

On-line analyser systems — Guide to design and installation

ICS 71.040.40

National foreword

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The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and Control, to Subcommittee GEL/65/4, Process instruments for gas and liquid analysis, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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**Systèmes analyseurs continus –
Guide de conception et d'installation**

**On-line analyser systems –
Guide to design and installation**



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CONTENTS

	Page
FOREWORD	5
INTRODUCTION	7
Clause	
1 General	8
1.1 Scope	8
1.2 Reference documents	8
1.3 Preliminary remarks	9
1.4 Further considerations	10
1.5 Reliability	10
1.6 Design	10
1.7 Centralisation	10
1.8 Local mounting	11
1.9 Pre-assembled systems	11
2 Health and safety	11
2.1 Introduction.....	11
2.2 Prevention of explosions and fires	12
2.2.1 Flammable gases and vapours.....	12
2.2.2 Combustible dusts	13
2.2.3 Flammable gases, vapours and combustible dusts	14
2.3 Prevention of toxic hazards	14
2.4 Plant safety.....	14
2.5 Radiation hazards	14
2.6 Safety facilities	14
2.7 Manual shut-down facilities	15
2.8 Noise	15
2.9 Alarm indication	15
3 Housings	15
3.1 Introduction.....	15
3.2 Definitions	16
3.3 Selection of housing	17
3.3.1 Analyser case	17
3.3.2 Analyser cabinet	17
3.3.3 Analyser shelter	17
3.3.4 Analyser house (AH)	18
3.4 Area classification and toxic danger	18
3.4.1 Electrical area classification	18
3.4.2 Toxic danger	19
3.5 Construction and mounting	19
3.5.1 General.....	19
3.5.2 Analyser housing	19
3.5.3 Analyser house (AH)	20

Clause	Page
3.6	Analyser housing ventilation requirements
3.6.1	General.....
3.6.2	Analyser cases
3.6.3	Analyser shelters
3.6.4	Analyser cabinets and analyser houses.....
3.7	Design for natural ventilation
3.7.1	Ventilation requirements
3.7.2	Heating requirements.....
3.8	Design for forced ventilation
3.8.1	Ventilation requirements
3.8.2	Air intake system
3.8.3	Fan requirements.....
3.8.4	Air distribution requirement.....
3.8.5	Heating requirement.....
3.9	Analyser housing safety monitors and alarms
3.9.1	General.....
3.9.2	Ventilation failure
3.9.3	Flammable gas or vapour detection.....
3.9.4	Toxic gas detection
3.9.5	Oxygen deficiency detection
3.9.6	Fire detection and protection.....
3.9.7	Purged equipment.....
3.9.8	Alarms
4	Sampling systems
4.1	Introduction.....
4.2	Definitions
4.3	General requirements
4.4	Sample point location
4.5	Fast circulating systems.....
4.6	By-pass systems.....
4.7	Sample recovery systems
4.8	Special considerations
4.9	Multi-stream systems.....
4.10	Construction
4.10.1	General.....
4.10.2	Material selection.....
4.10.3	Flushing facilities
4.10.4	Blockage removal
4.10.5	Heat tracing and insulation.....
4.10.6	Minimising risks from leakage
4.10.7	Location of equipment.....
4.10.8	Instrumentation
4.10.9	Identification
4.11	Effluent disposal
4.11.1	General.....
4.11.2	Vapour.....
4.11.3	Liquid.....

Clause	Page
4.12 Calibration facilities	41
4.13 Automatic calibration	42
5 Analyser communications	43
5.1 Introduction.....	43
5.2 Signal transmission.....	43
5.3 Safety	44
5.4 Cables	44
5.5 Linearisation	44
5.6 Use of signal.....	44
5.7 Alarms	45
5.8 Verification/calibration	45
Annex A Typical analyser process line sampling probe for line sizes NPS 2" and above	46
Annex B Determination of sample probe lengths.....	47
Annex C Sample system calculations	55
Annex D Natural ventilation calculations	68
Annex E Forced ventilation calculations	74
Annex F Example of verification/calibration sequence of data to computer	75
Annex G Analyser house with forced ventilation – Summary of recommended control shut-down actions for flammable hazard operation	76
Annex H Analyser houses with forced ventilation – Ventilation failure and flammable gas detection trip logic.....	77
Annex I Typical analyser system schematics	78
Annex J Example schematic showing a typical wall penetration using a transit	80
Annex K Bibliography	81

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ON-LINE ANALYSER SYSTEMS – GUIDE TO DESIGN AND INSTALLATION

FOREWORD

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Technical reports do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful by the maintenance team.

