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Petroleum and natural gas industries –
Offshore production installations –
Heating, ventilation and air-conditioning (ISO 15138:2018);
English version EN ISO 15138:2018

Industries du pétrole et du gaz naturel –
Plates-formes de production en mer –
Chauffage, ventilation et climatisation (ISO 15138:2018);
Version anglaise EN ISO 15138:2018

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Nationales Vorwort

Dieses Dokument (EN ISO 15138:2018) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“, Unterkomitee SC 6 „Processing equipment and systems“, in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ erarbeitet, dessen Sekretariat von NEN (Niederlande) gehalten wird.

Für Deutschland hat hieran der Arbeitskreis NA 109-00-01-06 AK „Verfahrenstechnische Anlagen und Ausrüstungen“ im DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) mitgearbeitet.

Diese Europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung von EN ISO 15138:2018 und ISO 15138:2018.

Für die in diesem Dokument zitierten internationalen Dokumente wird im Folgenden auf die entsprechenden deutschen Dokumente hingewiesen:

ISO 7235	siehe	DIN EN ISO 7235
ISO 8861	siehe	DIN EN ISO 8861
ISO 12241	siehe	DIN EN ISO 12241
ISO 12499	siehe	DIN EN ISO 12499

Änderungen

Gegenüber DIN EN ISO 15138:2008-07 wurden folgende Änderungen vorgenommen:

a) Anpassung des Anwendungsbereiches;

b) normative Verweisungen wurden hinzugefügt;

c) die Durchführung von Windtunneltests wurde aus den Anforderungen gestrichen, siehe 5.2.1.3;

d) die Beschreibung von Organisationen mit Datenbanken mit meteorologischen Informationen wurde gestrichen, siehe 5.2.3.3.1;

e) der Einsatz von Schalldämpfern ist nur unter bestimmten Bedingungen zulässig, siehe 5.2.3.3.4;

f) neue normative Verweisung für die Anforderungen für den Schutz von nicht-gefährlichen Räumen mit Zugang zu gefährlichen Räumen, siehe 5.2.5.3.3.4;

g) einige Anforderungen zu Lüftern wurden gelöscht, siehe 5.2.8.3;

h) Anforderungen für die Konstruktion und Prüfung von Wohnquartieren, Zufluchtsorten und Druckbereichen wurden hinzugefügt, siehe 5.3.2.3.2;

i) Anforderungen zu LQ-Modulen wurden gelöscht, siehe 5.4.2.3.6;

j) Anforderungen zu Brandschutzklappen wurden hinzugefügt, siehe A.9.2.1;

k) Anforderungen für die Konstruktion von Luftbehandlungsgeräten wurden hinzugefügt, siehe A.12.2.1;

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l) Anforderungen für die Zwischenüberhitzer mit konstantem Volumen wurden geändert, siehe A.14.2.1;

m) Anforderungen für die Verbindungsstücke wurden hinzugefügt, siehe B.1.1;

n) redaktionelle Überarbeitung;

o) Literaturverzeichnis aktualisiert.

Frühere Ausgaben

DIN EN ISO 15138: 2003-05, 2008-07

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Nationaler Anhang NA
(informativ)

Begriffe und Abkürzungen

Die Benummerung der folgenden Begriffe und Abkürzungen ist identisch mit der Benummerung in der englischen Fassung.

3 Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

ISO und IEC stellen terminologische Datenbanken für die Verwendung in der Normung unter den folgenden Adressen bereit:

— ISO Online Browsing Platform: unter http://www.org/obp

— IEC Electropedia: unter http://www.electropedia.org/

3.1
aktives System
System, das von spannungsführenden Bauteilen abhängig ist

3.2
Luftverdrängungseinheit
Zufuhrvorrichtung für Luftbewegung im Raum durch kolben- oder stopfenförmige Bewegung

Anmerkung 1 zum Begriff: Bei einem optimalen Verdrängungsstrom vermischt sich die Raumluft nicht, was für das Entfernen von Schmutzpartikeln in einem Raum vorteilhaft ist.

3.3
flüchtige Emission
andauernde Emission auf molekularer Ebene aus allen potentiellen Lecks einer Anlage unter normalen Betriebsbedingungen

Anmerkung 1 zum Begriff: Aus praktischen Erwägungen kann eine flüchtige Emission als Emission ausgelegt werden, die weder durch Sicht, Gehör oder durch Berührung, sondern mit Blasenprüfungen oder Prüfungen mit ähnlicher Empfindlichkeit festgestellt werden kann.

3.4
offene Fläche
Fläche im Freien, auf der Dämpfe schnell vom Wind auseinandergetrieben werden

Anmerkung 1 zum Begriff: Die typischen Luftgeschwindigkeiten liegen auf solchen Flächen selten unter 0,5 m/s und häufig über 2 m/s.

3.5
passives System
System, das nicht von spannungsführenden Bauteilen abhängig ist

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3.6
Not-Zufluchtsort
TR
(en: temporary refuge)
Stelle, an der die Besatzung für eine zuvor bestimmte Dauer Schutz finden kann, während Untersuchungen, Notfallreaktionen und die vorläufige Planung einer Evakuierung durchgeführt werden

3.7
Stagnationsbereich
Bereich mit unzureichender Lüftungsrate

4 Abkürzungen

AC/h	Luftwechsel pro Stunde (en: air changes per hour)
AHU	Luftbehandlungsgerät (en: air handling unit)
AMCA	Internationale technische Prüforganisation für lufttechnische Geräte und Anwendungen (en: Air Movement and Control Association Inc.)
API	Interessenverband der Öl- und Gasindustrie einschließlich der petrochemischen Industrie in den USA (en: American Petroleum Institute)
ASHRAE	Berufsverband aller in Heizungs-, Kühlungs-, Lüftungs- und Klimaanlagenbau Tätigen in den USA (en: American Society of Heating, Refrigerating and Air-Conditioning Engineers)
BS	Britische Norm (en: British Standard)
CCR	Hauptkontrollraum (en: central control room)
CFD	Numerische Strömungsdynamik (en: computational fluid dynamics)
CIBSE	Berufsverband der Gebäudetechnikingenieure (en: Chartered Institution of Building Services Engineers)
CVU	Anlage mit konstantem Volumen (en: constant-volume unit)
D&ID	Kanal- und Instrumentierungsdiagramm (en: duct and instrumentation diagram)
DX	Direktexpansion (en: direct expansion)
EN	Europäische Norm (en: European Standard)
ESD	Notabschaltung (en: emergency shutdown)
F&G	Feuer und Gas (en: fire and gas)
GWP	Treibhauspotential (en: global warming potential)
HSE	Gesundheit, Sicherheit und Umwelt (en: health, safety and environment)
HVAC	Heizung, Lüftung und Klimatisierung (en: heating, ventilation and air conditioning)
HVCA	Verband der Heizungs- und Lüftungsbauer (en: Heating and Ventilating Contractors' Association)

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IACS	Internationaler Verband der Klassifikationsgesellschaften (en: International Association of Classification Societies)
IEC	Internationale Elektrotechnische Kommission (en: International Electrotechnical Commission)
IMO	Internationale Seeschifffahrtsorganisation (en: International Maritime Organization)
IP	Institut für Erdöl (en: Institute of Petroleum)
LQ	Mannschaftsräume (en: living quarters)
MODU	Bewegliche Offshore-Bohreinheit (en: mobile offshore drilling unit)
NFPA	Nationale Feuerschutzvereinigung (en: National Fire Protection Association)
NS	Norwegische Norm (en: Norsk Standard (Norwegian Standard))
TR	Not-Zufluchtsort (en: temporary refuge)

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Nationaler Anhang NB
(informativ)

Literaturhinweise

DIN EN ISO 7235, *Akustik — Labormessungen an Schalldämpfern in Kanälen — Einfügungsdämpfung, Strömungsgeräusch und Gesamtdruckverlust*

DIN EN ISO 8861, *Schiffbau — Maschinenraum-Lüftung auf Schiffen mit Dieselmotoren-Antrieb — Grundlagen für Entwurf und Auslegung*

DIN EN ISO 12241, *Wärmedämmung an haus- und betriebstechnischen Anlagen — Berechnungsregeln*

DIN EN ISO 12499, *Industrieventilatoren — Mechanische Sicherheit von Ventilatoren — Berührungsschutz*

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This European Standard was approved by CEN on 23 May 2018.

