

Petroleum and natural gas industries — Offshore production installations — Heating, ventilation and air- conditioning

The European Standard EN ISO 15138:2000 has the status of a
British Standard

ICS 75.180.20

National foreword

This British Standard is the official English language version of EN ISO 15138:2000, including Corrigendum July 2002. It is identical with ISO 15138:2000, including Technical Corrigendum June 2001.

The UK participation in its preparation was entrusted to Technical Committee PSE/17, Petroleum and natural gas industries, which has the responsibility to:

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Summary of pages

This document comprises a front cover, an inside front cover, the EN ISO title page, the EN ISO Foreword page, the ISO title page, pages ii to iv, pages 1 to 105, the Annex ZA page, an inside back cover and a back cover.

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English version

**Petroleum and natural gas industries - Offshore production
installations - Heating, ventilation and air-conditioning (ISO
15138:2000)**

Industries du pétrole et du gaz naturel - Installations en mer
- Chauffage, ventilation et climatisation (ISO 15138:2000)

This European Standard was approved by CEN on 26 October 2000.

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Foreword

This document (EN ISO 15138:2000) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum and natural gas industries", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2001, and conflicting national standards shall be withdrawn at the latest by May 2001.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 15138:2000 has been approved by CEN as EN ISO 15138:2000 without any modifications.

NOTE Normative references to International Standards are listed in Annex ZA (normative).

INTERNATIONAL STANDARD

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Petroleum and natural gas industries — Offshore production installations — Heating, ventilation and air-conditioning

*Industries du pétrole et du gaz naturel — Installations en mer —
Chauffage, ventilation et climatisation*



Reference number
ISO 15138:2000(E)

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Contents

Page

Foreword.....	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Abbreviated terms	2
5 Design	3
5.1 Introduction	3
5.2 Development of design basis	6
5.3 System design — General	10
5.4 Area-specific system design	11
Annex A (informative) Guidance to clause 5 Design	14
Annex B (informative) Equipment and bulk selection	41
Annex C (informative) Installation and commissioning guidance	61
Annex D (informative) Operation and maintenance.....	66
Annex E (informative) Data sheets	69
Annex F (informative) Flange standard.....	101
Bibliography	104

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15138 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*.

Annexes A through F of this International Standard are for information only.

Petroleum and natural gas industries — Offshore production installations — Heating, ventilation and air-conditioning

1 Scope

This International Standard specifies requirements and provides guidance for design, testing, installation and commissioning of heating, ventilation, air-conditioning and pressurization systems and equipment on all offshore production installations for the petroleum and natural gas industries which are:

- new and existing;
- normally occupied by personnel and not normally occupied by personnel;
- fixed or floating but registered as an offshore production installation.

NOTE For installations that could be subject to "Class" or "IMO/MODU Codes & Resolutions", the user is referred to HVAC requirements under these rules and resolutions. Should these requirements be of a lesser degree than those being considered for a fixed installation, then this International Standard, i.e. requirements for fixed installation, should be utilized.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 8861, *Shipbuilding — Engine-room ventilation in diesel-engined ships — Design requirements and basis of calculations*.

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

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1

displacement ventilation

movement of air within a space in piston- or plug-type motion

NOTE No mixing of room air occurs in ideal displacement flow, which is desirable for removing pollutants generated within a space.

3.2

fixed offshore installation

all **facilities** located and installed on **fixed offshore structures**, which are provided to extract oil and gas hydrocarbons from subsea oil and gas reservoirs

3.3

fixed offshore structure

structure permanently fixed to or located on the sea bed, including moored ships and hulls, which is held in position by anchors or tensioned cables and is provided to (structurally) support topsides facilities

NOTE Vessels and drilling rigs, etc. which are in transit or engaged in exploration and appraisal activities are specifically excluded from this definition.

3.4

fugitive emission

emission which is always present on a molecular scale from all potential leak sources in a plant under normal operating conditions

NOTE As a practical interpretation, a fugitive emission is one which cannot be detected by sight, hearing or touch but may be detected using bubble-test techniques or tests of a similar sensitivity.

3.5

open area

area in an open-air situation where vapours are readily dispersed by wind

NOTE Typical air velocities in such areas should rarely be less than 0,5 m/s and should frequently be above 2 m/s.

3.6

temporary refuge

TR

place where personnel can take refuge for a pre-determined period whilst investigations, emergency response and evacuation pre-planning are undertaken

[ISO 13702:1999, definition 2.1.52]

4 Abbreviated terms

AC	Alternating Current
AC/h	Air Changes per hour
AHU	Air Handling Unit
AMCA	Air Movement and Control Association Inc.
API	American Petroleum Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BS	British Standard
CCR	Central Control Room
CFD	Computational Fluid Dynamics
CIBSE	Chartered Institution of Building Services
CMS	Control and Monitoring System
CVU	Constant-Volume Terminal Reheat Unit
DC	Direct Current

DE	Driven End
DX	Direct Expansion
EN	European Standard
ESD	Emergency Shutdown
F&G	Fire and Gas
HAZOP	Hazard and Operability Study
HSE	Health, Safety and Environment
HVAC	Heating, Ventilation and Air Conditioning
HVCA	Heating and Ventilating Contractors' Association
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
IP	Institute of Petroleum
IP	Integrity Protection
LFL	Lower Flammable Limit
LQ	Living Quarters
MODU	Mobile Offshore Drilling Unit
NDE	Non-driven End
NFPA	National Fire Protection Association
NS	Norsk Standard (Norwegian Standard)
QRA	Quantitative Risk Analysis
r.m.s.	Root mean square

5 Design

5.1 Introduction

Clause 5 together with annex A provide requirements and guidance on all aspects of the design of heating, ventilation and air-conditioning (HVAC) systems for offshore installations for the petroleum and natural gas industries. The HVAC systems form part of the safety services of the installation. The safety goals are to:

- prevent, through pressurization, the ingress of potentially flammable gas-air mixtures into all designated nonhazardous areas;
- prevent the formation of potentially hazardous concentrations of flammable gaseous mixtures in hazardous areas by provision of sufficient ventilation for the dilution, dispersion and removal of such mixtures;

- maintain ventilation to all equipment and areas/rooms which are required to be operational during an emergency when the main source of power is unavailable;
- provide a controlled environment in which personnel, plant and systems can operate effectively, including smoke control.

These high-level goals are supported by lower-level goals of a functional nature which are stated later in the appropriate sections of this document.

Subclause 5.2 concentrates on functional requirements in the development of a basis of design for either a new project or major modification to an existing installation. The requirements are related to:

- a) platform orientation and layout;
- b) hazard identification and hazardous area classification;
- c) environmental conditions;
- d) choice of natural or mechanical ventilation systems;
- e) development of the controls philosophy;
- f) material selection;
- g) design margins and calculations;
- h) design development and validation using wind tunnel testing or Computational Fluid Dynamics (CFD).

Ventilation may be natural (i.e. the wind) or mechanical or a combination of both. Throughout this International Standard, the use of the term "ventilation" should be taken to include either natural or mechanical ventilation, as appropriate.

Natural ventilation is preferred over mechanical ventilation where practical, since it is available throughout gas emergencies, does not rely on active equipment and reduces effort required for HVAC maintenance.

For new designs, the development of a design basis may be progressed using the guidance and examples of good engineering practice that are identified in this document, though it should be recognized that it involves a process of iteration as the design matures and does not take place as the sequential series of steps used in this document to facilitate presentation. The processes outlined here are equally applicable to major redevelopments to existing installations, but some compromise may need to be made as a result of historical decisions regarding layout, equipment selection and the prevailing level of knowledge at the time. The challenge of providing cost-effective solutions in redevelopment may be significantly greater than for a new design.