IEC 61831, which is a technical report, has been prepared by subcommittee 65D: Analyzing equipment, of IEC technical committee 65: Industrial-process measurement and control.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
65D/41/CDV	65D/52/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

This document which is purely informative is not to be regarded as an International Standard.

With the kind permission of the Engineering Equipment and Materials Users Association this report is based on and includes extracts from EEMUA Publication 138.

The committee has decided that this publication remains valid until XXXX. At this date, in accordance with the committee's decision, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

This technical report has been prepared as there is a perceived lack of guidance in overall design and installation of on-line analyser systems, although there are various standards in existence covering specific aspects of analyser performance, sample system performance and safety related issues.

Individual users of on-line analysers have varying practices but the fundamental approach is generally similar. Therefore this guide will encourage standardisation within industry and lead to reduction in design and construction costs and to 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 european standards or international standards it should be noted that national authorities may have statutory requirements that are mandatory.

ON-LINE ANALYSER SYSTEMS – GUIDE TO DESIGN AND INSTALLATION

1 General

1.1 Scope

This technical report is a guide applicable to on-line analyser systems. It provides the necessary guidance for the system supplier and user to specify or design a complete analyser system from sample point in the process to the final output for display or control purposes.

1.2 Reference documents

IEC 60079-1:1998, *Electrical apparatus for explosive gas atmospheres – Part 1: Construction and verification test of flameproof enclosures of electrical apparatus (consolidated edition)*

IEC 60079-2:1983, *Electrical apparatus for explosive gas atmospheres – Part 2: Electrical apparatus – Type of protection "p"*

IEC 60079-10:1995, *Electrical apparatus for explosive gas atmospheres – Part 10: Classification of hazardous areas*

IEC 60079-11:1999, *Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic safety "i"*

IEC 60079-13:1982, *Electrical apparatus for explosive gas atmospheres – Part 13: Construction and use of rooms or buildings protected by pressurisation*

IEC 60079-14:1996, *Electrical apparatus for explosive gas atmospheres – Part 14: Electrical installations in hazardous areas (other than mines)*

IEC 60529:1989, *Degrees of protection provided for enclosures (IP Code)*

IEC 60746 (all parts), *Expression of performance of electrochemical analyzers*

IEC 61115:1992, *Expression of performance of sample handling systems for process analyzers*

IEC 61207 (all parts), *Expression of performance of gas analyzers*

IEC 61241 (all parts), *Electrical apparatus for use in the presence of combustible dust*

IEC 61285:1994, *Industrial-process control – Safety of analyzer houses*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety related systems*

EN 50016, *Electrical Apparatus for Potentially Explosive Atmospheres – Pressurized Apparatus "p"*

EN 50054, *Electrical Apparatus for the Detection and Measurement of Combustible Gases – General Requirements and Test Methods*

EN 50057, *Electrical Apparatus for the Detection and Measurement of Combustible Gases – Performance Requirements for Group II Apparatus Indicating up to 100 % Lower Explosive Limit*

BS 3116, *Specification for Automatic Fire Alarm Systems in Buildings – Part 4: Control and Indicating Equipment*

BS 5345, *Code of Practice for the Selection, Installation and Maintenance of Electrical Apparatus for use in Potentially Explosive Atmospheres (other than mining applications or explosive processing and manufacture)*

BS 5446, *Specification for Components of Automatic Fire Alarm Systems for Residential Premises – Part 1: Point-Type Smoke Detectors*

BS 5839, *Fire Detection and Alarm Systems in Buildings – Part 1: Code of Practice for Installation and Servicing – Part 2: Specification for Manual Call Points*

BS 5925, *Design of Buildings – Code of Practice for Ventilation Principles and Designing for Natural Ventilation*

BS 6467, *Electrical Apparatus with Protection by Enclosure for use in the Presence of Combustible Dusts – Part 1: Specification for Apparatus*

BS 6467, *Electrical Apparatus with Protection by Enclosure for use in the Presence of Combustible Dusts – Part 2: Guide to Selection, Installation and Maintenance*

BS 7535, *Guide to the use of Electrical Apparatus Complying with BS 5501 or BS 6941 in the Presence of Combustible Dusts*

API, *Manual of Petroleum Measurement Standards – Part 8: Chapter 8.2 Automatic Sampling of Petroleum Products (ANSI/ASTM D4177)*