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European foreword

This document (EN ISO 15138:2018) has been prepared by Technical Committee ISO/TC 67 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” in collaboration with Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by NEN.

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 January 2019, and conflicting national standards shall be withdrawn at the latest by January 2019.

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

This document supersedes EN ISO 15138:2007.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 15138:2018 has been approved by CEN as EN ISO 15138:2018 without any modification.

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, SC 6, *Processing equipment and systems*.

This third edition cancels and replaces the second edition (ISO 15138:2007), which has been technically revised.

The main changes compared to the previous edition are as follows:

— minimum and maximum temperatures have been added to 5.2.3.3.4 below Table 2 for clarification;

— a requirement for black start has been added to 5.3;

— requirements for the specific areas stairways/escape routes and air locks have been added to 5.4;

— phase-down and phase-out of high and medium global warming potential (GWP) refrigerants are addressed in 5.4;

— a reference to new filtration standard and note for chemical filtration have been added to Table A.1;

— fail safe criteria for fire damper for safety critical areas have been added to Clause A.9;

— requirements for duct earthing have been added to B.1.1;

— the datasheet for DX cooling coil has been updated with electronic expansion valve;

— the datasheet for heating coils has been updated with data for self-generated noise.

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

1 Scope

This document specifies requirements and provides guidance for the 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 that are

— new or existing,

— normally occupied by personnel or not normally occupied by personnel, and

— fixed or floating but registered as an offshore production installation.

This document is normally applicable to the overall facilities. For installations that can be subject to "Class" or "IMO/MODU Codes & Resolutions", the user is referred to HVAC requirements under these rules and resolutions. When these requirements are less stringent than those being considered for a fixed installation, then it is necessary that this document, i.e. requirements for fixed installations, be utilized.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7235, *Acoustics — Laboratory measurement procedures for ducted silencers and air-terminal units — Insertion loss, flow noise and total pressure loss*

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

ISO 12241, *Thermal insulation for building equipment and industrial installations — Calculation rules*

ISO 12499, *Industrial fans — Mechanical safety of fans — Guarding*

ISO 14694:2003, *Industrial fans — Specifications for balance quality and vibration levels*

ISO 21789, *Gas turbine applications — Safety*

IEC 60079-0, *Electrical apparatus for explosive gas atmospheres — Part 0: General requirements*

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

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

IEC 61892-7, *Mobile and fixed offshore units — Electrical installations — Part 7: Hazardous Areas*

EN 1751, *Ventilation for buildings — Air terminal devices — Aerodynamic testing of dampers and valves*

EN 1886, *Ventilation for buildings — Air handling units — Mechanical performance*

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EN 50272-2, *Safety requirements for secondary batteries and battery installations — Part 2: Stationary batteries*

API RP 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Zone 0, Zone 1 and Zone 2*

IMO Resolution MSC 61(67): Annex 1, *Part 5 — Test for Surface Flammability*

IMO Resolution MSC 61(67): Annex 1, *Part 2 — Smoke and Toxicity Test*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
active system
system that relies on energized components

3.2
air-displacement unit
supply device to achieve movement of air within a space in piston- or plug-type motion

Note 1 to entry: No mixing of room air occurs in ideal displacement flow, which is desirable for removing pollutants generated within a space.

3.3
fugitive emission
continuous emission on a molecular scale from all potential leak sources in a plant under normal operating conditions

Note 1 to entry: As a practical interpretation, a fugitive emission is one which cannot be detected by sight, hearing or touch but can be detected using bubble-test techniques or tests of a similar sensitivity.

3.4
open area
area in an open-air situation where vapours are readily dispersed by wind

Note 1 to entry: Typical air velocities in such areas are rarely less than 0,5 m/s and frequently above 2 m/s.

3.5
passive system
system that does not rely on energized components

3.6
temporary refuge
TR
place where personnel can take refuge for a predetermined period while investigations, emergency response and evacuation pre-planning are undertaken

3.7
stagnant area
area where the ventilation rate is less than adequate

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4 Abbreviated terms

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 Engineers
CVU	constant-volume unit
D&ID	duct and instrumentation diagram
DX	direct expansion
EN	European Standard
ESD	emergency shutdown
F&G	fire and gas
GWP	global warming potential
HSE	health, safety and environment
HVAC	heating, ventilation and air conditioning
HVCA	Heating and Ventilating Contractors' Association
IACS	International Association of Classification Societies
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
IP	Institute of Petroleum
LQ	living quarters
MODU	mobile offshore drilling unit
NFPA	National Fire Protection Association
NS	Norsk Standard (Norwegian Standard)
TR	temporary refuge

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5 Design

5.1 General

This clause provides requirements on all aspects of the design of heating, ventilation and air-conditioning (HVAC) systems for offshore installations for the petroleum and natural gas industries.

For requirements and guidance on air change rates and pressurization requirements, reference is made to classification codes for the specific project.

The HVAC systems form part of the safety services of the installation. The key functional requirements for HVAC systems applicable to all areas of the installation are as follows:

a) sufficient ventilation, heating and cooling capacity in all adverse weather conditions;

b) acceptable air quality in all adverse weather conditions;

c) reliable performance through concept selection, the design having the following features in decreasing order of importance:

   1) simplicity, with a preference for passive systems;

   2) inherent robustness by providing design margins for systems and equipment;

   3) fault/status indication and self diagnostics;

   4) sparing of systems and equipment;

   5) maintainability through testability, inspectability and ease of access.

The following additional requirements apply to specific areas in the installation to ensure their safety goals are met:

— maintain survivability in the TR by preventing ingress of potentially flammable gas-air mixtures through appropriate siting, isolation, pressurization, provision of multiple air-intake locations, sufficient number of air changes, gas detection and emergency power supply;

— prevent the formation of potentially hazardous concentrations of flammable gaseous mixtures in hazardous areas by the provision of sufficient ventilation and air distribution for the dilution, dispersion and removal of such mixtures, and contain such mixtures, once formed, through maintaining relative pressures, avoiding cross-contamination and providing dedicated systems for hazardous areas;

— prevent, through pressurization, the ingress of potentially flammable gas-air mixtures into all designated non-hazardous areas;

— maintain ventilation to all equipment and areas/rooms that are required to be operational during an emergency when the main source of power is unavailable;

— provide a humidity- and temperature-controlled environment as required in which personnel, plant and systems can operate effectively, free from odours, dust and contaminants, including smoke control.

These high-level goals are supported by the lower-level functional requirements that are stated later in the appropriate subclauses of this document.

Functional requirements for the development of a design basis for either a new project or major modification to an existing installation are the focus of 5.2. These requirements are related to the following:

— platform orientation and layout (5.2.1);

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— hazard identification and hazardous-area classification (5.2.2);

— environmental conditions (5.2.3);

— choice of natural or mechanical ventilation systems (5.2.4);

— development of the controls philosophy (5.2.5);

— operating and maintenance philosophy (5.2.6);

— materials selection (5.2.7);

— design margins and calculations (5.2.8);

— design development and validation using wind-tunnel testing or computational fluid dynamics (CFD) (5.2.9).

Ventilation may be natural (i.e. the wind) or mechanical or a combination of both. Throughout this document, 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 shall be progressed using the practices that are identified in this document, though it should be recognized that the design involves a process of iteration as it matures and does not happen as a sequential series of steps as is presented in this document for simplicity. The processes outlined here are equally applicable to major redevelopments of existing installations, but it can be necessary to make some compromise 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 can be significantly greater than for a new design.

The finalized basis of design may be recorded on datasheets such as those provided in Annex D.

The completed design shall be subject to hazard-assessment review. The hazard and operability (HAZOP) study technique may be used for this.