The finalized basis of design may be recorded on data sheets such as those provided in annex E.

The completed design should be subject to hazard assessment review. The Hazard and Operability Study (HAZOP) technique may be used for this.

In 5.2, objectives are identified which establish the goals. Functional requirements are outlined which will enable the objectives to be achieved. The functional requirements are supported by technical guidance given in annex A, which discusses the suitability of different techniques for different applications and identifies examples of good engineering practice or cost-effective solutions that have been used in some parts of the world. The functional requirements may be satisfied by other methods not identified in this document, but it is the responsibility of the user to assess whether the method is technically acceptable and acceptable to the local regulator.

Subclause 5.3 addresses the fundamental choice in system design, i.e. between natural and mechanical methods of ventilation.

Subclause 5.4 gives functional requirements associated with the design of HVAC systems for different areas of a typical offshore installation which require particular technical considerations due to their location and/or their function.

Figure 1 is intended to illustrate the processes undertaken at various stages of the installation life cycle and to identify reference documents and the appropriate clauses of this International Standard which provide the necessary guidance.

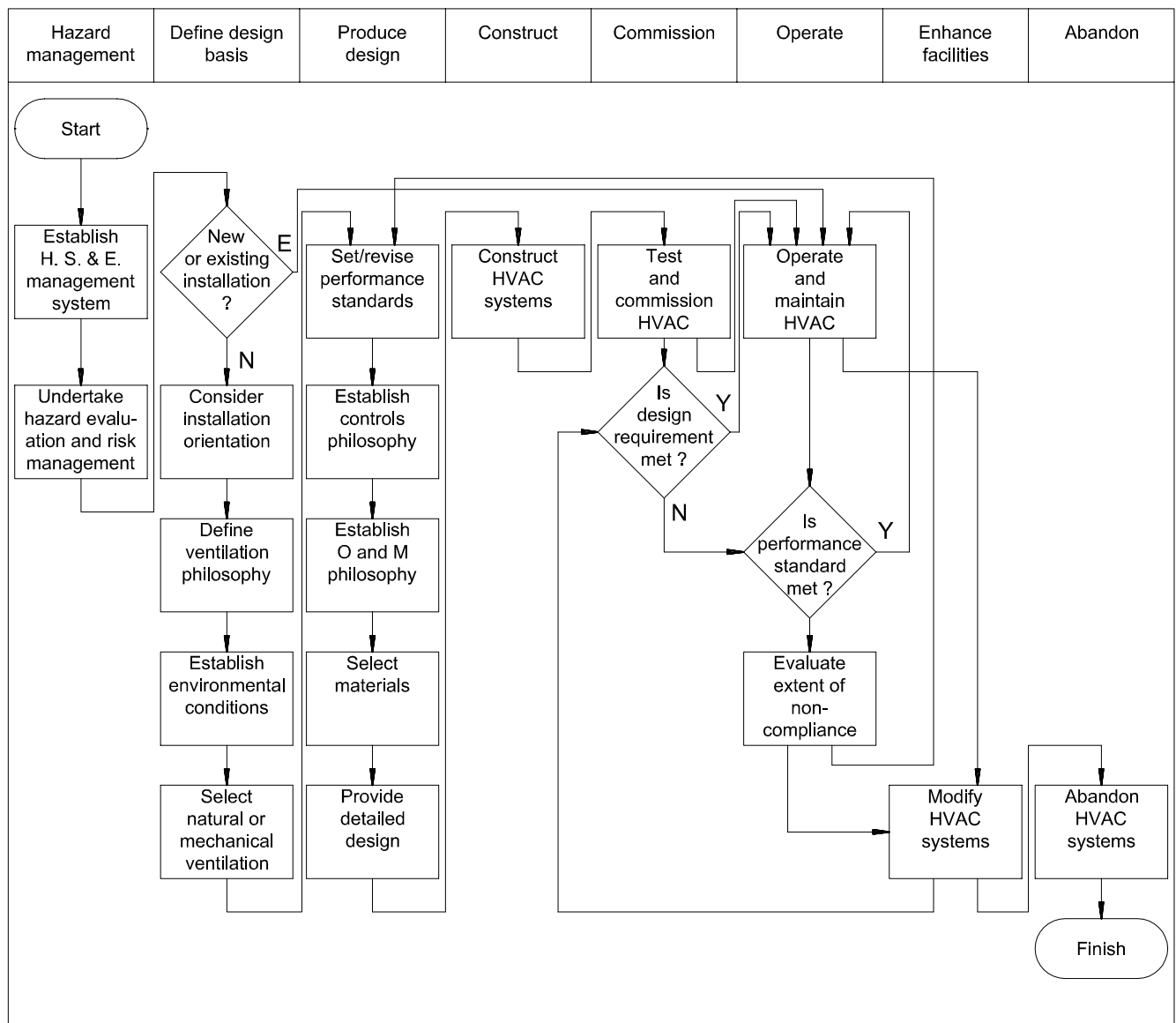


Figure 1 — Application of this International Standard to a project life cycle

5.2 Development of design basis

5.2.1 Orientation and layout

5.2.1.1 Objective

To provide input into the early stages of design development so that areas and equipment that may have a requirement for HVAC, or be affected by its provision, are sited in an optimum location, so far as is reasonably practicable.

5.2.1.2 Functional requirements

Installation layout requires a great deal of coordination between the engineers involved during design and the operation, maintenance and safety specialists. Attention shall also be paid to the minimization of construction, offshore hook-up and commissioning. It is not the intention of this International Standard to detail a platform-layout philosophy, but to identify areas where considerations of the role of HVAC, and requirements for it, might have an impact in the decision-making surrounding installation orientation and layout.

Each installation should have a temporary refuge (TR). The TR should in almost all cases be the LQ, where they are provided. The survivability of the TR, which is directly related to the air change rate, may introduce consideration of active HVAC systems for pressurization of the Living Quarters (LQ) or enclosed escape and evacuation routes. Active systems require detailed risk assessment exercises to be undertaken as part of the design verification, and passive systems are generally preferred since they do not rely on equipment functioning under conditions of emergency.

Hazardous areas, particularly those containing pressurized hydrocarbon systems, should be located as far as practicable from the TR so that any gas leaks will be naturally dispersed.

The layout shall include correct positioning of ventilation inlets and outlets, engine inlets and exhausts, vents and flares to allow for safe operation, particularly of the TR. Hot exhausts shall not interfere with crane, helicopter, production or drilling operations or the LQ, and shall be directed so as not to be drawn into gas turbine air intakes.

Air intakes to hazardous and nonhazardous areas shall be located as far as is reasonably practicable from the perimeter of a hazardous envelope and not less than the minimum distance specified in the prevailing area classification code.

For guidance, reference is made to clause A.1.

5.2.2 Hazardous area classification and the role of HVAC

5.2.2.1 Objective

To adopt in the design and operation processes a consistent philosophy for the separation of hazardous and nonhazardous areas and the performance of ventilation in those areas.

5.2.2.2 Functional requirements

IEC 60079-10 shall be used for classification of a hazardous area. The choice of hazardous area code determines the choice of equipment to be used in particular areas of the installation and also provides input to the performance standards for HVAC systems in those areas.

For guidance, reference is made to clause A.2.

5.2.3 Environmental conditions

5.2.3.1 Objective

To determine an environmental basis of design that enables HVAC systems to be designed in order to meet the objectives for HVAC.

5.2.3.2 Functional requirements

External and internal environmental bases suitable for the location of the installation shall be established for the design.