EEMUA Publication No. 175, *Code of Practice for Calibration and Checking Process Analysers (Formerly IP 340)*

Kemps Engineering Year Book

Crane – Flow of Fluids Through Valves, Fittings and Pipes (Publication 410M (Metric Edition))

Perry and Chilton – Chemical Engineers Handbook

Fisher Controls – Control Valve Handbook

1.3 Preliminary remarks

Analysers have proved to be profitable and effective and their application is usually justified for one or more of the following reasons:

- a) operability of process plants, utilities and offsites;
- b) restriction of product degradation and reprocessing costs in cases of plant upsets, change in mode of operation, blending operations and start-ups;
- c) control of products as closely as possible to maintain specification and minimise give-away of quality;
- d) maintaining high efficiency of plant, such as boilers, furnaces, distillation columns and reactors;
- e) corrosion control;
- f) personnel and plant safety;
- g) pollution measurement and control.

1.4 Further considerations

Points also to be taken into consideration are:

- a) analysers and associated sampling systems are often complex installations demanding attention from specialist personnel responsible for their design and maintenance;
- b) the justification for analysers cannot usually be found by the reduction in the cost of laboratory testing, since this saving is often offset by the increase in analyser maintenance costs. To promote the effective use of analysers by operators it has proved necessary to discontinue the duplicating of analyses by laboratory testing. Laboratory facilities are still required for proving the analyser systems as required, and for any statutory requirements;
- c) single stream analysers should be a first consideration especially where analysers are to be used as part of an automatic control loop where, for example, a single failure could result in loss of several control loops, sample update times are incompatible with control system dynamics or there is an unacceptable risk of sample cross-contamination;
- d) for effective use, analysers may require environmental protection in the form of housings.

1.5 Reliability

To achieve reliable operation, the following considerations are relevant:

- a) proper design of the sampling system;
- b) reliable utilities;
- c) proper protection against cold, solar radiation, rain, dust and corrosion;
- d) ease of accessibility of all analyser system components;
- e) adequate preventive maintenance;
- f) protection against electromagnetic radiation.

1.6 Design

The design should permit maintenance, adjustments 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 need to dismantle/remove other components and without the aid of portable ladders or other temporary means. The overall design should keep to a minimum the emission of hazardous or noxious gases and vapours and the possibility of liquid spillage.

1.7 Centralisation

The centralisation of analysers has a number of likely economic advantages, such as:

- a) single housing;
- b) combined instrument cable channels;
- c) common supplies for power, water, steam and compressed air. Common drain, vent and purge lines;
- d) more convenient for maintenance.

1.8 Local mounting

There are, however, cases where local mounting is desirable for the following reasons:

- a) when the cost of centralisation would be disproportionate to the expected advantages;
- b) when centralisation would result in excessive sample transport time lags;
- c) when sample handling problems are to be expected, e.g. waxy samples, trace components.

1.9 Pre-assembled systems

Pre-assembled analyser systems are generally convenient and economically attractive. They may include one or more analysers with their associated sample conditioning and utility connections. However, care must be taken with the integration of the analyser system into the total plant installation.

There are many advantages in this type of construction:

- a) systems designed and factory constructed by a specialist supplier are generally superior to those normally produced by a contractor on site;
- b) detailed design and effort by site contractor are reduced;
- c) factory construction is independent of weather and labour conditions at site;
- d) manpower at site is not usually skilled and experienced in this type of work;
- e) systems can be fully tested under simulated operating conditions and major design, equipment and construction faults corrected before delivery to site;
- f) proven designs can be used with consequent savings in costs and improved reliability;
- g) all relevant documentation may be incorporated into a single dossier by the specialist supplier.

2 Health and safety

2.1 Introduction

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

The principle hazards are ignition of flammable substances and contact with toxic substances. Ignition sources can be mechanical, thermal, acoustic energy, optical and electromagnetic radiation as well as those more commonly associated purely with electrical installations. It is also important that personnel coming into contact with analyser systems do not suffer injury from additional hazards such as burns, electric shock and cuts from exposed sharp edges.

A number of statutory requirements pertaining to safe practices (e.g. the European ATEX Directive 94/9/EC) are in force in many countries and should be referred to as necessary.

For flammable gases and vapours, hazardous area classifications can vary from country to country but there are two commonly accepted approaches one of which originated in Europe with the concept of "zones" and the other which originated in North America with the concept of "divisions". Where applicable, this report refers to classified area definitions of zone 0, zone 1 and zone 2 in accordance with European and IEC standards. The equivalent North American classifications are division 1 (covers both zone 0 and zone 1) and division 2 (covers zone 2).

