



Explosion protection for process analysis

Safe operation up to the explosion limit

by Jürgen Poidl and Helmut Schulz



Figure 1: Analyser house (TVR – Transportable Ventilated Room) suitable for desert conditions with explosion-protected equipment installed on the exterior

Gas analysers are used for the continuous on line measurement of the composition of process flows in chemical production systems. These measurements provide support to key process functions of controlling and monitoring the temperature, humidity, and chemical composition of gases and liquids.

In some cases, commercial considerations and demands are resulting in the operation of production processes in chemical plants increasingly close to the explosion limit. It is therefore essential that the explosion-protected gas analysers used for monitoring the explosion limit continuously supply the necessary and reliable data to the process control systems. Using the special safety systems from SIEMENS AG and R. STAHL, it is possible to operate gas analysers, the electrical equipment and the safety devices even when the process conditions are close to the limit. →

The article ›Safe even in the desert‹ on page 46 of this issue describes how process analysers are installed in container-like housings or separate rooms (Figure 1). The formation of explosive atmospheres are to be expected due to the possible release of inflammable gases or liquids during sampling. The introduction of inflammable gases, vapours or liquids into the instrument rooms produces risks, as do leaks in the pipe system, or the entry of explosive atmospheres from the surroundings. Two aspects therefore require particularly close attention. Firstly the prevention of explosive gas mixtures and, secondly, the maintenance of an environment that is not harmful to health.

To address these aspects, the related plant room is ventilated. When dimensioning the ventilation system, the maximum quantities that could be released from the containment system must be taken into account (Table 1). The objective is to ensure a reduction in the concentration to values below the Lower Explosion Limit (LEL; concentration of inflammable gas or vapour in air below LEL is not explosive).

There are three important standards that describe the safety requirements:

- › EN 61285 ›Industrial-process control. Safety of analyser houses‹ [1]
- › EN 50381 ›Transportable ventilated rooms with or without an internal source of release‹ (TVR) [2]
- › EN 60079-10 Classification of hazardous areas [3]

Definition of the type of protection ›v‹

- › 3.18 Type of protection v
 - a type of protection intended to reduce the risk of explosion to an appropriate level by the prevention of the formation of an explosive atmosphere in the vicinity of a source of ignition.
- › 3.18.2 Type of protection v2
 - suitable for areas in which explosive atmospheres caused by gases, vapours or mists are likely to occur. Type of protection v2 ensures the requisite level of protection, even in the event of frequently occurring disturbances or equipment faults which normally have to be taken into account by maintaining a positive pressure differential between the atmosphere within the TVR (Transportable Ventilated Room) and the external, and where appropriate adequate ventilation.
- › 3.18.3 Type of protection v3
 - suitable for areas in which explosive atmospheres caused by gases, vapours or mists are unlikely to occur or if they do occur, are likely to do so infrequently and for a short period only. Type of protection v3 ensures the requisite level of protection during normal operation by maintaining a positive pressure differential between the atmosphere within the TVR and the external, and where appropriate adequate ventilation.