For guidance, reference is made to clause A.3.

5.2.4 Natural/mechanical ventilation

5.2.4.1 Objective

To select a means of providing ventilation to any hazardous or nonhazardous area of an installation.

5.2.4.2 Functional requirements

Provide ventilation to any area which may require it, giving consideration to:

- a) meteorological conditions, particularly prevailing wind and its strength, external temperature, and precipitation;
- b) risk-driven segregation of hazardous areas;
- c) heating and cooling design loads;
- d) life cycle costs of the purchase and maintenance of mechanical HVAC and associated Emergency Shutdown (ESD) systems;
- e) environmental considerations, such as personnel comfort, particulate control, and noise;
- f) weather integrity of instrumentation and controls;
- g) need for structural integrity;
- h) control and recovery from hydrocarbon loss of containment;
- i) process heat conservation.

NOTE Many of these factors are controlled by local legislation, which should be consulted for implications.

For guidance, reference is made to clause A.4.

5.2.5 Selection of controls philosophy

5.2.5.1 Objective

To provide a system for controlling HVAC systems from a frequently manned location that provides the operator with essential information on the status of the plant and is integrated with the installation fire and gas (F&G) and ESD systems, so that actions in an emergency minimize the risk to personnel.

5.2.5.2 Functional requirements

The control and monitoring system shall:

- a) provide the operator with the status of the HVAC plant;
- b) provide the minimum necessary controls for the plant consistent with the operation and maintenance philosophies;
- c) provide a link to the installed F&G and ESD systems, if required;
- d) comply with the installation smoke and gas control philosophy.

For guidance, reference is made to clause A.5.

5.2.6 Operating and maintenance philosophy

5.2.6.1 Objective

To provide an HVAC design which provides as high a degree of operational availability, so far as is reasonably practicable, within the constraints imposed by installed cost, maintenance resources and the consequences of failure.

5.2.6.2 Functional requirements

The design shall include the necessary standby arrangements, plant operating margins, access provisions and requirements for routine maintenance to enable a specified operational availability to be achieved at minimum cost over the lifetime of the installation.

For guidance, reference is made to clause A.6.

5.2.7 Materials and corrosion

5.2.7.1 Objective

To specify materials and protective coatings for equipment and components that minimize, as far as is reasonably practicable, life cycle costs for the installation and potential harm to personnel who may be affected by their operation.

5.2.7.2 Functional requirements

The design shall recognize the saliferous atmosphere and relative humidity that will be present throughout the installation life.

Non-combustible, non-toxic materials shall be used throughout; such materials, when heated, shall not emit toxic fumes.

The design shall recognize that operation in conjunction with flammable atmospheres may be required for some components.

For guidance, reference is made to clause A.7.

5.2.8 Design margins and calculations

5.2.8.1 Objective

To ensure that design integrity is demonstrated in the provision of cost-effective HVAC systems by calculations which take due account of the accuracy of HVAC system data and extremes of design environmental conditions.

5.2.8.2 Functional requirements

The design shall be documented in accordance with suitable industry standards, i.e. those of ASHRAE, CIBSE or similar recognized authorities.

Specification of equipment shall recognize the maturity of the design and the level of information provided by other disciplines in the design process.

For guidance, reference is made to clause A.8.

5.2.9 Wind tunnel and CFD modelling

5.2.9.1 Objective

To undertake a modelling programme that reproduces installation conditions within a reasonable accuracy, so that design options may be consistently evaluated and the chosen option optimized with a high degree of confidence that the design performance will be replicated by actual measurements.

5.2.9.2 Functional requirements

If required, a modelling programme shall be undertaken to predict

- natural ventilation rates and frequencies;
- wind pressure distribution around the installation to fix air inlet and outlet positions;
- requirements for secondary ventilation;
- gas build-up inside hazardous modules;
- helideck configurations and operating envelopes;
- hot plume and contaminant (noxious exhaust and hydrocarbon) smoke or gas flows around the installation.

For guidance, reference is made to clause A.9.

5.2.10 Performance standards

5.2.10.1 Objective

To define performance standards for HVAC systems which may be used as a basis for managing risk throughout the life of the installation.

5.2.10.2 Functional requirements

Performance standards are statements which can be expressed in qualitative or quantitative terms of the performance required of the system, item of equipment, person or procedure, and which are used as a basis for the management of risk throughout the installation life. They shall be set commensurate with the magnitude of the risk to be managed and shall clearly define the level of performance required for compliance.

For guidance, reference is made to clause A.10.

5.3 System design — General

5.3.1 Natural ventilation

5.3.1.1 Objective

Natural ventilation shall, wherever possible, be provided to

- dilute local airborne concentrations of flammable gas due to fugitive emissions;
- reduce the risk of ignition following a leak by quickly removing accumulations of flammable gas.

5.3.1.2 Functional requirements

It is important to note that the distribution of air within an area/module is considered to be at least as important as the quantity of air supplied. As a consequence, compliance with the following basic requirements is necessary if ventilation of an area/module by natural means alone is to be considered sufficient:

- minimum ventilation rate shall be provided throughout the area;
- minimum ventilation rate shall be as stated for mechanical ventilation.

Consideration shall be given to the working environment by the adoption of a natural ventilation philosophy.

For guidance, reference is made to clause A.11.

5.3.2 Mechanical ventilation

5.3.2.1 Objective

To provide mechanical ventilation when ventilation by natural means is unable to satisfy requirements.

5.3.2.2 Functional requirements

The HVAC systems shall be designed to prevent contamination between areas and maintain acceptable working and living environments for personnel and non-destructive conditions for equipment.

For practical reasons, systems may be separated for the following areas:

- a) nonhazardous areas;
- b) hazardous areas;
- c) living quarters;
- d) areas to be in operation during emergency situations;
- e) auxiliary systems for naturally ventilated areas;
- f) drilling areas;
- g) substructure;
- h) areas with contaminated air (separate extract).

The minimum ventilation air volumes shall be documented.

For guidance, reference is made to clause A.12.

5.3.3 Secondary ventilation systems

5.3.3.1 Objective

To provide a system to supplement natural or mechanical ventilation when the distribution of air is not adequate.

5.3.3.2 Functional requirements

Stagnant areas formed by structural steelwork, decking plates, sumps and equipment, etc. shall be assessed and ventilated accordingly.

Consideration shall be given to the dilution of fugitive hydrocarbon emissions and dissipation of internal heat gains.

A uniform ventilation pattern shall be provided between primary supply and extract points.

For guidance, reference is made to clause A.13.

5.4 Area-specific system design

5.4.1 Process and utility areas

5.4.1.1 Objective

To provide mechanical ventilation when ventilation by natural means is unable to satisfy requirements.

5.4.1.2 Functional requirements

Systems provided for hazardous areas shall be entirely separate from those serving nonhazardous areas. The system design shall include a fan-powered supply plant which draws 100 % of its outside air from a nonhazardous area and supplies it to the module.

Airflow in terms of air changes per hour for a nonhazardous area shall be sufficient to meet the pressurization requirements determined by the local regulation or hazardous area code classification adopted, free-cooling and personnel needs. Specific exhaust requirements, e.g. fume cupboards, welding benches/booths, etc., may also require consideration.

At outside maximum and minimum design temperatures, areas shall not exceed the temperature set by local regulation, applicable codes of practice or company standards. Refer to Table A.2 in A.3.4.

Air change rates determined in 5.2.2 shall be applied, but at a rate sufficient to dilute fugitive hydrocarbon emissions. Any free-cooling requirements for the area shall also be met.

