

Design and installation of On-line analyser systems

PUBLICATION 138

Edition 2

ENGINEERING EQUIPMENT AND MATERIALS USERS' ASSOCIATION

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Registered and Trading Address
10-12 Lovat Lane London EC3R 8DN
Telephone: +44 (0)20 7621 0011
Fax: +44 (0)20 7621 0022
E-mail: sales@eemua.org
Website: www.eemua.org



ENGINEERING EQUIPMENT AND MATERIALS USERS' ASSOCIATION

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Foreword

This publication provides guidance on the design and installation of on-line analyser systems. There are many International Standards and documents (referenced at the end) that relate to specific parts of the design and safety of on-line analyser systems. However, there is limited practical guidance available on the overall concepts, approaches, tools and methodology for the design and installation of on-line analyser systems to ensure they perform with the required reliability and precision. This publication addresses these areas in five parts:

1. General
2. Health, Safety and Environmental Considerations
3. Housings
4. Sampling Systems
5. Analyser Communications

Whilst individual EEMUA member companies have varying practices for the design and installation of on-line analyser systems, the fundamental approach is generally similar. It is therefore hoped that this document will encourage standardisation within industry and lead to reduced design and construction costs, and improved safety.

The word analyser has been used throughout this document to refer to instruments variously known as on-line analysers, process stream analysers, quality analysers, quality measuring instruments and process quality monitors.

Where reference is made to International Standards it should be noted that National Authorities may have statutory requirements that are mandatory.

1. General

1.1 Introduction

The chemical, food, petrochemical and pharmaceutical industries need to be able to control their processes to ensure safety and environmental compliance and to optimise operations for maximum profitability. The use of on-line process analysers is a valuable tool in helping to achieve these objectives because analysers provide frequent (continuous or cyclic) analytical information on key process properties. This allows continuous on-line optimisation of the plant and rapid identification and correction of off-spec or undesirable operating conditions. Analyser repeatability is also usually better than the laboratory reference method as it allows closer control and targeting to product specification.

The correct design and installation of on-line analysers are essential to achieve the full benefits from analyser systems. Analysers are expensive to install and maintain and should only be installed when there is a clearly defined and quantified benefit. On-line process analysers are usually justified for one or more of the following reasons:

- personnel and plant safety;
- pollution control, measurement and prevention;
- optimising plant operations for throughput and yield;
- control of final products as closely as possible to maintain specification and minimise product quality give-away;
- minimising product degradation and reprocessing costs in cases of plant upsets, change in mode of operation and start-ups;
- improving energy efficiency of boilers, distillation columns, furnaces and reactors; and
- corrosion control.

1.2 Further Considerations

The following considerations are also important in the application of on-line analyser systems.

- Analysers and associated sampling systems are often complex installations demanding attention from specialist personnel responsible for their maintenance. Therefore, it is essential the end user has the appropriate, correctly trained manpower resources and spare parts available to ensure the analysers operate at the required level of performance to capture the anticipated benefits.
- The justification for analysers is not usually based on the reduction in the cost of laboratory testing as this saving is often offset by the associated increase in analyser maintenance costs. To promote the effective use of analysers by operators it is often beneficial to discontinue the duplication of analyses by laboratory testing. Laboratory facilities are still required for validating and calibrating the on-line analyser systems and for any statutory requirements.
- Single stream analysers are preferred and are usually essential for continuous automatic control.

On-line analysers usually require environmental protection in the form of housings to ensure reliable operation.

1.3 Reliability

The following points are important considerations in the design and installation of on-line analyser systems:

- correct location and orientation of sample point;
- proper design of the sample conditioning and sample transport systems;
- availability of clean and reliable utilities;
- environmental protection against corrosion, dust, heat/cold, humidity, rain and solar radiation;
- ease of accessibility for maintenance of all the analyser system components;
- proper design of calibration and validation facilities; and
- adequate preventive maintenance.

1.4 Design

The design should permit adjustments, maintenance and repairs to be carried out quickly and preferably whilst the analyser is in operation. Components likely to require attention should be accessible without the aid of portable ladders or other temporary means and should have fixings/mountings located such that they are also accessible from the front. The overall design should eliminate or keep to a minimum the emission of hazardous or noxious gases and vapours, and the possibility of liquid spillage.