In 5.2, objectives are identified which establish the goals. Detailed requirements that enable the objectives to be achieved are outlined.

In 5.3, the fundamental choice in system design, i.e. between natural and mechanical methods of ventilation, is addressed.

In 5.4, the functional requirements associated with the design of HVAC systems for different areas of a typical offshore installation that require particular technical considerations due to their location and/or their function are given.

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 subclauses of this document that provide the necessary requirements.

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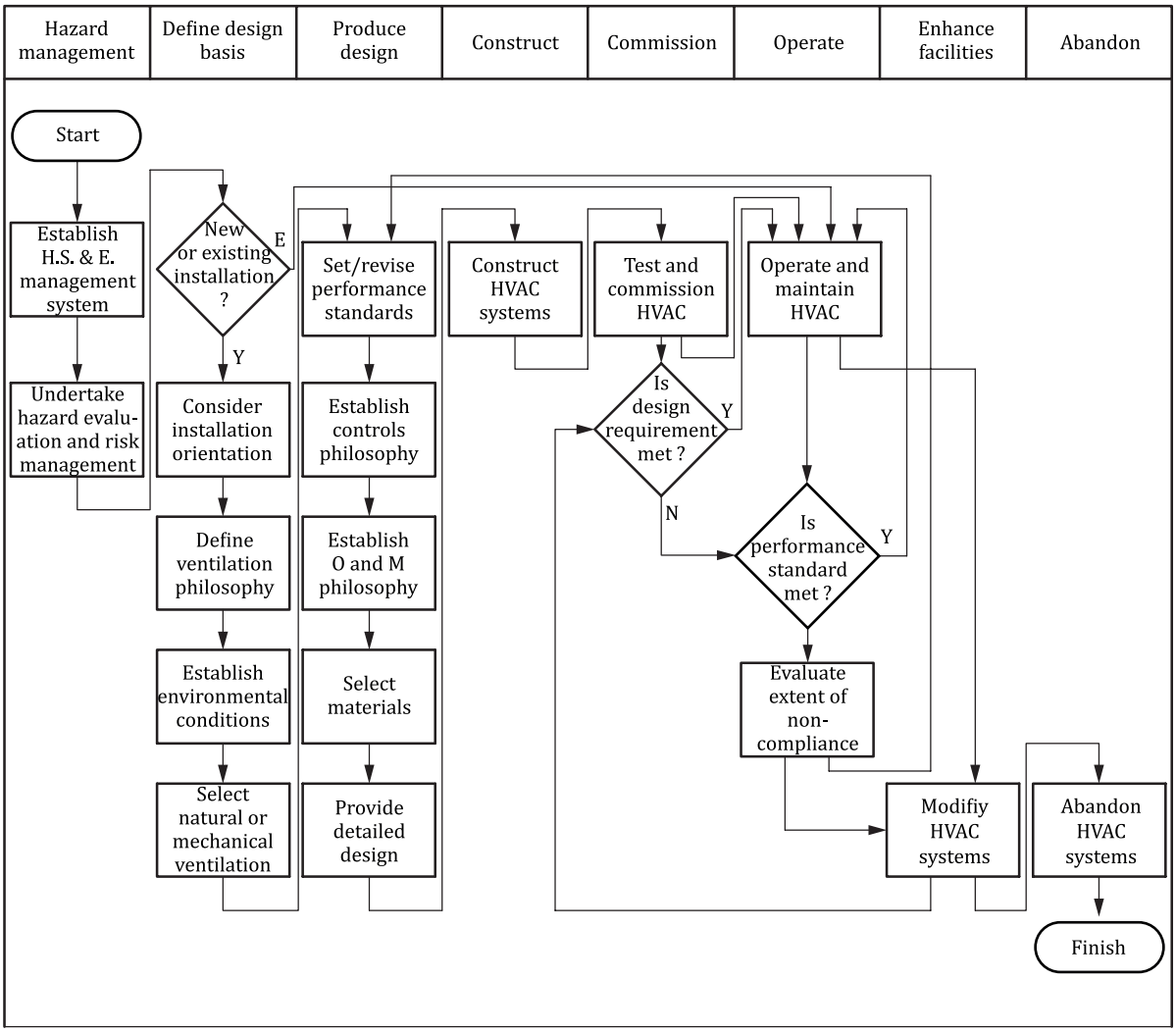

Figure 1 — Application of this document to a project life cycle

5.2 Development of design basis

5.2.1 Orientation and layout

5.2.1.1 Objective

The objective is to provide input into the early stages of design development so that areas and equipment that can 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 document to detail a platform-layout philosophy, but to identify areas where considerations of the role of HVAC, and requirements for it, can have an impact in the decision making surrounding installation orientation and layout.

Installations can have a temporary refuge (TR). The TR is in almost all cases the living quarters (LQ), where they are provided. The survivability of the TR, which is directly related to the air leakage rate

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can introduce consideration of active HVAC systems for pressurization of the TR 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 are 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 non-hazardous 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. The location of the air inlet shall also be evaluated for availability in emergency situations.

5.2.1.3 Detailed requirements

Results of wind-tunnel model tests or CFD calculations on the installations shall be used as a basis for determining the external zone(s) of wind pressure in which to locate the intake(s) and outlet(s) for the HVAC system(s). Particular care shall 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 can be classified as non-hazardous and have stable wind conditions. However, consideration shall 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. The air inlets/outlets shall be protected against the dynamic wind pressure.

Air intake and discharge from the same system on conventional installations shall, where reasonably practical, be located on the same face of the installation or in external zones of equal wind pressure. Particular care shall be taken in orienting air intakes and discharges on systems serving adjacent hazardous and non-hazardous areas, such that while the wind can affect the absolute values of pressurization in each area, the differential pressure requirements between them does not vary to a significant degree. For floating production systems (FPS), however, the downwind area can provide an appropriate intake location but it shall be positioned to avoid ingestion of smoke or contaminants and capable of operation in adverse weather (reference is also made to 5.3.2).

Air intakes shall 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,

— other ventilation systems, and

— supply and support vessels.

The positioning of the air intake and exhaust of gas turbines and generators requires careful consideration. They shall be located in a non-hazardous area and with consideration of the following points.

a) The air intake shall be located at 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

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100 year storm wave level). If enclosed, the intakes shall be located such that powder and dust are 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 shall be avoided and may be demonstrated by wind-tunnel tests or CFD. These tests shall also show that exhaust flue gas emissions do not interfere with helicopter, production, drilling and crane operations.

The party that initiates the project shall establish a maximum allowable air temperature rise above the surface of the helideck for helicopter operation.

Computer models are available to simulate hot- and cold-plume dispersion patterns and may be used to establish outlet positions.

5.2.2 Hazardous area classification and the role of HVAC

5.2.2.1 Objective

The objective is to adopt in the design and operation processes a consistent philosophy for the separation of hazardous and non-hazardous 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 for use in particular areas of the installation and also provides input to the performance standards for HVAC systems in those areas.

5.2.2.3 Detailed requirements

The application of a recognized hazard identification and assessment process can identify a requirement for the separation and segregation of inventories on an installation. Area classification codes specify separation distances between hazardous and non-hazardous areas in order to avoid ignition of those releases that 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 the “as safe as is reasonably practicable” approach to the 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 may be calculated from data in API 4589,[14] using the methodology given in API RP 505.

Areas shall be classified using the general guidance of IEC 60079-10. Specific guidance for classifying petroleum facilities can be found in documents such as EI 15 (2015) 4th version[33] and API RP 505.

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

— provide a suitable atmosphere for personnel and equipment,

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— remove excess heat, and

— provide an enhanced rate of ventilation to mitigate against the creation of a potentially explosive atmosphere.

5.2.3 Environmental conditions

5.2.3.1 Objective

The objective is to determine an environmental basis for the design of HVAC systems 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.

5.2.3.3 Detailed requirements

5.2.3.3.1 External meteorological conditions

The requirement for shelter shall be evaluated, which can reveal a subsequent need for an HVAC system.