For guidance, reference is made to clause A.14.

5.4.2 Living quarters

5.4.2.1 Objective

To provide a controlled environment for personnel.

5.4.2.2 Functional requirements

HVAC systems shall be designed to maintain internal-air conditions defined by local legislation or codes of practice at maximum and minimum outside air conditions, taking into account detectable and latent loads from lighting, personnel and other sources.

Ventilation rates (in terms of air changes per hour) shall be established from requirements for heating or cooling outdoor air and the need for pressurization.

The air change rates for galley and laundry shall include consideration of the cooling load requirements imposed by the equipment and the efficiency of extract hoods and systems.

The design of supply and extract systems shall include adequate protection to prevent cross-contamination or the circulation of odours through the LQ on partial or total system failure.

For guidance, reference is made to clause A.15.

5.4.3 Drilling and drilling utility areas

5.4.3.1 Objective

To provide mechanical or natural ventilation to satisfy requirements.

5.4.3.2 Functional requirements

The HVAC system shall be designed to reduce the exposure of personnel to dust, fumes, heat, etc. to the level specified by local legislation or industry codes.

Any special requirement for the ventilation of equipment in normal or emergency operation shall be incorporated in the design.

For guidance, reference is made to clause A.16.

5.4.4 Gas turbine enclosures

5.4.4.1 Objective

To provide sufficient ventilation to satisfy requirements.

5.4.4.2 Functional requirements

The ventilation system shall be designed to remove heat from machinery and to dilute flammable gas.

Pressurization shall be provided in accordance with the hazardous area classification philosophy adopted for the area.

For guidance, reference is made to clause A.17.

5.4.5 Emergency plant ventilation

5.4.5.1 Objective

To provide sufficient ventilation to equipment that may be required to operate in an emergency under the conditions that may be present at the time.

5.4.5.2 Functional requirements

HVAC systems serving emergency plants shall be designed to ensure the equipment continues to function under the conditions prevailing when it is called upon to work.

For guidance, reference is made to clause A.18.

5.4.6 Battery and charger rooms

5.4.6.1 Objective

To provide sufficient ventilation to satisfy requirements.

5.4.6.2 Functional requirements

The HVAC system serving battery and charger rooms shall be sized for the removal of all noxious and flammable products and any heat generated.

For guidance, reference is made to clause A.19.

5.4.7 Laboratories

5.4.7.1 Objective

To provide sufficient ventilation to satisfy requirements.

5.4.7.2 Functional requirements

Laboratories shall be provided with a dedicated fan-powered extraction system to prevent personnel exposure to exhaust fumes.

For guidance, reference is made to clause A.20.

5.4.8 Purge air systems

5.4.8.1 Objective

To provide sufficient ventilation to satisfy requirements.

5.4.8.2 Functional requirements

HVAC services for air supplies to components and plant requiring to be kept purged, such as draw-works and rotary table motors, shall at all times have outside air drawn from a nonhazardous source.

For guidance, reference is made to clause A.21.

5.4.9 Rooms protected by gaseous extinguishing agents

5.4.9.1 Objective

To provide sufficient ventilation to satisfy requirements.

5.4.9.2 Functional requirements

Where rooms are provided with gaseous extinguishing systems, ventilation supply and exhaust dampers and fans shall be interlocked with the F&G control to shut prior to gas release.

For guidance, reference is made to clause A.22.

5.4.10 Engine-room ventilation in diesel-engined ships

Design requirements and basis of calculation shall be in accordance with ISO 8861.

Annex A (informative)

Guidance to clause 5 Design

A.1 Guidance to 5.2.1

Results of wind tunnel model tests or CFD calculations on the installations should be considered in order to determine the external zone(s) of wind pressure in which to locate the intake(s) and outlet(s) for the HVAC system(s). Particular care should be taken in locating air intakes and discharges with regard to the location's coefficient of pressure and its subsequent effect on fan motor power.

The underside of a platform can be a convenient location for HVAC inlets and outlets because a large proportion of the below-platform zone may be classified as nonhazardous and have stable wind conditions. However, consideration should be given to the effects of the wind and waves and the location of items such as dry powder dump-chutes and cooling water discharges, when locating the outdoor air intakes and extract discharges below the platform.

Air intake and discharge from the same system on conventional installations should, where reasonably practical, be located on the same face of the installation or in external zones of equal wind pressure. Particular care should be taken in orienting air intakes and discharges on systems serving adjacent hazardous and nonhazardous areas, such that whilst the wind may affect the absolute values of pressurization in each area, the differential pressure requirements between them will not vary to a significant degree. For floating production systems (FPS) however, the downwind area may provide an appropriate intake location but it will be necessary to show that it is positioned to avoid ingestion of smoke or contaminants and capable of operation in adverse weather.

Air intakes should be located to avoid cross-contamination from

- exhausts from fuel-burning equipment;
- lubricating oil vents, drain vents and process reliefs;
- dust discharge from drilling, dry powders;
- helicopter engine exhaust;
- flares;
- supply and support vessels.

The siting of gas turbines and generators usually poses a challenge to layout designers. They should be located in a nonhazardous area and with consideration to the following points.

- a) The air intake should be sited the maximum possible distance from hazardous areas and as high above sea level as possible to avoid water ingress (an absolute minimum of at least 3 m above the 100-year storm wave level). If enclosed, the intakes should be located such that powder and dust is not ingested. Since most particulate matter in the air is generated on the platform from drilling operations and grit blasting, the preferred arrangement is for air intakes to be located above the upper-deck level.
- b) Recirculation from the exhaust back to the inlet should be avoided and be demonstrated by wind tunnel tests or CFD. These tests should also show that exhaust flue emissions do not interfere with helicopter, production, drilling and crane operations.

In the absence of any performance standards set by the local aviation authority, a maximum air temperature rise above the surface of the helideck should be agreed for helicopter operation.

Computer models are available to model hot and cold plume dispersion patterns and may be used to establish outlet positions but the final layout/model should be wind tunnel tested at an early stage in platform design development.

A.2 Guidance to 5.2.2

The application of a recognized hazard identification and assessment process may identify a role for the separation and segregation of inventories on an installation. Area classification codes specify separation distances between hazardous and nonhazardous areas in order to avoid ignition of those releases which inevitably occur from time to time in the operation of facilities handling flammable liquids and vapours.

All area classification codes should be interpreted in a practical manner. They offer only best guidance and often the particular circumstances require a safety and consequence review and the subsequent application of "as safe as is reasonably practicable" approach to location of classified area boundaries and potential ignition sources nearby. In order to correctly and consistently establish area zoning, historical data from similar plant operating conditions may be used as a basis for assessment.

Ventilation impacts upon hazardous area classification and provides a vital safety function on offshore installations by

- diluting local airborne concentrations of flammable gas due to fugitive emissions;
- reducing the risk of ignition following a leak by quickly removing accumulations of flammable gas.

The quantity of ventilation air to maintain a non-flammable condition in areas with fugitive emissions can be calculated from data in API 4589 [29], using the methodology given in API RP 505 [28].

It is recommended that areas be classified using the general guidance of IEC 60079-10. Specific guidance for classifying petroleum facilities can be found in documents such as The Institute of Petroleum Area Classification Code for Petroleum Installations, Model Code of Safe Practice Part 15 (IP Code Part 15) and API RP 505 [28].

It should be recognized that a higher level of ventilation than the default lower limit of acceptable ventilation given in the hazardous area codes might be required to

- provide a suitable atmosphere for personnel and equipment;
- remove excess heat;
- provide enhanced rate of ventilation to mitigate against the build-up of potentially explosive atmosphere.