1.5 Centralisation

The grouping together of a number of analysers where practical in a shared analyser house or shelter has a number of advantages:

- a single housing;
- common multi-core signal cables to the control system;
- common location for compressed air, power, steam and water supplies;
- common drain, purge and vent lines;
- more efficient for maintenance; and
- common heating, ventilation and air conditioning (HVAC) systems.

1.6 Local Mounting

However, local mounting is desirable in the following cases.

- When the cost of centralisation would be disproportionate to the expected benefit.
- When centralisation would result in excessive sample transport time lags.
- When sample handling problems are to be expected, for example with waxy samples or trace components.

1.7 Pre-Assembled Systems

Pre-assembled analyser systems supplied by specialist contractors or the analyser vendors are generally the most convenient and economical approach to install

new analyser systems in the plant. They may include one or more analysers with their associated sample conditioning system and common utility connections mounted together in the appropriate housing(s). There are many advantages to this approach.

- Systems designed and factory constructed by a specialist supplier are generally superior to those produced in the field by a contractor on site.
- Detailed design and field construction by a site contractor are reduced.
- Factory construction is independent of labour conditions and weather on site.
- Manpower on site is not usually skilled and experienced in this type of work.
- Systems can be fully tested under simulated operating conditions and major design, equipment and construction faults corrected before delivery to the site.
- Proven designs can be used with consequent savings in costs and improved reliability.
- All relevant documentation can be incorporated into a single design and operating manual by the specialist supplier.

2. Health, Safety and Environmental Considerations

2.1 Introduction

Analyser systems must be designed, installed and operated in such a manner that they are non-hazardous to personnel, the process plant and the environment.

The principle hazards are: asphyxiation in enclosed spaces; contact with toxic substances; ignition of flammable substances; and the release of harmful or polluting materials into the environment. It is also important that personnel coming into contact with analyser systems do not suffer injury from additional hazards such as burns, cuts from exposed sharp edges and electric shock.

A number of statutory requirements pertaining to safe design and practices are in force in many countries such as the ATEX and Pressure Equipment Directives in Europe. There are also specific standards relating to the safety of analyser systems e.g IEC 61825 Safety Of Analyser Houses. See the References Section for a full list of relevant Standards

2.2 Prevention of Explosions and Fires

The same conditions apply to the installation of analysers as with any other electrical equipment in electrically classified hazardous areas. The appropriate legal regulations and standards should be followed for the country in which the equipment is being installed.

The extent to which the measures need to be applied can be minimised by restricting the likely size of an internal release in the housing by:

- minimising and restricting the quantity of potentially dangerous materials entering the housing;
- reducing the number of joints in sample lines;
- using the lowest possible operating pressures;
- reducing the power dissipation of the electrical equipment installed within the main enclosure of the equipment; and
- ensuring that the design does not produce surface temperatures above the ignition temperature of the gases or vapours that may be present

2.3 Prevention of Toxic and Asphyxiant Hazards

When a system is designed, the toxicity of the substances should be considered so that under the worst fault conditions the legal short-term exposure limit (STEL) of the substances in the atmosphere are not exceeded. The design must also ensure that under the worst fault conditions the atmosphere inside enclosed spaces which personnel may enter cannot reach asphyxiating levels. It should be noted that many substances will reach the STEL or asphyxiant levels long before the lower flammable limit value (LFLV). Analysers handling toxic substances may need to be separately housed and clearly identified.

Sampling systems containing toxic or otherwise dangerous substances should be purged with air or an inert material prior to disassembly. Warning signs should be provided to alert personnel to possible toxic and asphyxiant hazards. Certain analysers contain toxic components and care is needed during their maintenance e.g. reagents in wet chemical analysers and certain materials of

construction. Toxic calibration samples should be stored and piped from outside analyser housings.

2.4 Radiation Hazards

Apparatus and enclosures containing radioactive sources shall be clearly identified and handled in accordance with the relevant Statutory Regulations.