The design of the HVAC systems shall take design codes into consideration. Conservative selection of criteria can carry a cost, mass and power penalty.

Seasonal extremes of temperature, humidity and wind speed vary widely throughout the world, and local regulations governing working conditions can also dictate the allowable extremes in occupied or unoccupied spaces. Local environmental information shall be specified in the basis of a design. This should not require the installation of additional capacity to accommodate the small proportion of the time during which meteorological extremes are encountered.

Sub-local effects on the external environmental conditions shall 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, shall 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 shall be given to the nature of the work (sedentary or physical) being undertaken.

The selected data source shall be acceptable to the party that initiates the project.

The following provides typical data that may 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 being exceeded;

— minimum temperature: 98 % probability of being exceeded;

— design wind speed: 1/12th year — 1 h mean velocity at a reference height of 10 m;

— maximum wind speed: maximum 1/12th year — average 3 s gusts at the height of equipment.

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

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

Table 1 — Wind correction factors

Height above mean sea level	Duration of gust		Sustained mean wind duration		
m	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 (n)	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 m/s × 1,42 = 34 m/s.

The wind-velocity factor, v_h, at another height, h, expressed in metres above sea level, can be obtained from the reference value at 10 m using the power law profile as given in Formula (1):

$$v_h = v_{10} \times \left(h/10 \right)^n \tag{1}$$

where

v_h is the velocity at height h above sea level;

n is the power law exponent (see Table 1).

EXAMPLE 2 The velocity, v_{10}, at the 10 m base of a wind with an average velocity of 7 m/s (1 h mean velocity) at a deck level 50 m above mean sea level can be calculated as

v_{10} = 7 m/s × (100/122) = 5,378 m/s

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

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

5.2.3.3.2 Maximum sea temperature

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

5.2.3.3.3 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

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occurs, taking into account the associated relative humidity. 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 is noted that maxima of room-cooling loads can 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 may be applied from ASHRAE[15] 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 shall also be considered.

5.2.3.3.4 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 regulations. An alternative approach based on a measurement of population acceptance is given in ISO 7730[5]. The ISO 7730 method applies only to manned areas. Table 2 gives guidance that may be used if the approach outlined in ISO 7730 is not adopted.

Table 2 — Recommended indoor environmental conditions

Description	Examples	Minimum temperature (winter) °C	Maximum temperature (summer) °C	HVAC noise limit dBA	Comments
Manned areas — sedentary work	Control room Radio room	19	24	40	
Living quarter areas	Recreation areas Cabins	19	24	40	
	Dining room	19	24	50	
	Corridors/toilets Laundry Stores/galley	16	25	50	
	Switch room	10	35	65	
	Plant room	10	35	65	Noise level up to 85 dBA can be acceptable, if measures are taken to avoid unacceptable noise levels in adjacent areas.
	Offices	19	24	40	
	Dry store Gymnasium	16	24	50	
	Sick bay	21	25	40	A room controller should allow adjustment of room temperature to a maximum of 25 °C when outside min./max. design temperature are prevalent.
Light manual work	Laboratories	18	24	50	
	Stores Workshops	16	24	60	
Unmanned without electrical equipment	Utilities module	5	35	80	

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Table 2 *(continued)*

Description	Examples	Minimum temperature (winter) °C	Maximum temperature (summer) °C	HVAC noise limit dBA	Comments
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	25	70	35 °C maximum may be accepted for certain types of batteries.
Unmanned	Production modules	5	35	80	

The HVAC plant shall as minimum have the following capacity:

a) heating to achieve the minimum temperature during winter conditions;

b) cooling to achieve the maximum temperature during summer conditions.

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 shall be located at points in the HVAC systems where they can control both break-out and break-in of noise. 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 noise levels. Care shall 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.

Consideration shall be given to reducing the noise levels at source in the first instance.

Outdoor air inlets and outlets shall be attenuated to a value where they do not exceed the local predicted background level by 5 dB or exceed 80 dBA (or national standards) at a distance of 3 m from the outlet, whichever is the more stringent.

Permissible noise limits shall not be exceeded as a result of sound power generated by, or transmitted through, the HVAC systems. See also guidance given in Table 2. An analysis shall be performed to demonstrate the noise and vibration contribution from the HVAC system.

Where sound attenuators are required in the LQ and laundry extract systems, they shall be suitably designed to reduce the risk of lint accumulation and subsequent fire hazards.

Sound attenuators are not permitted in galley extract systems, unless sufficient measures are taken to eliminate grease.

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

5.2.4 Natural/mechanical ventilation

5.2.4.1 Objective

The objective is to select a means of providing ventilation to any hazardous or non-hazardous area of an installation.

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5.2.4.2 Functional requirements

Provide ventilation to any area that requires it, giving consideration to the following:

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.

5.2.4.3 Detailed requirements

The major consideration in installation layout and ventilation philosophy is likely to be risk, whether it is 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 can be expected to contribute to the modelling of smoke and gas releases as part of the decision-making process.

The requirements for heat-tracing, insulation, corrosion protection and maintenance cost shall also be considered when evaluating natural ventilation versus enclosed mechanically ventilated areas.

Production areas generally shall 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, shall 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 hot climates, roofing or other protection may be provided instead of mechanical ventilation.

Mechanical ventilation shall be used when ventilation by natural means is unable to satisfy requirements as given in A.2. Powered systems shall operate satisfactorily in wind conditions varying from still air to design wind velocity and plant margins shall be included in the design or fans conservatively sized in order to ensure the requirements are met during adverse wind conditions.

Free cooling, i.e. cooling by outside air, is preferred to cooling by refrigeration. In some parts of the world, it can be practical and energy-efficient to use seawater cooling, for which further requirements are given in A.5. Environmental data from project locations shall be used to determine available free-cooling potential, and shall 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 can exceed the design maximum for short periods during peak outside conditions.

Designs shall 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, in particular, shall be included in the cooling-load calculations, as experience demonstrates that underestimation of resultant system temperature rise is a common problem.

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

Where heat gains are excessive, 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, may be used.

Drilling facilities, such as shale-shaker and mud-tank areas/modules, shall have an air change rate determined by the air quantity required for the extraction of fumes, heat and dust. By necessity they require an 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 may be used for make-up.

The design of HVAC systems in drilling facilities is shown in more detail in 5.4.4.

5.2.5 Selection of controls philosophy

5.2.5.1 Objective

The objective is 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, and

d) comply with the installation smoke and gas control philosophy.

5.2.5.3 Detailed requirements

5.2.5.3.1 General

The philosophy outlined in 5.2.5.3 is a requirement for large, integrated installations and is not always appropriate for very small installations and those that are not normally manned where HVAC is not considered to have a role in asset protection.

The systems shall be integrated into the overall monitoring and safety systems of the installation and shall be provided with controls for normal and emergency operations that shall be within, or readily accessible from, a normally manned central location, usually the central control room (CCR).

Decisions regarding the extent of manual control shall 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 might not be considered necessary to route 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 shall be grouped in a logical sequence, either in a dedicated HVAC-panel or integrated with a central control and monitoring system (CMS).

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

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

5.2.5.3.2 HVAC shut down philosophy

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 to be determined early in design development. Where mechanical ventilation systems are installed, careful attention shall be paid to their operation and/or shutdown in conjunction with F&G detection and protection systems. The nature of the shutdown philosophy related to fire detection can vary among different operators and among different statutory regulators.

5.2.5.3.3 Control and monitoring — Normal operation

5.2.5.3.3.1 Dedicated and integrated HVAC panels

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

a) controls:

   1) start: all fans;

   2) stop: all fans;

   3) automatic changeover: for each run/standby fan set (including shut-off dampers) switch with lector;

   4) open + close: all fire/gas dampers, as required by the F&G philosophy;

b) indicators:

   1) run: all fans;

   2) stop: all fans;

   3) tripped: all fans;

   4) filter dirty: each filter (not separate vane sections);

   5) on/tripped: each heater;

   6) lamp test;

   7) on/tripped: each package equipment item;

   8) open: each fire/gas damper protecting fire-rated bulkheads or providing boundary isolation to a TR;

   9) close: each fire/gas damper protecting fire-rated bulkheads or providing boundary isolation to a TR;

   10) loss of pressurization: any area requiring pressurization, and each gas turbine hood;

c) alarms: a common alarm indication shall be provided to a normally-manned control location for the following:

   1) fan trip;

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2) heater trip;

3) filter dirty;

4) package equipment trip;

5) loss of pressurization;

6) fire/gas damper operating-mode failure.