For flammable dusts, hazardous areas are presently divided into two zones. The two dust zones are zone Z and zone Y (equivalent to the gas/vapour zone 1 and zone 2 respectively). The IEC standards in preparation (IEC 61241-1 and IEC 61241-2) have agreed a nomenclature similar to gases and vapours but with a prefix of a 2 to give zone 20, zone 21 and zone 22.

Unless reference is specific to flammable gas/vapour or combustible dust the terms of zones 0, 1 and 2 will be used for hazardous area classification reference. In this case the equivalent zone Z and zone Y (zones 20, 21 and 22 using IEC nomenclature) will be implied.

When installing analysers within houses' safety aspects discussed in this report are in accordance with IEC 61285.

2.2 Prevention of explosions and fires

2.2.1 Flammable gases and vapours

Generally the same conditions apply to the installation of analysers as with installation of any other electrical equipment in hazardous areas. These conditions are outlined in IEC 60079-14 and IEC 60079-10. These publications in turn call for the use of equipment manufactured to IEC standards covered in other parts of IEC 60079. IEC 60079 covers individual types of protection used, for example:

- | | | |
|----------------|--------------------|--------|
| – IEC 60079-1 | Flameproof | Ex "d" |
| – IEC 60079-2 | Pressurised | Ex "p" |
| – IEC 60079-11 | Intrinsically safe | Ex "i" |

Analysers tend to differ from other electrical equipment in that in many instances they bring hazardous materials inside the electrical enclosure and therefore need special consideration for electrical certification.

IEC 60079-2, which deals with type of protection Ex "p", covers both for situations where the source of release of flammable material is external to the equipment and for internal sources of release.

The measures taken for internal sources of release are designed to reduce the possibility of an explosion by eliminating any joints inside the enclosure to minimise the potential for a release in the first place and by ensuring that a hazardous condition is not produced in the unlikely event of an internal release of flammable material. This is achieved by the use of one or more of the following methods.

- a) Hermetically sealed pipework connections inside the enclosure. This applies in the main to liquid samples for which no leak of any size can be tolerated.

- b) Restriction of internal components with potential as a source of ignition to suitably certified equipment for use in zone 1 or zone 0 applications.
- c) Dilution of the atmosphere inside the enclosure with air to below 20 % of the lower explosive limit.
- c) Limit the source of release externally by means of flow restrictors/shut-off valves.
- d) Pressuring the enclosure with an inert gas.

In order to ensure that a dangerous condition does not develop if the protective gas supply fails when using dilution purging or pressurisation with inert gas suitable flow and pressure alarms should be installed. The actions taken on receiving the alarm will depend on whether the atmosphere external to the enclosure is zone 0, zone 1 or zone 2 and whether the equipment inside the enclosure is protected by some other means.

The extent to which the measures outlined above need to be applied can be minimised for instance:

- a) minimising the quantity of potentially dangerous materials used and that can be released in the event of a leak;
- b) using the lowest possible operating pressures and temperatures for the sample being presented for analysis;
- c) reducing the power dissipation of any non certified electrical equipment installed within the main enclosure of the equipment;
- d) ensuring that the design does not produce surface temperatures above the ignition temperature of the gases or vapours that may be present.

2.2.2 Combustible dusts

Many dusts can be combustible and if such dusts are likely to be present and in contact with analyser systems then the electrical equipment and systems for installation in hazardous areas generated by combustible dusts should comply with relevant national and international standards (e.g. BS 6467, Part 1, and BS 7535, IEC 61241-1 and IEC 61241-2).

Electrical equipment for use in the presence of combustible dust should be selected in accordance with each of the following criteria:

- a) the construction in order to avoid accumulation of dusts, frictional problems and thermal gain;
- b) the ingress protection in respect of the area classification and the nature of the dust;
- c) the maximum surface temperature in respect of the minimum ignition temperature of the dust.

Apparatus in zone Z areas should be to ingress protection IP6x (dust tight to IEC 60529).

Apparatus in zone Y areas should be to a minimum of ingress protection IP5x (dust protected to IEC 60529).

Where ignition of a small amount of dust within an enclosure can spread to the external atmosphere (train firing), the ingress protection IP6x should be used whatever the area classification.

2.2.3 Flammable gases, vapours and combustible dusts

On installations where there can be simultaneous presence of flammable gas or vapour and combustible dust, the area classification should consider the probability of both hazards and the area classification should reflect the results of both studies.

