7.5.1 Mechanical ventilation

Mechanical ventilation is the term used to describe air flow through an enclosure induced by mechanical means, i.e. fans. Ventilation air flows set up by mechanical means can be high (for example greater than 12 volume changes per hour).

The gas concentration within an enclosure ventilated by mechanical means will, in general, be much less than that resulting from a similar release into a naturally ventilated enclosure.

NOTE In case of very high gas concentrations (above LFL), or in the area above a flammable liquid with low flashpoint, an increased ventilation may lead to an increased volume of the explosive atmosphere.

In a well-designed ventilation system the whole volume within an enclosure is swept by the ventilation air flow. Where the geometry of the enclosure gives rise to regions of poor air movement or "dead spaces," a gas/air mixture may accumulate. Therefore, detectors should be sited in these spaces.

NOTE Smoke tracers may assist in identifying the air movement within an enclosure and the presence of any dead spaces where gas/air mixture may accumulate.

If a sensor is installed in the intake or exhaust duct of a mechanical ventilation system (depending on where the release might occur), then the alarm set point should be set as low as reasonably practical.

Some sensors use sintered materials as flame arrestors and the ability of an air/gas mixture to diffuse through the sinter to the sensing element can be adversely affected by very high air velocities that may occur in ducting arrangements. If this happens, additional shrouding of the sensor can help.

7.5.2 Environmental considerations

Environmental operational parameters should be included in the instruction manual of the intended apparatus.

Where environmental conditions are beyond specified values, the manufacturer should be contacted to ensure that the apparatus is suitable.

8 Design and installation of fixed gas detection systems

A fixed gas detection system should be capable of giving an early warning of both the presence and the general location of an accumulation of flammable gas, in order to initiate one or more of the following actions, either automatically or under manual control:

a) safe evacuation of premises;

b) appropriate fire-fighting and other emergency procedures;

c) removal of hazard;

d) shutdown of process or plant;

e) increasing ventilation.

The consequences to the safety of personnel, and the economic effects of potential damage, following an undetected release should be of major concern. This should lead at the outset to consideration of integrity of the system, redundancy, integrity of power supplies, fail-safe operation, etc.

Therefore, it is of great importance that gas detection apparatus should be installed and used in such a way that only authorized personnel will have access to the functional controls of the apparatus.

A major consideration is the selection of the quantity, and the locations, of detector heads or sample points. Practically this must be done by consideration of a wide range of factors including industry standards and regulatory authority requirements, the local environment and safety, and therefore usually requires a wide range of expertise.

8.1 Basic considerations for the installation of fixed systems

If the apparatus or any auxiliary components are installed in a hazardous location (i.e. 'classified' or 'zoned' area), they should be suitable for the area in which they are installed and so marked.

Three main types of fixed systems are commonly used.

a) Systems consisting of remote sensors connected to the alarm and control equipment by electrical cables

These systems are the most suitable for the majority of industrial applications. A system of this type should, in general, be installed so as to be capable of continuously monitoring every part of the plant or other premises where flammable gases may accidentally accumulate. It should be capable of giving the earliest possible warning of an accidental release or accumulation of gas within practical limits of the system, for example as related to the number and location of sensors.

Remote sensors and stand-alone apparatus should be connected to their associated control and alarm equipment according to the national requirements for installation of electrical equipment. The sensors and any other parts of the system which are located in a hazardous area should incorporate an explosion protection technique covered by the ~~IEC~~ ANSI/ISA-60079 series of standards for the intended zone of use.