5.2.5.3.3.2 Local control of fans

An emergency stop station, such as a push button, shall 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, shall be provided with start/stop control, complete with run indication, local to the equipment or working position.

For ventilation of refrigerating plants, refer to ISO 5149-3[2].

5.2.5.3.3.3 Fire/gas damper controls

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

a) remote manual operation;

b) local manual operation (for closure only);

c) automatic closure by the installation of a fire- and gas-detection panel;

d) automatic fail-safe by release of a local heat-detection device.

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

Local, remote, manual or automatic functioning (open and close) and interlocks shall be based on an area safety assessment.

5.2.5.3.3.4 Loss of differential pressure

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

In each non-hazardous area adjacent and connecting to a hazardous area, each extract fan shall be prevented from starting until its associated supply fan run-up velocity has been reached and the supply shut off damper has opened.

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

Arrangement and protection of non-hazardous rooms with access to hazardous areas shall be in accordance with IEC 60079-13 and IEC 61892-7.

5.2.5.3.3.5 Temperature control

Duct- or unit-mounted water/steam heat exchangers (heating and cooling coils) shall 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 shall be controlled using either one- or two-step direct-switching thermostats or contactors or thyristors.

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

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

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

Outdoor-air and recirculation dampers, where fitted, shall be automatically controlled by external ambient and recirculation air temperature sensors, and shall be fixed such that sufficient outdoor air is introduced, as given in 5.4.2.3.1.

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

5.2.5.3.4 Control and monitoring — Emergency conditions

The HVAC-systems shall receive signals from the ESD/F&G/manual trips consistent with the selected shutdown tripping philosophy.

Once stopped, the fans shall be prevented from being restarted 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 shall be restarted in accordance with the initial start-up procedure.

It can 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 can continue to operate during an emergency, consistent with the TR philosophy. The requirement for space cooling depends on the rate of temperature rise due to electrical/electronic equipment heat. Emergency-powered cooling shall be provided only when maximum operating-space temperatures or the permissible “heat stress” is exceeded within the required emergency operating period. It shall be recognized that equipment-heat dissipation during an emergency can be significantly less than under normal circumstances.

Where room-cooling units are installed and are required to operate to provide cooling during emergencies, they should normally only recirculate air. Outside air supply shall be isolated in emergencies through fire/gas damper operation.

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

5.2.6 Operating and maintenance philosophy

5.2.6.1 Objective

The objective is to provide an HVAC design that provides as high a degree of operational availability 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, design margins, plant operating modes, availability of power supply, 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.

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5.2.6.3 Detailed requirements

The functional requirements may 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, and

— criticality of key components in normal or emergency conditions.

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

Where a system and equipment are designed for continuous operation or considered as critical for operation/safety, consideration shall be given to the "sparing" philosophy. Sparing of equipment is preferred to minimize down-time and improve the availability of essential services. This requirement is normally fulfilled 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 can, however, be practical to adopt a single, 100 % supply fan philosophy if the safety/economics of production shutdown have been fully evaluated. Similarly, the adoption of 2 × 50 % supply fans and 1 × 100 % extract fan can 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 shall be provided on each fan to prevent backflow and facilitate maintenance. Controls shall ensure that damper opening and closure is coordinated with associated fan operation.

The central refrigeration plant shall have a specified level of standby to provide adequate cooling capacity where loss of cooling cannot be tolerated.

One objective of equipment selection shall be to reduce spare stock quantities and to incorporate maximum standardization of components to enable interchangeability between all HVAC systems on an installation. Special attention shall 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 requirement for operational availability, the system shall be designed to maximize intervals between maintenance periods and the emphasis shall 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.

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

a) Plant and equipment shall be floor-mounted wherever possible.

b) Plant and equipment shall have good access for maintenance purposes.

c) Permanent access platforms shall 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 shall be provided.

e) Ample withdrawal/removal space shall be provided for all items of plant and equipment.

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f) Designs shall include provision for lifting and handling of plant and components during construction/maintenance.

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

5.2.7 Materials and corrosion

5.2.7.1 Objective

The objective is 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 are affected by their operation.

5.2.7.2 Functional requirements

The design shall recognize the saliferous atmosphere and relative humidity that are 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 under fire-engulfed conditions can be required for some components.

5.2.7.3 Detailed requirements

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 borne 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 that

— minimize opportunity through control of environment, e.g. through control of humidity, effective filtration,

— 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 mass savings and corrosion-resistant capabilities. As a general caution,

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it should be recognized that the temperature of sparks from aluminium and many other alloys or carbon steel can be above the auto-ignition temperature of certain hazardous gases.

For short lifetimes, as for example on upgrade or refurbishment work, it can 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. These costs can be avoided by a more conservative, but expensive, choice of materials at the outset.

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

The specification of ductwork in mild steel that is painted or galvanized after fabrication can, depending on local market conditions, prove more cost-effective than the thinner stainless steel. Additionally, offshore construction of HVAC systems seldom involves an accuracy that removes the requirement 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 shall 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 shall 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.

5.2.8 Design margins and calculations

5.2.8.1 Objective

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

5.2.8.2 Functional requirements

The design shall be documented in accordance with suitable industry standards, e.g. those of ASHRAE[15], CIBSE[17] 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.

5.2.8.3 Detailed requirements

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

Fans shall be selected to operate on the steep part of their performance pressure/volume curve to ensure minimal volume fluctuations during adverse wind conditions. The airflow variations shall not exceed ±10 % at the project's dimensioning wind speed. The operating point used shall be at the required volume, as determined by the basis of design, with the pressure loss based on the actual system resistance, with filters being taken at their average pressure drop, plus any pressurization load that is required in non-hazardous modules.

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Maximum fan and/or system pressure in a no-air-flow situation (fans running against closed dampers) shall be considered with respect to any system or area consequence this can have.

The accumulation of individual equipment operating margins shall 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, it shall be demonstrated that the following have been 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, e.g. the doubling of small motor sizes is unlikely to create a problem, whereas the same approach on large motors can alter the size of generators, cabling and switchgear.

The performance of the combined supply and extract system shall then be checked for adverse wind conditions. A value of design wind velocity consistent with that given in 5.2.3.3 shall be used, with the effect being calculated using a computer-aided engineering package recommended by, e.g. ASHRAE[15] or CIBSE[17]. This load can 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 shall be evaluated. Variations in the process performance shall also be considered, as they can affect heat gains by, and fugitive gas leaks into, the space.

Where practical, the fan and motor shall be selected to accommodate 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 speed).

The final selection shall be checked for wind gusts producing velocities with an annual probability of exceedance of 0,1 %, to ensure the system recovers naturally 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.

5.2.9 Wind-tunnel and computational fluid dynamics modelling

5.2.9.1 Objective

The objective is to undertake a modelling programme that reproduces installation conditions within a reasonable accuracy, so that design options can be consistently evaluated and the chosen option optimized with a high degree of confidence that the design performance will be confirmed by actual measurements.

5.2.9.2 Functional requirements

A modelling programme, either CFD and/or a wind-tunnel test, shall be undertaken to predict

— natural ventilation rates and frequencies,

— wind pressure distribution around the installation to determine air inlet and outlet positions,

— requirements for secondary ventilation,

— gas build-up inside hazardous modules,

— helideck configurations and operating envelopes,

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— hot-plume and contaminant (noxious exhaust and hydrocarbon) smoke or gas flows around the installation,

— weather protection for the working environment.