2.3 Prevention of toxic hazards

When a system is designed, the toxicity of the substances should be considered so that the occupational exposure limits (OEL) of the substances in the atmosphere are not exceeded. These values are dependent on the particular national requirements and the relevant bodies need to be consulted (e.g. HSE in UK – Guidance Note EH40 Occupational Exposure Limits, ACGIH in USA, etc.) In Europe national limits are set in accordance with European directives where appropriate.

It should be noted that many substances will reach the short-term exposure limit long before the lower flammable limit value.

Analysers handling toxic substances may need to be separately housed and clearly identified (see 3.4.2).

Attention is drawn to the need for the purging of sampling systems containing toxic or otherwise dangerous substances prior to disassembly.

Some analysers contain toxic components and care is needed during 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 (see 4.12, paragraph 6).

2.4 Plant safety

Where an analyser system is being used to ensure plant or process safety (e.g. preventing a hazardous event or detecting loss of containment) it should also be designed, installed and operated in accordance with the requirements of draft IEC 61508.

2.5 Radiation hazards

Apparatus and enclosures containing radioactive sources shall be clearly identified and handled in accordance with the relevant national statutory regulations, e.g. SI 808 Ionising Radiations Regulations (UK) and Radioactive Substances Act (UK).

2.6 Safety facilities

Gas monitoring and alarm systems for flammable and toxic substances may be necessary (see 3.9).

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 (see 3.9).

Escape facilities may be necessary (see 3.5.3).

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

2.7 Manual shut-down facilities

Manual shut-down devices should be fitted close to the analysers.

In the case of analyser cabinets, shelters or houses, these devices should be outside the housing.

These devices should isolate sample, carrier gas and electrical supplies to the analyser and associated equipment.

A separate shut-down device should be fitted for house ventilation fans.

2.8 Noise

Attention should be paid to noise levels within analyser housings, e.g. Code of Practice for Reducing the Exposure of Employed Persons to Noise – Issued by the UK Department of Employment.

The most likely sources of noise are from ventilation systems and water chiller units.

2.9 Alarm indication

Alarm lamps should be situated outside analyser houses and be visible from all entrance and access routes. Analyser house status lamps should be provided for both alarm and normal conditions – indication of normal condition (e.g. green lamp) provides a fail safe configuration.

Visual alarm indications should also be provided for inside the analyser house accompanied by a common audible alarm. In areas of high noise levels a high visibility strobe light should be used.

3 Housings

3.1 Introduction

Analysers and analyser sampling systems require varying degrees of protection, depending on the type of analyser, importance of 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:

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

- f) maintenance and accessibility requirements of the system components;
- g) economic considerations (e.g. whole life cost, capital expenditure).

This clause 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 or toxic samples, services, calibration mixtures, large potential releases of asphyxiants, or air from a hazardous area are 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.

Safety aspects associated with analyser houses are covered by the IEC 61285. For clarity and continuity, duplication of some of this standard has been unavoidable in the following guidance.

3.2 Definitions

For the purpose of this technical report, the following definitions apply:

3.2.1 housing

a general term including any of the following. In accordance with IEC 61285 the term analyser house (AH) is used when referring specifically to an analyser house

3.2.2 analyser case

an enclosure forming part of the instrument

3.2.3 analyser cabinet

a small enclosed housing in which analysers are installed singly or grouped together. Maintenance is carried out from outside the cabinet with the door(s) open

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 one or more analysers are installed. The maintenance of the analyser is normally performed in the protection of the shelter

3.2.5 analyser house (AH)

an enclosed building or part of a building containing one or more process analysers and associated equipment where streams for analysis are brought in and which is regularly entered by authorised personnel. Either natural or forced ventilation is used. The maintenance of the analyser is normally carried out from within the house

3.3 Selection of housing

3.3.1 Analyser case

Analysers such as pH meters, electrolytic conductivity meters, etc. 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 accumulation, in terms of flammable gases and vapours, of an explosive atmosphere outside the casing. This is the lowest cost method of installation. The disadvantages are that there is no environmental 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 AH. This method of housing is generally unsuitable when analysers require heating or extensive maintenance.

3.3.2 Analyser cabinet

Analysers may be installed singly or grouped in cabinets provided that the equipment is installed in accordance with the hazardous area classification within the cabinet which in turn will depend on the location of the cabinet, its construction, the degree of ventilation and whether internal sources of release are present within the cabinet.