2.5 Safety Facilities

Gas monitoring and alarm systems for asphyxiant, flammable and toxic substances should be installed in enclosed analyser houses and cabinets as necessary. Fire extinguishers and/or fire blankets should be made readily available at housings containing flammable substances. Fire detection and automatic suppression equipment may also be appropriate. Escape facilities should also be provided as necessary.

Housings containing toxic, acid or alkaline materials should have eye baths and showers in a readily accessible nearby location.

2.6 Manual Shut-Down Facilities

Manual shut-down devices for the incoming carrier gas, power, sample and other potentially hazardous utilities should be fitted close to the analysers. In the case of analyser cabinets, shelters or houses, these devices should be clearly identified and located outside the housing. A separate shut-down device should be fitted for any associated house ventilation fans.

2.7 Noise

Attention should be paid to noise levels within analyser housings to ensure maximum short term and long term noise exposure limits are not exceeded. The most likely sources of noise are from heating, air conditioning and ventilation systems, air vortex coolers, water chiller units, purge systems, pneumatic valve switching and sample pumps.

3. Housings

3.1 Introduction

Analysers and analyser sampling systems require varying degrees of protection. This depends on the type of analyser, the importance of the application and the environment in which it has to operate. Where the instrument case itself is not suitable for the working environment, additional protection should be provided. This additional protection is to ensure satisfactory performance of the instrument and to facilitate maintenance.

The selection of the housing required for a particular analyser system depends on a number of factors, such as:

- the hazardous area classification of the area in which the analyser is to be located;
- special requirements specified by the relevant safety authority, user or vendor;
- the range of ambient conditions at site (e.g. corrosive atmosphere, direct sunlight, dust/ sand, humidity, rain, snow, temperature, wind);
- the environment specified by the analyser vendor for accurate, reliable and/or safe operation;
- the protection required for equipment and personnel during maintenance operations;
- maintenance and accessibility requirements of the system components;
- initial installed cost.

This Chapter primarily describes analyser housings located in hazardous areas and/or into which hazardous samples are introduced. Analyser housings located in a non-hazardous area and into which no flammable, asphyxiant or toxic samples, services, calibration mixtures or air from a hazardous area is introduced are only required to provide the necessary environment for accurate and reliable operation without any special conditions for ventilation. Four types of housing are considered:

- Analyser Case
- Analyser Cabinet
- Analyser Shelter
- Analyser House

3.2 Definitions

3.2.1 Analyser Housing

A general term including any of the following.

3.2.2 Analyser Case

An enclosure forming part of the instrument.

3.2.3 Analyser Cabinet

A small simple housing in which analysers are installed singly or grouped together. Maintenance is carried out from outside the cabinet.

3.2.4 Analyser Shelter

A structure with one or more sides open and free from obstruction to the natural passage of air, in which are installed one or more analysers. The maintenance of the analyser is normally carried out from within the shelter.

3.2.5 Analyser House

An enclosed structure in which are installed one or more analysers. Either natural or forced ventilation is used. The maintenance of the analyser is always carried out from within the house.

3.3 Selection of Housing

3.3.1 Analyser Case

Analysers such as electrolytic conductivity meters and pH meters may be installed directly in the open (enclosed only in the case) provided they comply with the specification of hazardous area classification and environment.

The advantages of this method are that the area around the case is naturally ventilated so there is no risk of accumulating an explosive atmosphere outside the casing. This is the lowest cost method of installation. The disadvantages are that there is no weather protection for equipment or maintenance personnel. Equipment must be carefully specified to minimise corrosion attack and it may not have as long an operational life as equipment which is installed in a cabinet, shelter or house. This method of housing is unsuitable when analysers require heating or extensive maintenance.

3.3.2 Analyser Cabinet

Analysers can be installed singly or grouped in cabinets provided that the equipment is installed in accordance with the hazardous area classification. Analyser cabinets provide a low cost means of improving environmental protection for analysers and can help make the equipment more easily accessible for maintenance.

The analyser manufacturer's environmental specifications can be met for example by including a heater in the cabinet if required. Ventilation, where necessary, is normally achieved by natural means. The advantage of a naturally ventilated method is that ventilation is permanent and independent of mechanical failure.