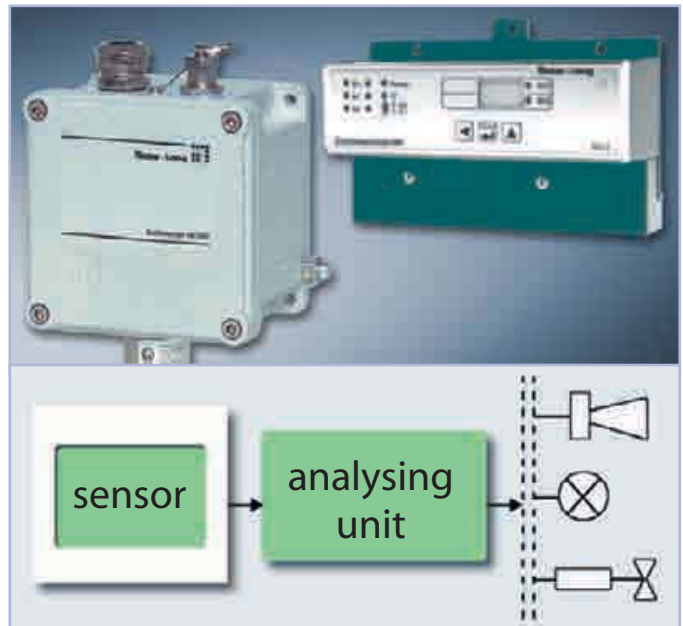


Figure 2: Gas detector and alarm systems

- › 3.18.4 Type of protection v4
 - suitable for areas normally considered safe but in which a risk of an explosive atmosphere caused by gases, vapours or mists might occur due to the operation of equipment within TVR and if they do occur, are likely to do so infrequently and for a short period only. Type of protection v4 ensures the requisite level of protection during normal operation by maintaining a negative pressure differential between the atmosphere within the TVR and the external, and where appropriate adequate ventilation.

The principle of type of protection ›v‹

Type of protection v is comparable with pressurization. As a result of the pressure conditions in the container compared to the surroundings, various possible operating states must be taken into consideration.

Depending on the type of system, there may be internal sources of release for inflammable liquids, gases or vapours. The assessment of when a hazardous mixture with the air in the interior can occur is undertaken based on the chemical substances inside the sample preparation system and the measurement system of the gas concentration. The standard EN 60079-10 is used to classify the concentration reduction levels around the release sources into zones. Using this zone classification and depending on the installation location, it is defined where equipment that is not explosion-protected can be installed and where explosion-protected equipment must be installed. A special aspect here is the fact that the container can be entered by staff. The large dimensions result in additional conditions in comparison to other equipment, as there may be people in these rooms.

Prior to starting operation, the entire room is purged with compressed air, »clean« ambient air or inert gas. The pre-purging phase creates the necessary pre-conditions for safe operation and ensures suitable air quality inside the portable ventilated room. The pre-purging time is defined during type testing as a function of the purge volume by measuring the time necessary to reduce the concentration of inflammable gases or vapours to a safe level.

Similar to the type of protection pressurization »p«, after the pre-purging phase the pressure difference to the surroundings is measured. After starting, the pre-purging volumetric flow rate and the differential pressure between the transportable ventilated room and the surroundings must be appropriately monitored. With the types of protection v2, v3 or v4, the lowest defined volumetric flow rate for the protection gas for the ventilation through the transportable ventilated room and the differential pressure are measured. If the values are within the defined limits, pre-purging is performed for the defined time. Once the pre-purging time has elapsed, the volumetric flow rate is reduced to the value for ventilation (continuous purging). Then the power supply to the equipment can be switched on. The internal overpressure (for v2 and v3) prevents the surrounding atmosphere from flowing in and is used as a measure for maintaining the explosion protection. With type of protection v4 no hazardous atmosphere is allowed to be released from the transportable ventilated room into the surroundings. For this reason the partial vacuum in relation to the surroundings is monitored.

In addition, the reduction in the concentration of toxic gases or vapours as well as a lack of oxygen or the accumulation of carbon monoxide and other asphyxiating gases is to be taken into consideration. Here the value of the maximum allowable concentration (MAC) at the place of work must be defined as the upper limit. During the type testing to determine the pre-purging volume, it must therefore be noted that many gases are already toxic well below 20 % of the LEL.

Maximum allowable concentration at the place of work

A general figure for the alarm thresholds for gas warning systems is the MAC-value at the place of work. The maximum allowable concentration is the highest concentration allowed of a substance in the form of a gas, vapour or suspended matter in air at the place of work that, based on current knowledge, even on repeated and long-term exposure, as a rule 8 hours a day, for an average working week of 40 hours (for single shift operation), in general will not harm the health of the employees and will not be unpleasant for the employees.