NOTE At excessively high and low temperatures the sensor may be operating outside the temperature range specified by the manufacturer and therefore may no longer comply with its electrical safety certification.

b) Systems consisting of sampling apparatus

These systems are used when comparatively static process conditions apply, and rapid response is less important. The main advantage is that they can permit all of the electrical parts of the apparatus to be located outside the hazardous area, with only tubes, filters, and other components ~~etc.~~, inside the area ~~it~~ and a suitable ~~of~~ flame arrester at the interface. Where a system involving a single detection apparatus with timed sequential sampling of a number of sample points is installed, the interval in time between two successive samples being taken at any one sample point should be sufficiently short that a potentially hazardous accumulation of flammable gas cannot occur during the interval. The length of any sample tube and the sampling flow rate should also be such that a potentially hazardous accumulation of flammable gas cannot occur during the time taken for a sample to pass from the sampling point to the sensor. For this reason, sample tubes should be as short as is reasonably practicable.

c) Open path / Line of sight systems

These systems have special requirements, limitations and characteristics that do not come within the scope of this standard, (see also the note at the end of Clause A.3). Such systems usually employ an infra red technique, where the emitter and sensor are installed at opposite ends of a 'line of sight' path traversing an area. A mirror can be used on one side of the area so that the emitter and sensor can be adjacent on the other side, and other configurations are possible. The open path / line of sight systems are generally used in outdoor open spaces and large indoor spaces containing hydrocarbon process and storage equipment.

Open Path or LOS gas detection systems are not recommended for applications where gas detection is used as a protection technique, as permitted in ANSI/NFPA 70 (NEC) Articles 500.7(K) and 505.8(I). For details concerning this protection technique see ANSI/ISA-TR12.13.03.

8.2 Location of detection points

IMPORTANT – The principal objective is that sensors and sampling points should be placed such that gas accumulations are detected before they create a significant hazard.

But there are other requirements:

Sensors and sampling points should be located in positions determined in consultation with those who have a knowledge of gas dispersion, those who have a knowledge of the process plant system and equipment involved, and safety and engineering personnel.

This determination should consider:

a) the combination of sources of release with propagation effects (Clause 7);

b) whether the sources of release can be inside our outside confining structures, buildings etc.;

c) what can happen at access points such as doorways, windows, tunnels, trenches etc.;

d) local environmental conditions;

e) occupational health and safety;

f) access for maintenance including calibration and verification, and protection of the system against operational hazards of the plant.

The decisions reached on the locations of sensors and sampling points should be recorded in a safety dossier for the plant (refer also 8.10).

8.2.1 General site considerations

Where it is necessary only to detect the escape of gas from within a given area, then sensors or sample points may be placed at intervals around the perimeter of the site. However, such an arrangement may not provide an early warning of a release. This arrangement should not be used alone if a release could cause a significant hazard to personnel or property within the perimeter itself.

Sensors or sample points should be located close to any potential sources of major release of gas, although to avoid nuisance alarms, detection points should generally not be located immediately adjacent to equipment which may produce inconsequential minor leakage in normal operation. In general, on open sites minor leaks may be dispersed without causing a hazardous accumulation.

Sensors should also be located in all areas where hazardous accumulations of gas may occur. Such areas may not necessarily be close to potential sources of release but might, for instance, be areas with restricted air movement. Heavier than air gases are particularly likely to flow like a liquid and to accumulate in cellars, pits and trenches if these are present. Similarly, lighter than air gases may accumulate in overhead cavities.

If there is significant ambient air movement, or if the gas is released into enclosed spaces, then the behaviour of gas is modified. The behaviour of gases following a release is complex and depends on many parameters. However, knowledge of the influence of these parameters is not sufficient, in practice, to predict the extent and/or build-up speed of a flammable atmosphere. The prediction may be improved by:

1) the application of generally accepted empirical rules developed by experts, based on their past experience;

2) on site experimentation to simulate and describe precisely the behaviour of the gases. This includes the use of smoke tube tests, anemometer readings or more detailed techniques such as tracer gas analysis;

3) numerical simulation of gas dispersion.

In general, sensors should be sited above the level of ventilation openings and close to the ceiling for the detection of gases lighter than air, and below the ventilation openings and close to the floor for the detection of gases heavier than air.

Where it is required to detect the possible ingress of gas or vapour into a building or enclosure from an external source, sensors should be sited adjacent to the ventilation openings. These sensors should be in addition to any required for the detection of releases within the building or enclosure.

If ceilings or floors are compartmentalized by equipment or other obstructions, sensors should be installed in each compartment.