A.3 Guidance to 5.2.3

A.3.1 External meteorological conditions

In the absence of local regulations, the need for shelter should be evaluated and may reveal a subsequent need for an HVAC system.

The design of the HVAC systems should be based on local regulations or design codes. Conservative selection of criteria may carry a cost, weight and power penalty.

Seasonal extremes of temperature, humidity and wind speed vary widely throughout the world, and local regulations governing working conditions may also dictate the allowable extremes in occupied or unoccupied spaces. Local environmental information should be specified in the basis of a design that does not result in

additional capacity being installed to cater for a small proportion of the year during which meteorological extremes are encountered.

Sub-local effects on the external environmental conditions should be considered for design purposes in case they have any influence on the design, such as heating of the air before the air reaches the intakes, intake contamination, shading of solar radiation, reflection of solar radiation from the sea surface, changes in wind speed and direction and consequently wind pressure.

Effective temperatures, resulting from wind chill or heat loading, should be determined to establish the effects on personnel operating efficiency (where personnel are required to work in thermally uncontrolled areas) and equipment, and consequently the extent of any required protection. In determining operating efficiency, consideration should be given to the nature of the work (sedentary or physical) being undertaken.

There are various agencies that can provide meteorological information. Most of these contribute to a worldwide database that can be accessed by local meteorological services, but there are also individual databases. Those data sets based on observations from passing ships are likely to be extensive, with many observations over a long time period for those locations near to shipping lanes. Satellite measurement is increasing in terms of history, detail and quality, and some agencies may provide data from this source for areas where ship data is not statistically significant. A third alternative, but probably the least reliable, is the extrapolation of data from nearby onshore sites.

The following provides typical data that could be used to establish an environmental basis of design in an area where microclimate is not an important factor and variations in any month follow a normal distribution:

Maximum temperature: 2 % probability of exceeding the all-year average

Minimum temperature: 2 % probability of exceeding the all-year average

Design wind speed: 1/12th year-1 h mean velocity at a reference height of 10 m

Maximum wind speed: maximum 1/12th average 3 s gust at the height of equipment

NOTE The 1/12th year mean condition is that which on average is exceeded 12 times a year.

Wind velocity data are usually reported at a standard 10 m height, but may be recorded at a different height on an installation. The corrections factors in Table A.1 should be applied to the commonly reported 1-h mean wind velocities.

Table A.1 — Wind corrections factors

Height above mean sea level m	Duration of gust		Sustained mean wind duration		
	3 s	15 s	1 min	10 min	1 h
10	1,33	1,26	1,18	1,08	1,00
20	1,43	1,36	1,28	1,17	1,09
30	1,49	1,42	1,34	1,23	1,15
50	1,57	1,50	1,42	1,31	1,22
60	1,59	1,52	1,44	1,34	1,25
80	1,64	1,57	1,49	1,39	1,30
100	1,67	1,60	1,52	1,42	1,33
120	1,70	1,63	1,55	1,46	1,36
150	1,73	1,66	1,58	1,49	1,40
Exponent (<i>n</i>)	0,100	0,100	0,113	0,120	0,125

EXAMPLE 1 Given a 1-h mean wind velocity of 24 m/s at 10 m height, the maximum 1-min sustained wind velocity at a height of 50 m is estimated to be $24 \text{ m/s} \times 1,42 = 34 \text{ m/s}$.

Wind velocity factors at other heights can be obtained from the reference value at 10 m using the power law profile in equation (A.1):

$$v_h = v_{10} \times (h/10)^n \quad (\text{A.1})$$

where

v_{10} is the velocity at 10 m above sea level;

v_h is the velocity at height h above sea level;

n is the power law exponent.

EXAMPLE 2 A wind measured at an average velocity of 7 m/s at deck level 50 m above mean sea level would have a velocity at the 10 m base of

$$v_{10} = 7 \text{ m/s} \times (1,00/1,22) = 5,77 \text{ m/s}.$$

In areas where there are high seasonal fluctuations from an average, such as in monsoon, typhoon and tropical regions, it may be necessary to consider setting design criteria based on the number of days or hours of exceedance if data is available for analysis in this form.

Where there is a significant microclimate, it may be necessary to analyse data under additional criteria for which the following guidance is appropriate.

A.3.2 Maximum sea temperature

The maximum monthly average water temperature during the warmest month at the depth of abstraction, which may be extrapolated from surface temperature measurements.

A.3.3 Direct and diffuse solar radiation intensities

For detailed design calculation, hourly radiation data for a period of clear days in the warmest month is necessary. The period is considered to coincide with a period in which the maximum temperature and the coincident relative humidity occur. The traditional method of designing structures assumes that the maximum room-cooling loads and the maximum refrigeration load for air-conditioning occur simultaneously, but it should be noted that maxima of room-cooling load may actually occur in a period which is not coincident with maximum outside temperature.

In the absence of solar radiation data for the location, data may be taken from a similar locality at the same latitude. In the absence of collected data, calculated values can be applied from reference [32] or a similar reference.

The reflection from the sea surface may be taken as 20 % of the total radiation intensity.

Radiation heat gains from flare stacks should also be considered.

A.3.4 Internal environmental conditions

Two approaches may be used for the specification of internal environmental conditions. The traditional approach relies on the specification of absolute values established by experience or local regulation. An alternative approach based on a measurement of population acceptance is given in ISO 7730 [8]. The ISO method applies only to manned areas. Table A.2 gives guidance which may be used if the approach outlined in the ISO standard is not adopted.

It is also recommended that the relative humidity be kept between 30 % and 70 %. These limits are set in order to decrease the risk of unpleasant wet or dry skin, eye irritation, static electricity, microbial growth and respiratory diseases.

Sound attenuators should be located at points in the HVAC systems where they can control both break-out and break-in of sound. Typical positions are at plant-room walls prior to the ductwork leaving the room, and at duct entry into control rooms and other areas requiring low sound levels. Care should be taken when designing the

HVAC systems to allow for the poor sound absorption characteristics of many of the areas served. As all spaces except the cabins and public areas are acoustically 'live', little attenuation of HVAC noise by the space is likely to occur.

Outdoor air inlets and outlets should be attenuated to a value where they do not exceed the local predicted background level by 5 dB or exceed NR 55 at a distance of 3 m from the outlet, whichever is the more onerous.

Sound power generated by, or transmitted through, the HVAC systems should not contribute to exceeding the levels stated in local regulations, recognized standards or the guidance given in Table A.2. An analysis should be performed to demonstrate the noise and vibration contribution from the HVAC system.

Where sound attenuators are required in the LQ, galley and laundry extract systems, they should be suitably designed to reduce the risk of grease/lint accumulation and subsequent fire hazard.

Sound attenuators should not be fitted in the shale shaker or mud tank extract systems, where excessive airborne dirt would nullify their effectiveness.

Table A.2 — Recommended indoor environmental conditions

Description	Examples	Minimum temperature °C	Maximum temperature °C	HVAC noise limit dB (A)	Comments
Manned areas – sedentary work	Control room Radio room	19	24	45	
Living quarter areas	Recreation areas Cabins	19	24	40	
	Dining room	19	24	50	
	Corridors/toilets Laundry Stores/galley	16	25	50	
	Plant-room Switch-room	10	35	65	
	Temporary LQ and Offices	19	24	40	
	Drystore Gymnasium	16	21	50	
	Sick bay	21	25	40	A room controller should allow adjustment of room temperature to a max. of 25 °C when outside min./max. design temp. are prevalent
Light manual work	Laboratories	18	24	50	
	Stores Workshops	16	24	60	
Unmanned without electrical equipment	Utilities module	5	35	80	
Unmanned with electrical equipment	Switch-rooms	5	35	70	As an option to cooling, heat may be provided to limit humidity to 80 %
Equipment rooms with temperature-critical instruments	Battery rooms	15	35	70	25 °C maximum may be determined by the use of some regeneration batteries

A.4 Guidance to 5.2.4

The major consideration in installation layout and ventilation philosophy is likely to be risk, whether it be measured in terms of potential harm to the individual, asset or the environment. Quantitative Risk Analysis (QRA) may be undertaken to evaluate the risk benefits of alternative layout arrangements during the option-selection phase, and HVAC engineers may be expected to contribute to the modelling of smoke and gas releases as part of the decision-making process.