Explosion protection measures

In the example plant, from the article »Safe even in the desert« (page 46), the type of protection »v« function is achieved using two related mechanisms. On the one hand, fresh air is drawn in through a 4 m high chimney; this air is used for pre-purging and for concentration reduction in the analyser house. It ensures that the concentration of the explosive gases in the interior remains below the LEL by means of the regulated volumetric flow rate. Even on release of

gases, liquids or vapours in the interior, the safety of the plant is not jeopardised. As these analyser rooms are themselves located in the explosive atmosphere, it must be assumed and noted that flammable gases may be introduced from the surroundings. For this reason the gas concentration in the air drawn in from the surroundings is monitored. If this situation arises, the purging is stopped.

If there are explosive atmospheres in the container surroundings, and at the same time hazardous gas has escaped into the interior due to a fault, the equipment in the transportable ventilated room is shut down step-by-step.

As in the case described, the plant is installed in the hazardous area or is directly adjacent to this area, and there is a safety-lock on the entry door. The gas concentration in the air-lock is monitored by two independent gas detectors. The inner door is only unlocked if the value measured in the air-lock is <20 % LEL.

Criteria for shutdown in case of a fault

If there is a potential release source, there must be at least 2 gas detectors. These are equipped with two limiting value transducers with shutdown function (Figure 2).

On the system from Siemens a gas alarm is issued at 10 % of the LEL. This device gives the operator time to take action to ensure the shutdown conditions defined in the standard are not reached. If 20 % of the LEL is reached, wall mounted power sockets without explosion protection and other unprotected equipment are shut down. →



Figure 5: Explosion-protected apparatus installed on the exterior: disconnecter, local reset, control unit with indicator lamps, flashing light and horn



Figure 3: Sealed flow restrictor valve

If 60 % of the LEL is reached, after a defined time all equipment including explosion-protected switchgear in the interior must be shut down. In the standard it is stated that, if within a certain amount of time (e. g. 24–72 h), no attention is paid to the indication, careful consideration must be given to whether this shutdown of the explosion-protected equipment is necessary. The hazard due to reaching 60 % of the LEL in the interior of the analyser room may be less than the possible hazard due to an emergency shutdown of the entire process. With this note in the standard, the fact is addressed that it is essential that the installation be maintained on the presence of a fault over a very long period. An alarm in the transportable ventilated room is indicated visually and acoustically inside and outside, and in manned control centres, e. g., the control station.

After the shutdown of the explosion-protected equipment inside the analysis room, no further inflammable substances are introduced into the containment system. The gas present in the containment system must be evacuated to a point outside the transportable ventilated room within 60 s. The pressure drop to atmospheric pressure is sufficient in this case, as the overpressure in the interior prevents further releases. To limit the release in the interior of the analy-

sis room, e.g. sealed flow restrictor valves (Figure 3), pressure reducers and safety valves installed outside in the pipe inlet into the analysis room are used. In addition, special valves outside the analysis rooms can be opened for fast pressure reduction.

Restart after automatic shutdown

To bring the entire unit back into operation, certain conditions must be met. The enabling of the electrical circuits and the supply of inflammable substances to the containment system is re-enabled if the value measured by the gas detectors has dropped to less than 20 % of the LEL, and the transportable ventilated room has been pre-purged by the ventilation system.

In addition, a manually actuated reset device installed at the transportable ventilated room must be actuated. In this way it is ensured that the transportable ventilated room is only recommissioning if a person has checked the source of the release and any repair work necessary has been performed.

Electrical equipment inside the transportable ventilated room

Explosion-protected equipment must be used in the air-lock and inside the transportable ventilated room, or the equipment must be shut down as soon as a certain gas concentration is measured. The zone classification in the interior defines which measures of explosion protection are required for the electrical equipment. An explosion-protected device is not capable of ignition in the context of the standard.