8.2.2 Environmental conditions

Fixed apparatus, or more particularly their sensors, may be exposed to a very wide range of environmental conditions for very long periods of time. Great care should be exercised in the selection and location of this apparatus in relation to the likely environmental conditions applying in normal and abnormal use.

8.2.2.1 Adverse weather conditions

Sensors located on outdoor sites and open structures may be subjected to severe environmental conditions, and account should be taken of these conditions at all times. For example high winds may cause drift of the zero reading. High winds may even cause apparent transient loss of sensitivity during calibration due to dilution of the calibration gas being detected, if using the manufacturer's normal calibration equipment. For high wind applications, the manufacturer should be consulted about these points.

Great care should be taken in the location of sensors in exposed sites, and adequate weather protection measures should be provided for the sensor. Steam, driving rain, snow, ice and dust, etc. may also adversely affect sensors. Certain materials, although otherwise suitable for sample lines or weather guards, may deteriorate from sunlight or other environmental conditions.

Sensors located in buildings or enclosures are generally not exposed to adverse weather conditions.

8.2.2.2 Excessive ambient temperatures

All sensors, sampling points, and apparatus should be mounted in areas which ensure compliance with the manufacturer's operating temperature specifications.

Where there are excessively high or low ambient temperatures, the detector may be operating outside the temperature range specified by the manufacturer, and detection errors and reduced sensor life may occur. In addition, at both excessively high and low temperatures, the apparatus may no longer comply with its hazardous area certification.

For example the electrolyte in many electrochemical sensors operating at temperatures much below –10 °C may be limited by freezing. Portable applications may get around this limitation by keeping the detector in a warm area when not in use.

In general, the positioning of gas detectors directly above sources of heat such as ovens and boilers should be avoided and a suitable position at an adequate height away from the source of heat should be chosen.

In tropical and subtropical applications, external sensors and apparatus should be shielded from direct sunlight, as this can raise equipment temperatures above 65 °C even with ambient temperatures around 40 °C. The normal maximum for hazardous area certification is 40 °C and the maximum for performance with ~~IEC~~ ISA-60079-29-1 is 55 °C, unless otherwise specified on the certificate.

8.2.2.3 Vibration

Where vibration is expected, particularly for apparatus mounted on machinery, care should be taken to ensure that it has been designed to withstand vibration, or that suitable vibration isolation mountings are provided.

8.2.2.4 Use of sensors in corrosive atmospheres

Precautions should be taken to protect sensors from damage resulting from exposure to corrosive atmospheres (for example ammonia, acid mist, Hydrogen Sulphide (H_2S) etc.). Particular care should be taken to protect wiring (and other components made of copper or brass) if ammonia can be present, as it can cause severe corrosion and electrical failures.

8.2.2.5 Mechanical protection

Sensors mounted in positions where they may be exposed to mechanical damage (e.g. from normal plant operations, or the use of mobile equipment such as fork lifts) should be adequately protected without impeding the free flow of air around them. If necessary, recommendations should be obtained from the manufacturer.

8.2.2.6 Electromagnetic immunity

Appropriate precautions, for example the use of screened cables, should be incorporated when installing the complete cabling system (including that to ventilation controls etc.) to ensure that the total system is adequately protected from the effects of electromagnetic interference.

NOTE Reference should also be made to applicable national regulations regarding electromagnetic compatibility.

8.2.2.7 Hosing down

The practice of "hosing down" a plant may cause severe degradation of gas sensors and contaminate sampling lines. It should, therefore, be avoided if possible. If it cannot be avoided, the sensors should be protected against this, without impeding the free flow of air around them. This can be a complex problem.

8.2.2.8 Airborne and other contaminants

Sensors should not be exposed to airborne contaminants which may adversely affect their operation.

For example, materials containing silicones or other known poisons should not be used where catalytic or semi-conductor sensors are installed.

Dusts, or wet, oily, or adhesive sprays and mists, or condensed droplets can block key items. such as the diffusion screens of sensors, or sample lines and their filters, causing loss of sensitivity or function. This is of even greater consequence if both wet and solid materials are present to form pastes. This contamination may require regular cleaning or similar maintenance. Sample extraction and special filtration may be required in extreme cases.