However, natural ventilation does not change the hazardous area classification inside the cabinet and where a non-certified analyser with cabinet is to be installed in a hazardous area a certified air purge system will be required. The disadvantages of cabinets are that there is a practical limit on the size of analyser installed and no protection is provided for maintenance personnel.

3.3.3 Analyser Shelter

This construction can be used when the analysers comply with the hazardous area classification of the location and the ambient environmental conditions comply with the analyser manufacturer's specification. A shelter may be conveniently used for equipment requiring minimal protection.

A shelter is advantageous where highly toxic materials are handled. It also facilitates the grouping of analysers and gives some protection for maintenance personnel as well as affording permanent natural ventilation. Its disadvantage is that it does not give the facility to change the hazardous area classification and affords only minimum environmental protection.

3.3.4 Analyser House

The analyser house is the highest cost installation but is usually justified for analysers which: require a high degree of protection; are expected to require regular attention; and from which a high service factor is required. These analysers may be installed in an analyser house which affords a controlled environment for operations and maintenance, and should reduce long term maintenance costs. This type of protection is essential where extreme ambient conditions are encountered.

The two alternatives for the ventilation system are either the natural ventilation system or the forced ventilation system. The natural ventilation system provides limited control of the environment and the area classification within the house will always be the same as the surrounding atmosphere. The advantages are a simpler and cheaper installation, since natural ventilation is permanent and independent of mechanical failure. The forced ventilation system can closely control the environment within the structure and the area classification within the house can be chosen depending on the source of the ventilation air. An advantage is that uncertified equipment can be used in the house provided ventilation air is drawn from a safe area and safety interlocks are included to isolate the equipment when the ventilation system is not operating.

3.4 Area Classification and Toxic Danger

3.4.1 Electrical Area Classification

The area within the above house, shelter or cabinet should be classified in accordance with the appropriate local regulations. These documents will lay down the type of equipment which is necessary and the precautions which must be taken to achieve the required level of safety within the housings. All equipment used in these housings should be suitable for use in accordance with the area classification.

3.4.2 Toxic and Asphyxiant Danger

Ventilation requirements for an analyser housing into which toxic materials are introduced should ensure that the relevant occupational exposure limit for those materials is not exceeded under normal or any likely fault condition. Entry into a housing where toxic materials can be present above the occupational exposure limit (OEL) should be prohibited without supervision and appropriate means of

detection and protection. A warning sign of the possible presence of a highly toxic gas within the housing should be given on doors or case.

Ventilation requirements for an analyser housing into which asphyxiant materials are introduced should ensure that dangerous asphyxiant levels are not exceeded under normal or any likely fault condition. A warning sign of the possible presence of an asphyxiant gas within the housing should be given on doors or case.

3.5 Construction and Mounting

3.5.1 General

The preference for the type of construction (within the options below) should be specified by the user.

3.5.2 Analyser Housings

The following guidelines are applicable to all types of analyser housing.

- Materials of construction should be of fire-resisting material and be resistant to attack from oil and chemicals. Other environmental factors such as frost, high humidity, solar radiation should also be considered. When used as a support for equipment, the enclosure should have sufficient rigidity to minimise vibration.
- Where necessary, anti-vibration mountings and flexible pipe connections should be used to isolate vibration-sensitive analysers from pipework or structural vibration. Lighting should be provided to give adequate illumination for operations and maintenance. Lighting should remain operational at all times and should be suitable for Zone 1 hazardous areas.
- Heating and air conditioning should be considered when extreme temperature and/or high-humidity conditions are expected. Heater surface temperature should not exceed the temperature allowed by the area classification and the heater element should be shielded against accidental contact by personnel.
- Air conditioning should be considered where ambient conditions or heat release within the analyser house results in unacceptably high temperatures.
- Where any form of environmental temperature control is considered within the housing, the wall and roofing materials and construction should be designed to minimise heat loss. This also applies to minimizing heat gain within the housing due to solar radiation. Where cavity walls are used care should be taken to ensure gas or liquid cannot build up within the cavity.

3.5.3 Analyser Houses

The following points are applicable to analyser houses.

