the remainder.

In part, this is where a proper fire evacuation plan needs to be enforced by the occupiers, but it also is critical to what we design.

In this case, we cannot assume that a fire is likely to begin at any given point in the building – after all, we have just designed an installation which takes account of fire starting at ANY likely point out of dozens or more.

This is where programmable cause and effect (and zoning) can come into its own.

Cause and effect programming is really beyond the scope of a brief design guide – it could run to pages and pages on its own.

Suffice it to say, for this guide, if you find that having designed the system, you will have need of staged evacuation, complex plant shut down, and really much beyond triggering a set of warning devices on activation, the choice is for an analogue system.

## **Wiring.**

It is good practice to mark on the building plan the likely routes cables will take. Having identified the “type” of system you are proposing, it is now possible to mark in the cable routes.

Cable should be selected for the system as to the requirements. In all cases, a fire alarm system must be wired end to end in fire resisting cable. However, in some areas, the cable is required to be of the “enhanced” type, and in others “standard” will be fine.

Typical areas requiring enhanced cable may include any large un-sprinklered area, or where extended operating time is likely to be required. This will very often include any system comprising staged evacuation as a minimum.

A standard fire rated cable will be certified to withstand fire for 30 minutes. An enhanced cable should be certified to withstand fire for up to 120 minutes.

On the matter of wiring – it is important to note that the main supplies to the fire alarm system are also required to be fire resisting. A dedicated supply from a consumer unit or distributions board must be supplied for the control panel, and the same primary source used to supply any power supply devices also included in the system. These supplies must be terminated adjacent to the equipment to be connected in a double pole isolating device, which is safe from tampering, or accidental disconnection.

There is debate about this subject, and for the avoidance of doubt, I will note here that the safer way of complying with this requirement is to specify a lockable double pole FCU (switched by a secret key), or to ensure a standard double pole FCU is mounted inside a lockable enclosure.

## **Summary.**

At this point, you should have arrived at a set of building plans which are marked up with your proposed system design.

Spend a little time here looking for any area that may have been missed, take advice from prospective manufacturers, and if necessary, consult again with others involved.

Once satisfied that you have designed a system which meets the criteria set, or has provided a solution which will allow the criteria to be met, you are ready to write the design specification, and submit for approval.

I hope this brief two part guide allows many of you to become a little more confident in fire system design, and encourages you to understand that as much as any part of it, good design is about consultation with all interested parties, as much as complying with what is undoubtedly a very complex, and technical standard.

I am happy at any time to offer further advice, or guidance, and who knows – if demand is there, I’m happy to write more short guides on specific areas as time allows.

Feel free to PM me, or to contact me through the company web site any time.

*Bill.*