5.2.9.3 Detailed requirements

5.2.9.3.1 General

The goal of CFD and wind-tunnel modelling is to undertake a modelling programme that reproduces installation conditions as accurately as possible so that design options can be consistently evaluated and the chosen option optimized with a high degree of confidence that the design performance will be reflected by actual measurements.

It is important to remember that these are bespoke techniques requiring careful implementation by experts. CFD and wind-tunnel modelling can give the wrong results if not properly applied.

Traditionally, both wind-tunnel and CFD modelling have been used to undertake the above scopes of work.

The development of ever-more-powerful computers and enhanced CFD software has, however, firmly tilted the balance in favour of CFD.

Where an existing wind tunnel is available, it can be useful in performing certain supplementary studies such as

a) helideck wind environment,

b) overall wind forces and moments, and

c) wind pressure distribution.

Other studies are best performed by CFD.

It should be noted that for studies b) and c) in particular, it is important that the Reynolds number effects on cylindrical structural elements and equipment be addressed. This is particularly important for gravity-base installations where the large-diameter concrete shafts can critically affect the flow patterns over the installation. If due allowance is made for Reynolds scaling effects, there can be either a departure from true scaling, full scale to model, apparent in the cylindrical structural tubing and equipment, or an implementation of enhanced surface roughness. If these Reynolds number corrections have not been implemented on the wind-tunnel model, the results can well be unsuitable for the studies of wind pressures and overall wind forces and moments.

5.2.9.3.2 Computational fluid dynamics — Preparation for analysis

5.2.9.3.2.1 General

CFD modelling shall be undertaken by companies or personnel experienced in this field of work with a track record in building CFD models from drawings and/or installation computer-aided design (CAD) files in a neutral format, such as initial graphics exchange specification (IGES). The input of the appropriate level of detail is particularly important to balance the accuracy of the result with the speed of computing.

5.2.9.3.2.2 Computer model

The computer model shall be constructed from tetrahedral or hexahedral elements. Grated floors, walkways, etc., shall be modelled by a suitable porous boundary condition. The platform features shall be modelled with sufficient detail. Areas of congestion, such as nests or runs of small piping, cable tray, shall be represented by a porous modelling approach. Appropriate drag coefficients of equipment and structures shall be included in accordance with Darcy's equations. The mesh shall extend downwind of the platform by at least six times the along-wind length of the platform. It shall also extend away

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from the platform by more than two times this length upwind and across wind. This bounding mesh shall be constructed such that the cell size increases away from the platform. The cell size shall be approximately uniform for three cell layers around the platform geometry or at least expand in a gradual manner, depending on the location of the geometry with respect to the regions of interest. The density of the cells shall increase in the regions of importance, particularly where large numerical gradients are predicted. The use of mesh adaption during the run is advantageous for dispersion and fire studies.

The influence of the grid on the results shall be minimized to prevent artificial dispersion of the flow characteristics. This is especially important around the regions of interest, such as above the helideck during a wind environment study and along the plume in a dispersion study. Changes of cell size in the computational mesh shall be gradual, particularly in a grid of tetrahedral cells. Meshes of hexahedral cells shall be aligned with the general direction of the flow where possible. The quality of the mesh shall be kept as high as possible by keeping the shape of the cells as regular as the surrounding geometry allows.

5.2.9.3.2.3 Boundary layer modelling

The boundary layer over the sea is determined by the mean wind velocity; the greater the wind speed, the rougher the sea's surface and, therefore, the higher the surface drag; the higher the surface drag, the greater the wind shear and turbulence intensity.

To specify the boundary layer at the windward face(s) of the computational mesh for a given mean wind speed, U, the mean wind speed, the dissipation rate, and the turbulence kinetic energy, k, shall be entered as functions of height above the sea surface. When the differential shear stress model is used, the shear stress shall be entered as a function of this height. The roughness factor of the sea surface shall be modelled such as to maintain the boundary layer defined upstream throughout the computational domain for each wind speed analysed.

5.2.9.3.2.4 Computational model

For most studies the isotropic or k-ε model can be used, but with at least a second-order differential. In order to resolve the vertical and along-wind turbulence components, the helideck wind environment studies shall be considered using a differential shear stress model.

5.2.9.3.3 Computational fluid dynamics — Analysis

5.2.9.3.3.1 Helideck wind environment

CFD shall be modelled using a non-isotropic model; for example, the differential shear stress model. The purpose of the non-isotropic model is to enable the turbulence to be resolved into its vertical and along-wind components for the analysis of helicopter operational safety on take-off and landing.

The results for each wind direction shall be presented in the form of colour-coded isopleth maps of the mean and root mean square (RMS) values for both the along-wind and vertical components. Two sets of isopleth maps shall be produced, orientated as follows:

— in the vertical plane across the helideck centre, transverse to the wind direction;

— in the vertical plane over the helideck centre, in line with the wind direction.

5.2.9.3.3.2 Gas turbine exhaust plume dispersal

The exhaust outlet shall be resolved sufficiently and the CFD analysis shall exploit adaptive meshing techniques to optimize the computational mesh around the dispersing exhaust plume.

The wind directions analysed shall be those carrying the exhaust plumes towards specified locations. The wind speeds shall be selected on the basis of a preliminary numerical analysis. The results shall be presented in the form of colour-coded sectional maps of temperature above ambient at each selected

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location. These sectional isopleth maps shall be supplemented by colour-coded isopleth maps of temperature above ambient in the vertical plane cutting the axis of the dispersing plume.

The results shall be interpreted in terms of helicopter operations, crane operations, drilling operations and safety of personnel.

5.2.9.3.3.3 Natural and partially natural ventilation

Ventilation assessment shall determine the following per module or area:

— the airflow patterns within the naturally ventilated areas on the platform;

— the net (or overall) air change rate and ventilation efficiency (VE1), which shall be computed for each naturally ventilated area;

— the local air change rate and ventilation efficiency (VE2), which shall be computed for each naturally ventilated area.

The flow over the platform and through the naturally ventilated areas shall be analysed for eight equally spaced wind angles plus those wind angles ±22,5° from the normal to the fire/blast walls, giving a total of 12 angles.

The net or overall ventilation efficiency, VE1, shall be such that the net air change rate in a naturally ventilated module or area be at least 12 AC/h for 95 % of the time. For this purpose, it is sufficient to ensure that the net air change rate is 12 or more for a wind speed that is exceeded 95 % of the year (the 5 % cumulative value of yearly wind speed).

The local air change rate and ventilation efficiency, VE2, is modelled to assess airflow patterns and local air change rates throughout the module. VE2 is used to define whether the module is adequately ventilated and for what percentage of time at least 12 AC/h are achieved in all parts of the module or area.

The CFD analysis shall be in two phases:

— a steady-state analysis, from which the overall, or net, ventilation rate in AC/h shall be computed;

— a transient analysis shall be conducted with a neutrally buoyant tracer from which the air-change rate at every point within each naturally ventilated area shall be computed.

The analysis shall be combined with the site wind-frequency data to predict the percentage of time that the air change rate exceeds 12 per hour. The range of wind speeds about the 5 % cumulative value shall be scaled about this pivotal value with correction for variation in wind shear.

The airflow patterns and air exchange over rates shall be presented as colour-coded isopleth maps in the form of horizontal slices through each naturally ventilated area. From the isopleth maps of local air changeover rates for the 5 % cumulative wind speed, the zones of locally entrained or trapped air where the 12 AC/h are not met are readily identified. The results shall be analysed with respect to possible problems that can occur from fugitive gas build-up and excessive chill factors.

5.2.9.3.3.4 Gas-leak dispersion

Gas leaks can occur in two forms: the first is when the sonic jet emerges in a confined area and breaks up on surrounding equipment, walls, floors, etc., which destroys the initial high momentum. The second is when the sonic gas release does not impinge on anything near the source; it forms a jet release. It is not practical to analyse the sonic release during the supersonic phase after emergence; therefore, the effective source modelled within the computational mesh shall be at a point beyond that point at which the jet becomes subsonic. The contractor shall, however, justify his/her approach.