There are many examples where paint overspray, or deliberate painting has been responsible for failure of sensors. This requires some education of maintenance personnel.

Care should be taken to avoid water condensation on diffusion screens and in sample line(s). Where high humidity samples are involved, this can require heating of critical parts or deliberately removing condensed water in traps, coalescing filters etc.

There are particular problems where a vapour of interest can condense on (or the liquid can otherwise come into contact with) diffusion screens, filters, or sample lines. This type of contamination will lead to incorrect and misleading signals until the last trace of contamination is removed. This can be extremely dangerous. If this type of contamination is possible, the only solution may be to heat the components that come into contact with the sample.

8.3 Access for calibration and maintenance

Sensors and sample points should be readily accessible to permit regular calibration, maintenance and electrical safety inspection. It must be possible to access and fit all accessories or test equipment needed for these operations at the detection point.

Where the sensor location makes this difficult (e.g. where it is high and over machinery) a system of lowering the sensing point on a pulley system or swinging arm to gain access may be practicable. Obviously, the cabling or sample tubing must be flexible or pivoted to permit this arrangement. The arrangement should preferably permit the original sensor orientation to be preserved for calibration.

If it is impossible to achieve regular direct access to the sensor then, as a minimum requirement, some form of remote gas calibration facility should be provided.

8.4 Additional considerations for sample lines

Sampling lines are usually permanently installed in fixed installations. Even if they are made of a flexible plastic material they will usually be less flexible and harder to install than cabling. Consideration should be made at the time of installation that they may need to be replaced in the future, for instance if they become badly contaminated or damaged. Joints need to be accessible.

Sample lines should be as short as possible since the response time is determined by the overall length.

Filters may be used to protect the apparatus from dust and interfering or poisoning substances. Generally a particulate filter is needed at each sampling point so that its sampling line is kept clean internally. Additional devices are required for this purpose where mists may be sampled. Frequently additional filtration is provided at the sensor apparatus.

Filters will increase the response time.

The lifetime of filters is dose dependent (dust or interfering substance). This may shorten the maintenance intervals of the apparatus. For details refer to the instruction manual.

The flow rate through the sampling line should be monitored.

The material of the sample line(s) should be selected so as to avoid adsorption, absorption and, chemical reactions with the gas being detected. In addition, care should be taken to avoid dilution of the sample by leakage or diffusion of dilutant air, or gas, into the sampling line or combustible gas out of the sampling line.

Where water condensation can occur it may block the sampling line. Water traps may be needed at any low spots along the sample line length. This is particularly the case if the line runs through areas that can be cooler than the sampling point (e.g. air conditioned areas in hot humid climates). Alternatively, the line may be heated, as below.

Consideration should also be given to the effects of condensation occurring with high flash point liquids on sampling systems, as this will reduce the concentration in the sample and hence the reading. Subsequent samples with lower concentrations of the vapour will permit it to re-evaporate, giving incorrectly high readings. To minimize this effect, heating of the sampling line may be necessary. In hazardous areas if this heating system is electrical it shall comply with the relevant regulations and standards. Steam or hot water trace heating may be an option.

8.5 Summary of considerations for the location of sensors or sampling points

The rationale for the selection of location of sensors should be formally recorded in the dossier (refer to 8.1 and 8.10).

NOTE Reference may be made to ~~IEC 60079-10~~ ISA-TR12.24.01 (IEC 60079-10) and/or ANSI/NFPA 70 for further information on area classification and gas dispersion.

The following is a basic check list, based on earlier clauses, of factors which should be taken into account, in no particular order of priority, in determining suitable sensor locations. These include, but are not limited to, the following:

a) indoor or outdoor site;

b) potential sources of emission – the location and nature of the potential vapour/gas sources (for example density, pressure, amount, source temperature, and distance) need to be assessed;

c) chemical and physical data of the potential gases/vapours present;

d) liquids with low volatility need sensors near the potential source of release (and low alarm or action points);

e) nature and concentrations of gas releases likely (for example high pressure jet, slow leaks, spillage of liquids);

f) presence of cavities and jets;

g) topography of the site;

h) air movements;

   1) indoors: natural ventilation, mechanical ventilation, convection,

   2) outdoors: wind speed and direction,

i) temperature effects;

j) environmental conditions of the plant;

k) location and number of personnel in the area;

l) location of potential sources of ignition;

m) structural arrangements (such as walls, troughs or partitions) which could allow vapour/gas to accumulate;

n) prescribed locations;

o) detectors should be installed so that they are not vulnerable to mechanical or water damage from normal operations; and

p) locations should be such that sensors can be readily maintained and calibrated.