Environmental conditions and the analyser manufacturer's specification should be met and the equipment made easily accessible for maintenance. Analyser cabinets provide a low cost means of improving environmental protection for analysers.

Natural ventilation is normally used for cabinet ventilation when required. The advantage of a naturally ventilated method is that ventilation is permanent and independent of mechanical failure. However, natural ventilation will at best only maintain the surrounding hazardous area classification and all equipment should be suitably certified accordingly.

When using natural ventilation and where use of a non-certified analyser is unavoidable and the cabinet is to be installed in a hazardous area, additional protective measures, such as pressurised purging, need to be applied to the analyser to prevent any flammable materials entering the cabinet coming into contact with potential sources of ignition inside the analyser. If the analyser design gives rise to the potential for an internal source of release of flammable material, additional measures need to be considered (see 2.2.1).

The disadvantages of cabinets are that it is difficult to make the analysers easily accessible other than from the front for maintenance, 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 may be used when the analysers comply with the hazardous area classification of the location and the 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.

The advantages are that it facilitates the grouping of analysers, allows easy access for maintenance and affords some protection for maintenance personnel, as well as affording permanent natural ventilation.

Its disadvantages are that it does not give the facility to change the hazardous area classification and affords only minimum environmental protection.

3.3.4 Analyser house (AH)

The AH is the highest cost installation but is usually justified for analysers, which require a high degree of protection, which are expected to require regular attention and from which a high service factor is required. These analysers may be installed in an AH which affords a controlled environment for operations and maintenance and should reduce long term maintenance costs.

This type of protection is advantageous 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 AH will at best 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 AH can be chosen depending on the protective system. An advantage is that uncertified equipment can be used in the AH provided ventilation air is drawn from a safe area and the ventilation system and the alarm system are operating.

3.4 Area classification and toxic danger

3.4.1 Electrical area classification

The area within the AH, shelter or cabinet should be classified in accordance with IEC 60079-10 and revised Chapter 3 of the IP Model Code of Safe Practice in the Petroleum Industry. If combustible dusts are present classification should be in accordance with relevant national standards (e.g. BS 6467, Part 2). Analyser housings are "enclosed or open premises" within the meaning of the IEC standards and the IP Electrical Safety Code. All equipment and protective measures used in these housings should be suitable for use in accordance with the area classification.

It should be noted that hazardous materials associated with the AH (e.g. hydrogen as a carrier gas, samples being analysed, calibration samples) may also affect the area classification of the location where the AH, shelter or cabinet is situated.

Where applicable this report refers to classified area definitions of zone 0, zone 1 and zone 2 in accordance with European and IEC standards. Equivalent North American classifications are division 1 (covers both zone 0 and zone 1) and division 2 (covers zone 2).

Unless reference is specific to flammable gas/vapour or combustible dust, the terms of zone 0, 1 and 2 will be used for hazardous area classification reference. In this case the equivalent zone Z and zone Y (zones 20, 21 and 22 using IEC nomenclature) will be implied.

3.4.2 Toxic danger

Ventilation requirements for an analyser housing into which toxic materials are introduced should ensure that the occupational exposure limit (OEL) 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 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. OEL levels are set nationally and the relevant bodies should be consulted, e.g. HSE in the UK which produces a Guidance Note EH40 on occupational exposure limits.

3.5 Construction and mounting

3.5.1 General

Any preference as to the type of construction, within the variations below, should be specified by the user.

3.5.2 Analyser housing

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 high humidity, frost, solar radiation, seismic activity, etc., should also be considered.

Construction should minimise possibility of static charge build-up by careful specification of materials, especially when employing materials such as glass reinforced plastic (GRP) and use of earth bonding.

Construction should minimise effects of corrosion. Suitable corrosion protection coatings should be applied where necessary and care should be taken to avoid local galvanic corrosion caused by use of dissimilar metals, e.g. stainless steel in direct contact with mild steel.

Penetrations should be minimised and meet structural and safety requirements. Bulkhead panels (with appropriate bulkhead fittings) or transits (fire wall penetrations developed for the offshore industry – a schematic showing the principle is shown in annex J) can be used for both electrical and piping penetrations. Use of transits can provide a more compact arrangement if space is at a premium.

When used as a support for equipment the enclosure should have sufficient rigidity to minimise vibration. Appropriate reinforcement may be required where equipment is wall mounted.

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 or emergency lighting is to remain operational at all times and be suitable, as a minimum, for zone 2 hazardous areas for housings situated in hazardous areas or handling hazardous samples.