Production areas generally should be ventilated by natural means where possible, as this is the least complex and most reliable method. However, effective temperatures, resulting from wind chill or heat exhaustion, should be determined to establish the effects on personnel operating efficiency (where personnel are required to work in thermally uncontrolled areas) and equipment, and consequently the extent of any required protection.

Fully open modules provide the ideal arrangement for natural ventilation. If weather protection is required, it can be provided in the form of weather louvres. The performance of properly designed weather louvres is superior to alternative forms of weather protection.

Alternative forms, utilizing open slots or perforated sheets, may be suitable but are unlikely to create a good diffusion effect and may not contribute significantly to moisture removal. Increased resistance to airflow and diffusion may dictate the need for additional mechanical ventilation.

In hot climates, roofing or other protection may be provided instead of mechanical ventilation.

Mechanical ventilation should be used when ventilation by natural means is unable to satisfy requirements.

Powered systems should operate satisfactorily in wind conditions varying from still air to design wind velocity and plant margins should be included in the design or fans conservatively sized in order to ensure the requirements are met during adverse wind effects.

Free cooling, i.e. cooling by outside air is preferred to cooling by refrigeration, where practical. In some parts of the world it may be practical and energy efficient to use seawater cooling, for which further guidance is given in clause B.4. Environmental data from project locations should be used to determine available free-cooling potential, and should be verified to ensure that temperature differentials, normally too low to allow margin for error, are correct. Assumed differentials are not acceptable. It is, however, accepted that space temperatures may exceed design maximum for short periods during peak outside conditions. Designs should ensure that ventilation air is provided to control heat gains from personnel, equipment and heat transmitted through the walls of the space(s) served. The practicality of free cooling is always likely to be marginal, and hence validation of cooling levels is particularly important. Heat gains from fans, fan motors and conduction into the ductwork should be particularly included in the cooling-load calculations, as experience demonstrates that underestimation of resultant system temperature rise is a common problem.

Consideration should be given to the removal of residual heat from equipment that has ceased operation.

It may be necessary, where heat gains are excessive, to use room air-conditioning units mounted within, or local to the space(s) served, such as control centres, switch-rooms, telecommunications/electronic equipment and radio rooms.

Drilling facilities, such as shale shaker and mud tank areas/modules, should have an air change rate determined by the air quantity required for the extraction of fumes, heat and dust, and will of necessity require outside air supply to meet the extract air requirements of the tanks and shakers. Under normal circumstances, these requirements are met by a powered supply system to provide adequate air distribution to the general space. The exception to this requirement is where the modules are of a semi-open nature, where air can be drawn in from a variety of openings. Under these circumstances natural ventilation can be used for make-up.

The design of HVAC systems in drilling facilities is discussed in more detail in clause A.16.

A.5 Guidance to 5.2.5

A.5.1 General

The philosophy outlined in this subclause is representative of good practice on large, integrated installations, and may not be appropriate to very small installations and those that are not normally manned where HVAC is not considered to have a role in asset protection.

The systems should be integrated into the overall monitoring and safety systems of the installation, and should be provided with controls for normal and emergency operations which should be within, or readily accessible from, a normally manned central location, usually the Central Control Room (CCR).

Decisions regarding the extent of manual control should be made early in design development. Depending on the manning and operating philosophies, the cost of additional signal capacity to HVAC panels and the consequence of failure to act, it may not be considered necessary to take some indication back to the HVAC panel and annunciate automatic alarms. Examples are "filter dirty" indication and alarms, and humidity indication and alarms.

All controls and indicators serving similar types of equipment should be grouped in a logical sequence, either in a dedicated HVAC-panel or integrated with a central Control and Monitoring System (CMS).

Where this is not practical, panels local to HVAC plant may be installed. In all cases a common alarm should be indicated at the F&G panel in the CCR. In addition, fire/gas damper status should be indicated at the F&G panel in the CCR as a minimum.

Control panels supplied as part of packaged equipment should be interlocked with either central or local HVAC panels.

The HVAC shutdown philosophy is an essential part of the Installation ESD and F&G philosophies. It is therefore important that the HVAC shutdown philosophy be determined early in design development. Where mechanical ventilation systems are installed, careful attention should be paid to their operation and/or shutdown in conjunction with fire and gas detection and protection systems. The nature of the shutdown philosophy related to fire detection may vary among different operators and among different statutory regulators. Two alternative HVAC shutdown philosophies for a large integrated offshore installation are described below.

A.5.2 Philosophy 1

In the event of a gas release, the objectives are to dilute and remove the resulting gas cloud and limit migration to other areas. The strategy to achieve this is normally to

- keep the HVAC system running upon detection of gas within a hazardous area in order to dilute and remove the gas;
- isolate the HVAC system upon detection of gas in an HVAC inlet, since it is assumed that the gas is being drawn in from other areas;
- isolate the HVAC system to a nonhazardous area upon detection of gas in the inlet to or within the nonhazardous area, since it is assumed that the gas is being drawn in from other areas.

In the event of a fire, the ventilation system should keep on running and thereby

- reduce the pressure build-up and thereby reduce the spread of smoke;
- secure evacuation from the area and possible manual fire-fighting.

This philosophy is based on a system design where the prevention of fire and smoke spread is built into the design from the initial phase. The following design parameters should therefore be incorporated:

- a) displacement ventilation provided with supply at low levels and extract at high levels;

- b) assessment should determine whether duct penetrations through area fire-barriers should be fire-rated or provided with fire dampers. The fire rating of the penetration and any associated fire damper should be at least equal to that of the boundary it penetrates;

NOTE For installations designed to IMO/MODU Codes, this may be mandatory.

- c) fire dampers which are automatic fail-safe by release of a local heat-detection device;
- d) manual/remote operation of fire dampers;
- e) fans powered from sources which will function at such times.

A.5.3 Philosophy 2

In the event of a gas release, the objectives and the strategy to achieve this are normally the same as for philosophy 1, but in the event of a fire the area should be isolated in order to

- limit the spread of the fire;
- limit the supply of combustion air to the fire;
- reduce the movement of smoke to other areas where it may impede emergency response.

Mechanical HVAC presents a path for any of the above and should therefore incorporate the following.

- a) Assessment should determine whether duct penetrations through area fire barriers should be fire rated or provided with fire dampers. The fire rating of the penetration and any associated fire damper should be at least equal to that of the boundary it penetrates.

NOTE For installations designed to IMO/MODU Codes, this may be mandatory.

- b) Fire dampers should automatically close and, where appropriate, HVAC should shut down manually or automatically, to isolate an area upon detection of fire in the area.
- c) Boundary fire dampers for enclosed TR facilities should automatically close upon detection of smoke at the HVAC inlet or a fire in any area where there may be a risk of smoke impingement upon the TR facility. Consideration may be given to the installation of smoke-control systems.