8.6 Installation of sensors

For the reliable operation of a fixed gas detection system each sensor should be placed in a suitable location according to its individual application, and as decided above.

However, inspection and maintenance, including recalibration with gas, need to be carried out periodically by trained personnel. Therefore, access for such operations also needs to be considered in detail during installation.

It is important that the instruction manual is read and followed.

In many cases, the orientation of the sensor may be specified by the manufacturer.

Adequate drainage and/or heating should be incorporated into the system design to minimize moisture and condensation in the apparatus, detector head and interconnecting cable/conduit system, or sampling tube.

Any potentially flammable gases introduced into sampling systems should be vented in a safe manner.

Lubricate all threaded connections, but ascertain that the lubricant contains no substance (for example silicone) that might be deleterious to the sensors.

Sensors shall be connected to their respective control unit, as specified by the manufacturer (observing maximum loop resistance, minimum wire size, isolation, etc.), and use a cable, wire and conduit system, or other system suitable and approved for the purpose, area classification, and suitable mechanical protection.

If the user is not able to address these points the work should be carried out by the manufacturer or other competent person.

8.7 Integrity and safety of fixed systems

8.7.1 General

If the gas detector system or channels of a system fail or are removed from service, so that areas of the plant cannot be monitored sufficiently, additional measures may be required to preserve safety. Planning for such eventualities should happen before installation.

It is similarly essential that safety is maintained when the gas detection system, or a part of it, becomes inoperative during routine calibration.

Additional measures to preserve safety may include:

a) signalling of gas detection apparatus faults;

b) use of portable or transportable gas detection apparatus;

c) increased ventilation;

d) elimination of ignition sources;

e) interruption of supply of flammable gases or liquids;

f) switching-off of plants or parts of them; and

g) duplication of the most essential sensors.

8.7.2 Redundancy in fixed systems

In general, a fixed system should be so installed that failure of individual elements of the system, or their temporary removal for maintenance, does not compromise the safety of the personnel and premises being protected. Duplication or triplication of remote sensors and control apparatus is recommended in all areas where continuous monitoring is absolutely essential. Devices that operate ‘fail safe’ should be used wherever possible.

8.7.3 Protection against loss of main power supply

Protection against loss of the main power supply should include:

a) main power supply

   The main power supply should be designed so that the unrestricted operation of gas detection apparatus and alarm functions are guaranteed.

   Breakdown or fault of main energy supply should be detectable. Safety of the monitored area shall be preserved by appropriate measures.

   The main power supply should have a separate circuit with specially marked fuse used only for the gas detection apparatus.

b) emergency power supply

   If an emergency power supply is required to maintain the function of the gas detection apparatus, it should do so until the normal state of supply is restarted or the monitored area no longer requires monitoring. Any peripheral external power supply shall be suitable for the

area for which it is to be used (both for environmental considerations and for the area classification).

Breakdown of emergency power supply should be indicated by an alarm signal.

It is strongly recommended that for indication of power and/or apparatus failure, contacts are used which are closed in the non activated state (fail-safe).

8.8 Timing of installation during construction operations

Sensors should be installed as late as possible in any programme of construction operations (i.e. the construction of a new plant, refitting or maintenance) but before the presence of gas or vapours in the system, so as to avoid damage to the sensors resulting in particular from such activities as welding and painting.

If already installed, sensors should be protected with an air-tight seal to avoid contamination during construction work, and should be clearly marked as being non-operational.