- Construction is typically of brick, concrete, stainless steel sheet or glass reinforced plastic/marine ply sandwich.
- Outward-opening doors should be provided at both ends of the housing to permit easy escape in an emergency. The position and size of doors and the access to them should be arranged to permit removal of housed equipment. Lockable doors should be avoided. Where these are considered essential, the doors must be capable of being opened from the inside in the locked condition and crash bars should be provided on all doors.
- Safety-type windows of a suitable material should be provided in each door unless specifically excluded by the user or safety authority.
- There should be unobstructed internal headroom of at least 2 m.
- Dead corners and trenches that may collect gas should be avoided.
- Equipment such as calibration sample containers, gas cylinders, laboratory sampling points and sample conditioning units should be located outside the housing with appropriate weather protection, unless otherwise specified by the user.
- Roofs should be inclined to prevent accumulation of water. Suitable vents should be installed at the highest and lowest points to prevent the accumulation of gas pockets.
- Where the housing is to be mounted on a concrete base it should be impervious to hydrocarbons, raised at least 0.1 m above the surrounding area and sloped to a suitable point outside the housing for draining of any spillage and cleaning.

3.5.4 Analyser Shelters

An analyser shelter should have a ventilated roof and the lower edge of the side sheeting terminated at a minimum height of 0.5 m above the ground. Consideration should be given to mounting equipment above the lower edge of the side sheeting.

3.6 Analyser Housings with Natural Ventilation

3.6.1 General

Natural ventilation is defined as ventilation induced by external wind forces and/or thermal gradients between inside the house and outside. Natural ventilation does not rely on mechanical means.

The following Sections 3.6.2 and 3.6.3 apply only to Houses and Cabinets.

3.6.2 Ventilation Requirements

The ventilation rates should be designed to dilute and dissipate any dangerous release (flammable, toxic or asphyxiant) within the house or cabinet.

By its very nature, the mechanism of natural ventilation does not give close control over ventilation rates. Statistical data is required on wind speeds, directions and frequencies at the proposed location of the house. From this data and knowledge of heat dissipated within the house from equipment (excluding environmental heaters) ventilation areas can be calculated.

Whichever mode of ventilation (wind induced or thermally induced) gives the smaller area requirements, this should be used. Wind calculations should use the minimum average wind speed exceeded for 90 percent (%) of the year. Wind or thermally induced calculations should use as a basis a minimum of 10 changes/hour or that necessary to achieve the following.

- Dilute escaping vapours from the rupture or failure of the most hazardous sample or service line to less than 20% lower explosive limit (LEL) around any potential means of ignition. Particular attention must be paid to those liquids which vaporise at ambient temperatures. Dilute to below the occupational exposure limit any toxic gases/vapours introduced into the house by accidental rupture of any one sample or service line within the house.
- Dilute to below the asphyxiant level any asphyxiant vapour/gases introduced into the house by accidental rupture of any one sample or service line within the house. Wind induced ventilation rates should also be calculated for maximum average wind speeds using a gusting ratio of 1.6:1. If resulting ventilation rates exceed 50 changes/hour then comfort factors will deteriorate.

3.6.3 Heating Requirements

Using the above design procedure the temperatures in the house will essentially follow that of the ambient outside. To improve temperature control thermostatically controlled heating can be included. The heater banks should be sized to give a maximum exit air temperature of between 50°C and 55°C with the heater full on.

The air flow across the heater should not exceed the equivalent of 20 to 30 changes/hour in the house. With heating inputs as above it may be found that with a nominal temperature control setting on the thermostat of 20°C a somewhat lower temperature will be achieved on the coldest days. This low value can be assessed by re-calculating the thermally induced ventilation rates. However increased heat input is not recommended on the grounds that it would be wasteful.

Fan assistance can be included to aid distribution of the warm air. Warm air should be distributed in the lower half of the house as close to the lower vents as possible. Appendix 4 shows a worked example.

3.6.4 Analyser Shelters

Shelters should be designed to prevent accumulation of gases and liquids.

3.6.5 Analyser Cases

The manufacturer's installation requirements should be followed.