To pre-empt gas or smoke ingress to HVAC ducts, it is recommended that these actions with respect to LQ/TRs are also coincident with any planned shutdown of the process facilities.

A.5.4 Control and monitoring — Normal operation

A.5.4.1 Dedicated and integrated HVAC panels

All controls and indicators serving similar types of equipment should be grouped in a logical sequence. A typical arrangement for a large, integrated installation is as follows:

a) **Controls**

Start	All fans
Stop	All fans
Automatic changeover switch with selector	For each run/standby fan set (including shut-off dampers)
Open + Close	All fire/gas dampers, as required by the F&G philosophy

b) Indicators

Run	All fans
Stop	All fans
Tripped	All fans
Filter dirty	Each filter (not separate vane sections)
On/tripped	Each heater
Lamp test	
On/tripped	Each package equipment item
Open	Each fire/gas damper protecting fire-rated bulkheads or providing boundary isolation to a TR
Close	Each fire/gas damper protecting fire-rated bulkheads or providing boundary isolation to a TR
Loss of pressurization	Any area requiring pressurization, and each gas turbine hood

c) Alarms

A common alarm indication should be provided to a normally-manned control location for the following:

- fan trip;
- heater trip;
- filter dirty;
- package equipment trip;
- loss of pressurization;
- fire/gas damper operating-mode failure.

A.5.4.2 Local control of fans

A manual on/off station should be provided local to each fan.

Extract fans serving local fume-producing activities or equipment, such as welding and paint-spraying booths or positions and fume cupboards, should be provided with start/stop control, complete with run indication, local to the equipment or working position.

A.5.4.3 Fire/gas damper controls

Control of the actuators should be through a signal from one or more of the following four sources:

- remote manual operation;
- local manual operation;
- automatic closure by the installation of a fire- and gas-detection panel;
- automatic fail-safe by release of a local heat-detection device.

Where several fire/gas dampers serve an area module, they should be grouped such that automatic operation of any one should automatically initiate operation of all the others.

Local, remote, manual or automatic functioning and interlocks should be based on an area safety assessment.

A.5.4.4 Loss of differential pressure

Differential pressure between areas requiring such protection should be alarmed when the differential reduces to a predetermined level that is deemed inadequate to maintain protection.

In each nonhazardous area adjacent and connecting to a hazardous area, each extract fan should be prevented from starting until its associated supply fan run-up velocity has been reached and the supply shut-off damper has opened. Failure of a supply fan should stop its associated extract fan, but failure of an extract fan should not stop its associated supply fan.

A time delay should be incorporated to minimize the nuisance value associated with door opening.

A.5.4.5 Temperature control

Duct- or unit-mounted water/steam heat exchangers (heating and cooling coils) should be automatically temperature-controlled by a duct- or room-mounted sensor modulating a heating-medium proportional controller.

Uncontrolled seawater heating/cooling coils may alternatively be considered.

Duct-mounted electric heaters should be controlled using either one- or two-step direct-switching thermostats or contactors or thyristors.

Appropriate thermal protection and interlocks for safe maintenance should be provided.

All unit heaters should have hand-operated on/off fan control. Additionally, electrically heated units should be complete with integral automatic supply and upper limit temperature controls.

Where a HVAC system employs both heating and cooling duct-mounted coils, controls should be interlocked to ensure complementary operation.

Outdoor-air and recirculation dampers, where fitted, should be automatically controlled by external ambient and recirculation air temperature sensors, and should be fixed such that sufficient outdoor air is introduced as given in clause A.2. An override facility should be provided within the HVAC control system, to supply full outdoor air if smoke is detected in occupied spaces.

Where heaters are used in a hazardous area, the heater coil temperature should not exceed the T-rating for the area as specified in IEC 60079-0 [14].

A.5.5 Control and monitoring — Emergency conditions

The HVAC-systems should receive signals from the ESD/F&G/manual trips consistent with the selected shut-down and tripping philosophy.

Once stopped, the fans should be prevented from being re-started until the hazard has been cleared and the signal has been reset through the ESD/F&G systems.

Upon total loss and subsequent reinstatement of electrical power, the HVAC systems should be restarted in accordance with the initial 'start-up' procedure.

Black-start ventilation should be achieved initially by natural ventilation and secondly by portable fans. The main ventilation plant should be made operational as a matter of priority.

It may be necessary for HVAC cooling equipment serving the CCR, emergency switch-rooms, telecommunications/electronic equipment and radio operator's room to be connected to the emergency electric power supply so that they may continue to operate during an emergency, consistent with the TR philosophy. The need for space cooling depends on the rate of temperature rise due to electrical/electronic equipment heat. Emergency-powered cooling should be provided only when maximum operating-space temperatures or the permissible "heat stress" is exceeded within the required emergency operating period. It should be recognized that equipment heat dissipation during an emergency may be significantly less than under normal circumstances.

Where room air conditioners are installed and are required to operate to provide cooling during emergencies, they should only recirculate air. Outside air should normally be supplied from the central system and should be isolated in emergencies through fire/gas damper operation.

All externally-mounted electrical components, such as air-cooled condensers, which are required to operate in an emergency should be suitable for zone 1.

A.6 Guidance to 5.2.6

The functional requirements can be achieved by giving consideration to

- installed cost of a component or system;
- reliability under continuous running or intermittent use, and the consequence of failure;
- simplicity of design and operation;
- standardization of components and holding of spares;
- ease of maintenance and consideration of access, special tools;
- criticality of key components in normal or emergency conditions.

Equipment normally operates continuously, but there will be times when it is idle or operates intermittently. The design should provide for these variations.

Where a system and equipment are designed for continuous operation, consideration should be given to the "sparing" philosophy. Sparing of equipment is preferred to minimize down-time and improve the availability of essential services. This need is normally served by providing all fans as duplicate sets giving a specified level of standby, with the exception of those extract units serving non-essential services. It may however be practicable to adopt a single, 100 % supply fan philosophy if the economics of production shutdown have been fully evaluated. Similarly, the adoption of 2×50 % supply fans and 1×100 % extract fan may be acceptable on some supply and extract systems, if contingency plans for breakdowns have identified the consequences of changes in differential pressure, the likelihood of rapid repair and the availability of alternative means of ventilation.

On duplex fan systems, dampers should be provided on each fan to prevent backflow and facilitate maintenance. Controls should ensure that damper opening and closure is coincident with associated fan operation.

Central refrigeration plant should have a specified level of standby to provide adequate cooling capacity where loss of cooling cannot be tolerated.

One objective of equipment selection should be to reduce spares stock quantities and to incorporate maximum standardization of components to enable interchangeability between all HVAC systems on an installation. Special attention may need to be paid to air filters and other consumables. To achieve standardization certain equipment may be upgraded or increased in size.

Due to the high cost of maintenance and the need for operational availability, the system should be designed to maximize intervals between maintenance periods and the emphasis should be placed on maintenance on a predictive rather than run to failure basis. Consideration should be given to the adoption of a condition-monitoring philosophy. Long-term reliability of components, materials and systems is essential, and particular attention should be given to life-cycle costs.

Plant should be well placed for ease of maintenance in order to ensure better overall reliability. Lack of withdrawal space inevitably increases maintenance costs and should be avoided. The following general principles should be followed.

- a) Plant and equipment should be floor-mounted wherever possible;
- b) plant and equipment should have good access for maintenance purposes;
- c) permanent access platforms should be provided for all items of equipment requiring regular maintenance or inspection, where adequate access from floor level is not possible;
- d) ample head room and good lighting should be provided;
- e) ample withdrawal/removal space should be provided for all items of plant and equipment;
- f) designs should include provision for lifting and handling of plant and components during construction/maintenance.