8.9 Commissioning

8.9.1 Inspection

The complete gas detection system including all ancillary equipment should be inspected prior to use to ensure that the design and installation has been carried out in a satisfactory manner, and that, where appropriate, the methods, materials and components used are in accordance with ~~IEC 60079-0~~ ANSI/NFPA 70. Among the items to be inspected are the following:

a) confirm electrical connections are properly tightened;

b) check for sample-line leaks and proper flow;

c) check for clogged or dirty flame-arresting systems;

d) check the battery voltage and/or battery condition and make any required adjustments or battery replacements (according to the instruction manual);

e) perform a test of the failure (malfunction) circuit(s).

A check should be made at this time to confirm that a full dossier of operating instructions, plans and records for the complete system have been supplied. This should have details of all sensing points (refer to 8.2). The instructions should include details on use, testing, calibration and operation, and should include all manufacturers' instructions (refer to 8.10).

8.9.2 Initial gas calibration

After installation on site each sensor should be calibrated according to the manufacturer's instructions, unless it carries currently valid factory calibration certification for the gas of interest. Calibration should only be carried out by a suitably trained and competent person.

After the initial gas calibration, fixed systems should automatically revert to the monitoring mode after a pre-determined interval without further adjustment. Alternatively, during calibration, the apparatus should produce a special (e.g. ‘maintenance) signal to prevent the output from being mistaken for a normal measurement.

Where a number of gases are likely to be present, reference should be made to the additional precautions described in 4.3.2.1 and 6.2.2.

To ensure correct operation, it is essential to carry out both inspection and recalibration periodically.

8.9.3 Adjustment of alarm set points

In the case of detection apparatus only indicating up to the lower flammable limit, the alarm set point (or the lowest set point, where there are two or more) should be as low as possible commensurate with the need to avoid false alarm signals.

This might need frequent review during the early stages of operation of a new plant or gas detection system.

Adjustments should be carried out in accordance with the manufacturer's instructions.

8.10 Operating instructions, plans and records

Instructions on the use, testing and operation of fixed gas detection systems should be made available and placed in the system dossier.

For maintenance and record purposes, plans of the installation should also be provided and put in the dossier. The locations of all parts of the system (control units, sensors and sampling points, junction boxes, etc.) should be shown together with the routes and sizes of all cables, wires and sample tubes. Junction box and distribution cable diagrams should also be included.

It is extremely important that the equipment manufacturer's installation manual be read thoroughly, and the instructions followed completely. Again a copy of this should be in the dossier.

These records should be updated when any changes are made to the installation.

Routine tests of the combustible gas detection system is an extremely important factor affecting the reliability of the individual units. Optimum system performance and reliable operation will only be achieved through a defined program of comprehensive tests.

All types of gas detectors will require periodic recalibration using appropriate calibration gases. Where sensors are used that have definite service lives and/or susceptibility to poisoning (e.g. catalytic, electrochemical, semi-conductor) regular recalibration, or at least response checking, will be required. The required frequency may be specified by regulations of the responsible authorities. In most cases advice or recommendations can be obtained from the manufacturer. Ultimately it will depend on the severity of the application, and is best determined by starting a process of regular frequent checks and logging the results (amount of adjustment required etc) in the dossier. Periodic review will enable the most desirable interval between calibrations and/or response checks to be found. If different intervals are defined, the shortest time period should be taken.

The detection system should be frequently reinspected by a competent person. The inspection should be in accordance with the instructions of the manufacturer and the specific requirements of the application. A visual inspection of all units of the gas detection system should be carried out and the test and alarm functions should be checked. Special attention should be taken to look for contamination (e.g. dust or soil) and condensation of water or solvents in sampling systems and at the sensor locations.

Where sampling systems are used, the sample lines should be checked for contamination and inwards leakage. An easy way to do the latter is to apply calibration gas via a bladder, or otherwise at atmospheric pressure, at the sample point (DO NOT USE PRESSURE) and see if a similar result is obtained as in the normal calibration.

The manufacturer’s operational instructions should be followed with regard to:

– periodic cleaning of filters, sensor windows etc.;

– assembly of required materials, for example auxiliary gas for some devices;