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 (IEC 60079-10) and the sheath should be shielded against accidental contact by personnel.

Where ambient conditions or heat release within the analyser house results in unacceptably high temperatures air conditioning should be considered.

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 minimising heat gain within the housing due to solar radiation.

Where cavity walls are used care shall be taken to ensure flammable materials cannot build up within the cavity.

Where liquid samples are being analysed, suitable provision should be made for removal of any spillages and/or cleaning materials. Suitable floor drains with the floor sloping to the drain should be provided.

3.5.3 Analyser house (AH)

Additionally, the following points pertain to an AH:

Construction is typically of brick, concrete, steel sheet or glass reinforced plastic/marine ply sandwich.

Outward-opening doors, preferably non-locking, should be provided and be self-closing. All doors require the fitting of a "panic bar" so that they can be quickly opened from the inside even if locks are used. The doors should be positioned to permit easy escape in an emergency from anywhere inside the AH. A single door may suffice depending on the AH house size and escape route provisions outside the house. However, if this main door and escape routes can be impeded either internally or externally, then a second door or an emergency exit such as a kick-out panel will be required as an alternative escape route remote from the main door.

The position and size of at least one door and the access to it should also be arranged to permit removal of equipment housed.

Any windows are usually restricted to inspection windows in the AH doors and should not be capable of being opened. 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 an unobstructed internal headroom of at least 2 m. Dead corners and trenches that may collect gas should be avoided. Equipment such as sample conditioning units, gas cylinders, calibration sample containers and laboratory sampling points should be located outside the AH 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 point to prevent the accumulation of gas pockets. Roof design should also allow for increased loadings due to snow, roof mounted equipment and personnel access as appropriate.

Where the AH is to be mounted on a concrete base, the base should be impervious to the materials being handled, raised at least 0,1 m above the surrounding area and sloped to a suitable point away from the AH for draining of any spillage and cleaning.

The floor inside the AH should be non-slip and any coatings should be resistant to materials likely to come into contact with the floor.

3.6 Analyser housing ventilation requirements

3.6.1 General

Analyser housing ventilation can be achieved by either natural or forced means.

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

Forced ventilation is defined as ventilation achieved by mechanical means such as fans.

3.6.2 Analyser cases

In the case of analyser cases, manufacturer's installation requirements should be followed and special design considerations for ventilation are not normally necessary. Analysers may have purged casings to meet hazardous area requirements but, in the context of this ventilation section, purging is a separate issue and described in 2.2.1.

3.6.3 Analyser shelters

Very little control over ventilation can be exercised with shelters and design should concentrate only on prevention of accumulation of gases and liquids by elimination of stagnant areas within the shelter. This type of design does little to prevent hazards that can arise from dust.

3.6.4 Analyser cabinets and analyser houses

AHs and cabinets are enclosed structures which require ventilation in which the analyser(s) plus purged cases as appropriate are contained. The object of these structures is to provide some degree of control over the environment for the analysers and associated equipment housed within them for operational and maintenance reasons. For this and for safety reasons it is necessary to pay special attention to ventilation design.

Where dusty atmospheres (either combustible or inert) are concerned ventilation air filtration needs to be considered. With natural ventilation especially, this will have significant impact on vent louver sizing and possible restriction of air flows.

AHs can be ventilated by either forced or natural means but for economic reasons analyser cabinets are normally naturally ventilated.

Whichever mode of ventilation is used (natural or forced) design calculations should use as a basis an absolute minimum of 5 changes per hour or that necessary to achieve the following:

- a) Dilute escaping vapours from the rupture or failure of the most hazardous sample or service line to less than the nationally accepted design percentage LEL (usually 20 % LEL but no circumstances higher than 50 % LEL) around any potential means of ignition. Particular attention must be paid to liquid samples which vaporise at ambient temperatures.
- b) Dilute to below the occupational exposure limit any toxic gases/vapours introduced into the housing by accidental rupture of any one sample or service line within the AH or cabinet.
- c) Dilute any release of asphyxiants by the accidental rupture of any one sample or service line within the AH or cabinet to ensure oxygen levels do not fall below 18 % to 19,5 % by volume at atmospheric pressure.
- d) Assist in maintaining the temperature inside the housing within limits specified by the user and/or those required for reliable operation of the analysers.

The primary ventilation design is based on average dilution rates and passage of air through the housing. At low rates of exchange local mixing effects may be too low resulting in poor dissipation of the leak and in some cases stagnant areas where gas could accumulate. Additional measures in the form of re-circulation systems could be considered to improve matters but it must be noted that these re-circulation rates do not figure in the basic ventilation requirements for overall dilution and prevention of build up of gas within the house.