The gas dispersion shall be modelled as a transient event, starting from initiation, then dispersion, followed by leak detection, and then after closure of isolating valves and leak fall-off as the inventory between the isolating valves depletes. The CFD analysis shall exploit adaptive meshing techniques to optimize the computational mesh around the gas dispersion plume.

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Gas-dispersal modelling shall take into account the effects of buoyancy.

The results shall be presented in the form of a time sequence of colour-coded, sectional isopleth maps at key locations for each of a number of selected wind conditions. The isopleth maps shall be supplemented by a series of isometric views of the time-varying envelope of the lower flammable limit (LFL) of the gas.

For each key location and wind condition, the time history of the gas concentration from the leak shall be plotted. The concentration representing the LEL shall be indicated together with that concentration representing an unacceptable level of any toxic component of the gas (such as H2S) and, therefore, impairment with respect to personnel at that location.

5.2.9.3.3.5 Fire combustion gas/smoke dispersion

Fires can be an evaporating hydrocarbon pool, gas jet or mixed fires. They can be partially enclosed (compartment fire) or external, for example, a sea fire, weather-deck-pool fire or an external jet fire.

For an internal (compartment) fire, the modelling procedures shall be described and justified by quoting reference sources of empirical data.

For a jet fire, the estimation of flame lift-off, flame-base diameter, flame length and diameter at the end of the flame shall be described, quoting reference sources for empirical data. The expansion (dispersion) of the combustion gas/smoke plume during the combustion or chemical reaction phase is less than that during the subsequent dispersion phase. The smaller cone angle during the combustion phase is not recognized (unless a full eddy break-up model is used). A description shall be included as to how this problem is overcome numerically.

The studies shall treat all fires as transient, predicting the time histories of the combustion gas/smoke plume dispersion from ignition, fire detection, closure of isolating valves and the reduction in fuel flow as the inventory is depleted. The time histories of temperature above ambient, CO concentration, oxygen depletion and optical density/visibility for the designated locations shall be produced. A description shall be given as to how the inventory depletion is calculated. The estimation of CO concentration, oxygen depletion and optical density/visibility in terms of combustion gas/smoke concentration shall be justified and empirical data sources shall be identified. The radiation heat flux shall also be computed.

The smoke and gas dispersal modelling shall take into account the effects of buoyancy.

For each fire scenario, the results shall be presented in the form of a time sequence of colour-coded, isothermal sectional maps at key locations for each of a number of selected wind conditions. The CFD analysis shall exploit adaptive meshing techniques to optimize the computational mesh around the dispersing gas/smoke plume.

For each key location and wind conditions, the following time histories shall be plotted:

— temperature above ambient;

— CO concentration;

— oxygen depletion;

— optical density (visibility);

— radiation flux.

Each of the above can be a hazard to personnel above specified limits and, therefore, represents an impairment. The time to impairment for each of the identified potential hazards shall be tabulated for each key location.

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5.2.10 Performance standards

5.2.10.1 Objective

The objective is to define performance standards for HVAC systems that shall be used as a basis for managing risk throughout the life of the installation.

5.2.10.2 Functional requirements

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

5.2.10.3 Detailed requirements

Performance criteria are normally established at a company or project level, and are the standards of performance of personnel, equipment and systems, identified as necessary for the achievement of the screening criteria or to move towards company objectives. Performance criteria are generally quantitative and measurable and shall clearly define the level of performance required for compliance.

An important principle to be adopted in the setting of performance criteria is that their number and level of detail shall be commensurate with the magnitude of the risk to be managed. Thus, caution shall be exercised to avoid setting performance criteria at a level of detail that makes little contribution to the management of the risks on an installation.

In developing performance criteria for an installation, it can be helpful to consider a hierarchy of criteria. High-level performance criteria can be applied to the installation as a whole (e.g. ability of the structure to survive defined extreme environmental conditions) or to major systems that comprise part of the installation (e.g. the frequency of impairment of the TR). In some cases, high-level performance criteria might not be directly measurable, but nevertheless they shall be capable of being verified from either analytical studies or from the results of assessments of low-level performance criteria.

Low-level performance criteria may relate to the principal systems used to manage major accidents on the installation. Three characteristics shall apply to performance criteria at this level.

a) The items selected shall make a significant contribution to the management of risk.

b) The parameters selected shall be directly relevant to the achievement of the system goals.

c) It shall be possible to verify the parameters selected.

In developing the parameters for the lower-level performance criteria, the following elements shall be considered.

1) Functional parameters of the particular system (a statement of the purpose and the essential duties that the system is expected to perform).

2) Integrity, reliability and availability of the system.

3) Survivability of the system under the conditions that can be present when required to operate.

4) Dependency on other systems which might not be available when the system is required to operate.

Performance criteria are normally set by an iterative process involving seeking a situation in which risks are as low as reasonably practicable. This is accomplished by initially setting performance criteria considered to be adequate based upon experience and normal operating practices. These initial performance standards are tested to see whether they produce conditions in which risks are as low as reasonably practicable, and then modifying them as necessary to achieve this objective.

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In the setting of performance standards, the following aspects are important.

— Performance criteria shall be particularly focused on those elements that are critical to achieving satisfactory health, safety and environmental conditions.

— Procedural or operational criteria shall not be neglected in favour of hardware-type criteria.

— Criteria shall be directly measurable and shall not require extensive computational effort after measurement.

— Measurement and recording of data to confirm compliance with performance criteria shall, wherever possible, be part of the normal operational and recording tasks associated with the particular activity. This reduces the possibility of duplication of effort and increases the probability that the task is undertaken in a conscientious and efficient manner.

— Measured parameters shall, wherever possible, be clearly identifiable as contributing to risk reduction. If this is not obviously so, efforts shall be made to explain the relevance of the particular performance criterion to the personnel involved.

It is essential to have an established system of standards, such as that described above, against which to judge the acceptability of the results of the health, safety and environment (HSE) evaluation and as the basis for risk management decision making. The system of setting, periodically reviewing and updating the standards and the comparison of the evaluation results with those standards is an integral part of the HSE management system and the framework within which informed management can take place.

5.3 System design — General

5.3.1 Natural ventilation

5.3.1.1 Objective

Natural ventilation shall, wherever possible, be provided in order to

— dilute local airborne concentrations of flammable/toxic gases due to fugitive emissions, and

— 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, in order to consider that ventilation of an area/module by natural means alone is sufficient, it is necessary to comply with the following basic requirements.

— A minimum ventilation rate shall be provided throughout the area.

— The 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.

5.3.1.3 Detailed requirements

It is preferable to ventilate production areas by natural means. The adequacy of this form of ventilation shall be demonstrated by wind-tunnel testing and/or CFD to ensure sufficient airflow into, within and out of modules (see 5.2.2). Single stagnant areas shall not exceed 5 % of the module volume.

To ensure sufficient air movement (distribution) throughout a naturally ventilated module, it can be necessary to provide secondary (scouring) ventilation. Refer to 5.3.3. Modules that cannot be

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sufficiently ventilated by natural means shall be provided with mechanical assistance, as above, or be enclosed and provided with fully mechanical means to achieve the required ventilation rate.

Fully open modules provide the ideal arrangement for natural ventilation. If weather protection is required, it may be provided in the form of weather louvers, if cost and mass are acceptable. The performance of weather louvers is far superior to alternative forms of weather protection. Correctly designed and installed, louvers also promote internal air circulation through good diffusion.

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

Whatever method is selected, the effectiveness shall be verified through the use of measurements under normal operating conditions.

5.3.2 Mechanical ventilation

5.3.2.1 Objective

The objective is 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 ingress of gas and smoke, control contamination between areas and maintain acceptable working and living environments for personnel (e.g. COSHH approach EH40[30]) and non-destructive conditions for equipment;

— ensure that hazardous substances are contained or controlled at their source by means of local exhaust ventilation;

— prevent the formation of potentially hazardous concentrations of flammable gaseous mixtures in hazardous areas by providing sufficient ventilation for the dilution, dispersion and removal of such mixtures.