In the example described equipment with regard to optimal costs was selected that, due to appropriate design by R. STAHL, is suitable for Zone 2 (equipment category 3). The selected type of protection Ex nR (restricted breathing) is suitable in this case for the

	Parts with negligible risk of leaks	Parts with limited risk of leaks	Additional measures for the reduction of the risk of leaks
Pipes	rigid metallic	flexible, non-metallic (hoses)	double sheath, metal armouring
Connections	welded	flange clamping ring fitting	check for correct installation leak test
Seals	spring-groove bellows*	O-rings glands	bellows* bellows* encapsulation
Flow meters	entirely metal	glass cone / plastic	
Pumps	injector magnetic or hydraulically coupled drive	hermetically sealed peristaltic	bellows* encapsulation
Valves	valves without gland	ball valves with soft seal	ball valves with soft seal and additional bellows*
Others	optical fibre systems	optical window	encapsulation

* bellows have limited service life

Table 1: Evaluation of parts for the risk of leaks in accordance with EN 61285 (IEC 61285:2004)

design of the special control system (Figure 4). The power is supplied via a distribution panel for Zone 1 with miniature circuit breakers individually protected as components by special flameproof enclosures (component-encapsulation). EXLUX 6000 lights, approved for Zone 1, manufactured by R. STAHL are used for lighting.

Electrical equipment on the exterior of the transportable ventilated room

The equipment installed on the exterior of the container is all suitable for use in Zone 1 (equipment category 2). The disconnecter used to electrically isolate the entire electrical installation, the flashing light, and the horn for the indication of alarm states in the transportable ventilated room, as well as the local reset after an alarm, are all fitted on the exterior (Figure 5). The status of the entire installation is displayed using indicator lamps.

Furthermore, additional protection against pests is achieved by the special design of the cable installation. A metal-sheathed sleeve connects the equipment and protects the cables. The sealing of the sleeve to the electrical equipment is ensured using suitable cable glands. The electrical equipment itself is adequately protected against pests.

Like all equipment or safety devices used in hazardous areas or that have an effect on these areas, the transportable ventilated rooms must be marked. Along with marking as per EN 60079-0 [4] or EN 60079-15 [5], additional information on the volume of the unit and information on the purging and correct operation is required in EN 50381 [2]. This information includes the minimum volume of the protection gas and the minimum duration of the pre-purging.

Equipment, switchgear and measuring instruments for ensuring the safe operation of the type of protection are to be specially marked, even if they are installed outside the hazardous area. In section 16 of EN 50381, marking with [Ex v] is required for safety-related control systems and safety devices.

Operating instructions

For all types of protection, operating instructions with the requirements on putting into service, use, assembling and dismantling, maintenance, and adjustment of the transportable ventilated room must be prepared by the manufacturer. The operating instructions are addressed at the user. These operating instructions must therefore be available in the appropriate places.

Adaptable safety system

After putting into service, a safe installation is available on site that complies with all the requirements stated above. The measured data required are provided, the installation can be entered without hazard, and safe operation in the explosion hazardous area is ensured. The safety system itself can be installed in Zone 1 or Zone 2, and in the safe area by the simple adaptation of the function and the selection of the electrical equipment. The process in the reactor can be safety controlled at the explosion limit.



Figure 4: Control system with restricted breathing (open) for monitoring the gas concentration

References

- [1] IEC/EN 61285: 2004-10
Industrial-process control. Safety of analyser houses
- [2] EN 50381: 2004
Transportable ventilated rooms with or without an internal source of release, + corrigendum 1: 2005
- [3] EN 60079-10: 2002-06
Electrical apparatus for explosive atmospheres part 10: Classification of hazardous areas
- [4] EN 60079-0: 2006
Electrical apparatus for explosive gas atmospheres. General requirements
- [5] EN 60079-15: 2003
Electrical equipment for explosive gas atmospheres part 15: Type of protection