All components requiring regular servicing should have removal and maintenance space envelopes developed and coordinated with other disciplines. Ideally, withdrawal and maintenance spaces should be common. These envelope drawings should indicate the position and test loads of all lifting points, and the actual withdrawal route. Routes for large items should be developed to crane-lift points or laydown areas.

In order to avoid problems during hook-up and subsequent maintenance, no part of any system requiring maintenance should overhang the sea.

A.7 Guidance to 5.2.7

Of the potential sources of corrosion on an installation, the following have the largest impact on HVAC:

- a) drilling chemicals in dust, paste and liquid forms;
- b) galvanic attack;
- c) products of combustion;
- d) salt aerosols.

Materials listed in item a) are mainly concentrated around drilling storage areas, but they are carried as wind dusts to surrounding areas following release from storage tank vents and dump chutes.

Items b), c), and d) occur throughout the installation.

The consequences of corrosion can be reduced by philosophies which:

- minimize opportunity through control of environment, e.g. through control of humidity, effective filtration, etc.;
- specify inherently corrosion-resistant materials;
- make use of corrosion-resistant coatings; or
- use corrosion allowances to extend the period before replacement.

Stainless steels are usually preferred as a means of minimizing corrosion. Other materials such as aluminium and composite offer weight savings and corrosion-resistant capabilities, but it should be recognized that the temperature of sparks from aluminium may be above the auto-ignition temperature of certain hazardous gases.

For short lifetimes, as for example on upgrade or refurbishment work, it may be cost-effective to adopt mild steel specifications for ductwork, etc., but in most areas of the world experience indicates that technical advances extend planned life longer than designers anticipate, with the result that high maintenance and replacement costs are incurred which could have been avoided by a more conservative, but expensive, choice of materials at the outset.

Coating of mild steel components offers a potential savings over stainless steel (for example in fan impellers), but coatings can suffer damage, thereby giving rise to potential for out-of-balance problems, and therefore materials and components made from inherently non-corroding materials are usually preferred.

The specification of ductwork in mild steel which is painted or galvanized after fabrication may, depending on local market conditions, prove more cost-effective than thinner stainless steel. Additionally, offshore construction of HVAC systems seldom involves an accuracy which removes the need for construction tolerances, and the additional work associated with on-site alteration of stainless steel components should not be overlooked. Good design should avoid the requirement for on-site alterations by "designing in" potential adjustment on site.

All items likely to suffer from corrosion prior to being made operational should be protected to ensure that they are in satisfactory condition at the time of mechanical completion. This applies to minor components, such as fire damper bearings, just as much as to larger packaged items.

Consideration should also be given to the sparking potential of components, particularly fans, naval brass or leaded brass rubbing rings and plates fitted to the casing, belt guard and impeller.

A.8 Guidance to 5.2.8

Evaluation of the ductwork system resistances and interaction of supply and extract systems with respect to room pressures and wind effects can be calculated manually or by a suitable computer program endorsed by either CIBSE, ASHRAE or a similar recognized authority. The calculations should be revised and updated as finalized discipline information and wind tunnel tests, etc., become available.

Fans should be selected to operate on the steep part of their performance pressure/volume curve to ensure minimal volume fluctuations during adverse wind conditions. The operating point used should be at the required volume, as determined by the basis of design, with the pressure loss based on the actual system resistance, filters being taken at their average pressure drop, plus any pressurization load that may be required in nonhazardous modules.

The accumulation of individual equipment operating margins should not form the basis of the overall system design. The purpose of including these margins is to ensure flexibility in the duty of peripheral equipment, rather than gross oversizing of fan duties.

If the designer is convinced that a margin is required, he should demonstrate that he has taken into account

- the stage of the design and the confidence in the ductwork routing and air volumes;
- the sensitivity of adding margins to the design with respect to the required motor size, i.e. the doubling of small motor sizes is unlikely to create a problem, where as the same approach on large motors may alter the size of generators, cabling and switchgear.

The performance of the combined supply and extract system should then be checked for adverse wind conditions. A value of design wind velocity consistent with that given in A.3.1 should be used, with the effect being calculated using a computer-aided engineering package recommended by ASHRAE, CIBSE or similar authority. This load will produce both positive and negative effects on the system pressure loss, resulting in variations in the supplied volume and module pressure. It should not be assumed that these changes are detrimental to the total safety of the system performance before first fully analysing their consequences. The influence on adjacent modules should be evaluated, along with the effect of the changes in infiltration. Variations in the process performance should also be considered, as they may affect heat gains and fugitive gas leaks to the space.

Where practical, the fan and motor should be selected to cater for capacity changes to compensate for system deterioration and possible modifications to the distribution duct routes (e.g. by using different belts and pulleys, adjusting inlet guide vanes or varying motor velocity).

Where duty/standby fans are required, they should be selected so that they are capable of starting against a 5 % backdraught volume. Depending on the arrangement and quality of the run and standby shut-off dampers, a margin of up to 5 % should be added to the fan design duty.

The final selection should be checked for wind gusts producing velocities with a probability of exceedance of 0,1 %, to ensure the systems will naturally recover after these adverse effects.

Small-volume fans require special consideration. For example, a system resistance should not double as a consequence of the addition of the wind load. The use of cowl-type inlets and outlets should be considered to mitigate the effects of wind loading. Components such as filters and attenuators, along with ductwork, should be increased in size to reduce the system resistance; in other words the system should be designed around a practical fan selection. This approach ensures good fan efficiency, thereby reducing the generated noise, vibration and power requirements.

A.9 Guidance to 5.2.9

A.9.1 General

CFD and wind-tunnel modelling are powerful tools to help design safer and cheaper installations. However, it is important to remember that the application of wind tunnel and CFD models to the goal is never routine. They are bespoke techniques requiring careful implementation by experts. CFD and wind tunnels give the wrong results if not properly applied. In particular, the results of wind tunnel and CFD models should always be accompanied by a clear statement of validation and of the uncertainties: are the results correct within $\pm 10\%$, 100 % or an order of magnitude? Without this, the information is of limited use. The following subclauses provide advice on the use of wind-tunnel models and CFD.

A.9.2 Wind-tunnel modelling

For external flows, the model scale should not be less than 1:150 and the model cross-section should be small compared to the wind tunnel cross-section (i.e. blockage by the model $< 10\%$). The use of scale models built for other purposes, such as display, is not acceptable because the model will not have the appropriate surface roughness height. Smooth poly(methyl methacrylate) models are not acceptable for the same reason. The model should have the main structural features of the installation. The finer detail (0,5 m and less) can be modelled by surface roughness elements. The roughness should be estimated from the details of the particular installation in question.

NOTE Further information on the rules for surface roughness is contained in reference [42].

The model Reynolds number should (conservatively) exceed 10 000 for sharp-edged platform structures of interest, such as the Temporary Refuge. For full-size circular-section structures where the Reynolds number is less than 1 000 000, the rule above applies. If the full-size Reynolds number exceeds 1 000 000, then it is not possible to model these as accurately. If the results of the wind-tunnel testing are strongly dependent on these structures, then the results should be treated with extra caution.

For internal flows or situations where there is a coupling between the internal and external flows, such as in well-ventilated modules, wind-tunnel models representing the entire facility are in many cases not appropriate. This is discussed further in A.9.4.

In smoke tests, concentrations at the points of interest should be measured and not estimated from video footage. Correction of the measured values to allow for the flame extension and smoke evolution point should be applied. The Froude number, buoyancy and the relative velocity between the free stream and the fire efflux rate should equal the full-scale values.