Ventilation air flow patterns should always be confirmed by smoke tests which will identify any poor air distribution.

3.7 Design for natural ventilation

3.7.1 Ventilation requirements

The ventilation rates should be designed to dilute and dissipate any dangerous release of gases and vapours within the AH 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 % of the year. Wind or thermally induced calculations should use as a basis the design conditions outlined in 3.6.4.

Wind induced ventilation rates should also be calculated for maximum average wind speeds using a gusting ratio of 1,6. If resulting ventilation rates exceed 50 changes per hour then comfort factors will deteriorate.

3.7.2 Heating requirements

With the above design procedure the temperatures in the house will essentially follow that of the ambient outside. To improve temperature control, thermo-statically 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 per 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 not be energy efficient.

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.

A worked example is given in annex D.

3.8 Design for forced ventilation

3.8.1 Ventilation requirements

The ventilation rates should be designed to dilute and dissipate any dangerous release within the housing.

The house should be ventilated with air at an internal pressure and flow pattern designed to keep flammable or toxic gases, either lighter or heavier than air and dusts, out of the house. Air should enter and leave the house by entry and exit ports as discussed in 3.8.4. The minimum differential pressure under operating conditions should be 25 Pa (0,25 mbar). It is normal practice to operate at an over pressure of 2 mbar to 5 mbar which meets the primary requirement with a good factor of safety without causing discomfort to personnel and undue stress on the house structure.

Calculations should use as a basis the design conditions outlined in 3.6.4.

The method of calculation is shown in annex E.

3.8.2 Air intake system

The air intake should be via a stack provided with a rain hood. The air source should be from a non-hazardous area where corrosive or toxic gases do not occur.

The design of the intake duct and the diameter of the stack should be sized to limit air velocity to a maximum of 15 m/s. Any ducting to the analyser house which passes through hazardous areas should be leak-tight. Ducting through zone 1 hazardous areas should be avoided where possible.

In some instances distance to the safe area may be excessive and in these cases air may be drawn from a zone 2 area in which case the following will apply:

- a) Analyser house equipment must be certified as suitable for zone 1 areas or zone 2 as a minimum. Alternatively the air inlet may be monitored by means of one or more gas detectors, which discontinue ventilation air flow when a value of 20 % LEL is exceeded; however, due consideration is needed on the consequences of "ventilation failure and the use of gas detection inside the house (see 3.9).
- b) Live maintenance should not be carried out except under a permit to work system or other approved safety procedure.
- c) Maintenance equipment should be isolated in the event of ventilation failure or gas detected.

3.8.3 Fan requirements

The forced ventilation equipment should be mounted outside the building and should be suitably protected. Ventilation should be by means of a centrifugal or axial fan. Motors positioned in the duct should be suitable for zone 1 operation for housings handling flammable samples and if combustible dusts are present, for zone Z regardless of filtration used.

Dual ventilation fan systems should be considered to minimise trips of non-certified equipment on ventilation failure. To facilitate maintenance, fans should be fitted in parallel with non-return valves and have suitable means of mechanical isolation. Power supplies to the fan motor should be independent of each other.

A filter should be installed in the ducting and should be easily accessible for cleaning or replacement. The area of the filter should be sized to require cleaning/replacement not more frequently than once per month under the worst dust conditions expected on site.

3.8.4 Air distribution requirement

The direction of flow of air within the housing should be such as to ensure a movement throughout the housing and around all equipment installed inside irrespective of wind direction and strength. The position and number of air entry and exit ports should be dependent on the nature of the hazardous materials handled inside the house (e.g. density greater or less than or equal to that of air, toxicity and the concentration necessary to achieve the LEL, OEL or oxygen deficiency). The air exit ports should be louvres or weight-balanced flaps. At least 50 % of the exit ports should be operable under all wind conditions. See annex E for forced ventilation calculations.

Air distribution can be aided by use of re-circulation fans to ensure any leak is well dissipated. This is not normally required but may be of importance especially with toxic hazards as local stagnation pockets could prove fatal if in areas where personnel are likely to be during normal operation or maintenance procedures.

3.8.5 Heating requirement

The temperature inside the AH should be controlled at a nominal 20 °C. However, any heating and/or cooling systems should be designed to maintain temperatures within the limits of 10 °C and 30 °C under extreme conditions dependent on equipment and/or maintenance restraints.