The system design shall include a fan-powered ventilation plant which draws 100 % of its outside air from a non-hazardous area and provides it to the target areas.

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

a) non-hazardous areas;

b) hazardous areas;

c) living quarters;

d) areas in operation during emergency situations;

e) areas fitted with secondary ventilation systems;

f) drilling areas;

g) substructure;

h) areas with contaminated air provided with separate extract, such as shale shakers/mud pits, welding bays, laboratories, galley, laundry.

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5.3.2.3 Detailed requirements

5.3.2.3.1 General

Hazardous and non-hazardous systems shall be designed to prevent possible contamination of non-hazardous systems caused by reverse flow through ductwork systems in the event of partial system failure.

Equipment shall normally operate continuously, but there are times when it can be idle or can operate intermittently. The design shall provide for these variations.

Designs shall endeavour, without prejudice to safety and operability, to minimize the following:

— extent of offshore hook-up;

— topside mass;

— space requirements;

— power requirements;

— maintenance requirements.

Additionally, the requirement for system testing and commissioning, i.e. location of balancing dampers and airflow testing, shall be considered early in the design development.

The capacity of the mechanical ventilation system shall be adequate to meet the objectives and requirements of 5.1 and 5.2. The system flow-distribution design may utilize single-system or primary and secondary ventilation systems.

The minimum fresh ventilation air volumes shall be documented.

Where non-hazardous areas are adjacent to hazardous areas, a differential pressure shall be maintained to meet the requirements of the chosen hazardous-area classification code. A form of relief venting from the space shall be provided to ensure that the doors can be opened during normal and emergency operations. For those applications where no powered extract system is proposed, pressure-relief dampers may be fitted. Further requirements on the selection of this equipment is given in A.10.

In order to ensure the installation of an effective HVAC system, consideration shall be given during design of mechanical ventilation systems to the aspects given in 5.3.2.3.2 to 5.3.2.3.5.

5.3.2.3.2 Differential pressure

Differential pressure may be achieved either by imbalance of design airflows or through pressurization control using mechanical dampers.

Construction of enclosures required to be pressurized shall ensure low leakage of pressurization air, for which pipe and cable seals and airtight construction are essential. A realistic approach to leakage through doors, dampers and fabric shall be taken at the design stage. The leakage performance of the living quarter, temporary refuge and areas required to be pressurized shall be tested at the end of the construction phase in order to check compliance with leakage criteria and regularly through the installation lifetime Leakage performance of the temporary refuge shall be measured throughout the installation's life.

5.3.2.3.3 Effect of wind

All equipment, ductwork and supports shall be designed to withstand all structural loadings as listed in the facilities structural design parameters established by the project.

From an operating perspective, wind can adversely affect fan performance and area pressurization, and plant margins shall be included in the design in order to ensure the requirements are met during

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adverse wind effects (see 5.2.8). Powered systems shall operate satisfactorily in wind conditions varying from still air to design wind velocity, though the specified values can be exceeded when wind velocities greater than design occur.

5.3.2.3.4 Inlets and outlets

The potential for contamination and reverse flow through the ductwork in the event of partial system failure shall be assessed, and inlets separated from outlets by a distance determined by the size of the opening, the potential flammability of the exhausted air, and the extract velocity. There are various calculation methods available, e.g. in ASHRAE[15], for this purpose.

Gas dampers, or fire dampers which satisfy the leakage requirement, shall be installed in all air inlets. Gas dampers normally also required for outlets, unless safety study demonstrates that they are not required. Position of gas detectors in air intakes shall ensure that any delay in detector/damper response time is covered.

In accordance with standards, air intakes shall always be located in non-hazardous areas. An exception may be made for air intakes to enclosures for process equipment that is located within a classified hazardous area. For these enclosures, it may be acceptable to take air from areas with the same classification, i.e. free-standing, noise-reducing enclosure for process equipment, analyser house, etc.

Air from non-hazardous areas shall be exhausted to a non-hazardous area.

Air inlets and outlets from the various systems shall be protected from wind-driven rain and snow entering the plant; see A.2.

5.3.2.3.5 Duct systems

Duct systems shall be designed to recognized standards, such as ASHRAE and CIBSE guides, and sized to give the design throughput at velocities that do not give rise to unreasonable noise.

Supply- and extract-duct systems should be sized to suit the recommended maximum velocities in Table 3.

Table 3 — Recommended maximum velocities in duct systems

Area	Velocity	
	Maximum m/s	**Preferred** m/s
Hazardous areas and non-hazardous areas normally unoccupied	15	10 in main runs
LQ high-velocity supply ducting, non-hazardous areas normally occupied	10	6 in branch ducts
LQ extract and recirculation ducts	7,5	5 in main runs

The use of velocities in excess of the above requires the consideration of noise-reduction measures and the consequences of high energy loss.

All duct systems shall be sized to be self-balancing as far as possible. Where this is not practicable, duct systems shall be designed to include balancing dampers at each branch duct to allow fully proportional balance, except those systems that utilize CVUs.

5.3.3 Secondary ventilation systems

5.3.3.1 Objective

The objective is to provide an additional system to supplement natural or mechanical ventilation in areas where the distribution of air by the main system is not adequate.

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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.

Secondary systems may draw air from the areas served.

5.3.3.3 Detailed requirements

Partial secondary ventilation can be adequate where primary mechanical or natural ventilation also promotes a degree of internal air distribution and circulation.

In areas where heavier-than-air gases can accumulate, hazard assessment can indicate a requirement for additional extracts. This may be provided by a locally ducted mechanical system.

On new designs, a secondary system can often have advantages when compared to traditional (essentially primary) systems with respect to efficiency, cost, mass, space and ease of design/installation.

There are three methods for the use of high-velocity secondary systems:

a) by inducing the room air to sweep the entire area in a predetermined direction and, in the process, dilute and entrain any hydrocarbon or noxious gas, and/or high-temperature air that can be present;

b) by creating localized areas of high turbulence around plant equipment that has been identified as a potential leak source for hydrocarbon or noxious gas, or in areas of potential accumulation;

c) by draining gullies or ceiling beam spaces, in order to move any accumulations into the general room-air stream.

5.3.4 Black start

Following a prolonged shutdown of the installation due to extraordinary maintenance activities and/or failure, services and utilities systems may contain hydrocarbon gas.

Black start ventilation shall be achieved initially by natural ventilation and secondly by portable fans providing a purging capacity in accordance with the project restarting plan. The main ventilation plant shall be made operational as a matter of priority.

Black start facilities as portable fan and nozzles for air connections on ventilation system shall be provided to allow the purging activity. All electrical equipment, where purging is required, shall not be powered until safe atmosphere within the ambient is proven.

5.4 Area-specific system design

5.4.1 Process and utility areas

5.4.1.1 Objective

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

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5.4.1.2 Functional requirements

Systems provided for hazardous areas shall be entirely separate from those serving non-hazardous areas. Non-hazardous areas adjacent to hazardous areas shall be kept at a positive pressure compared to the hazardous area. Specific exhaust requirements, e.g. fume cupboards, welding benches/booths, also require consideration.

See 5.2.3.3.4 for guidance on outside maximum and minimum design temperatures for areas.

Air change rates determined in 5.2.2 shall be applied and the ventilation shall be sufficient to dilute fugitive hydrocarbon emissions. Any free-cooling requirements for the area shall also be met.

5.4.1.3 Detailed requirements

Where a mechanically ventilated hazardous area is adjacent and connected to a non-ventilated, non-hazardous area, the extract ventilation system for the enclosed hazardous area shall ensure that the area is kept at a negative pressure.

Additional heating or cooling for maintenance personnel should be provided by temporary, portable equipment suitable for the area classification.

Heating, where provided by mechanical means, may be from a heater located in the supply duct. It can be necessary to provide a number of heaters for separate compartments, or for area zones where varying conditions are required.

The preferred method of cooling is free cooling, but other methods may be adopted when this means is impractical or uneconomical, or a close control of the environment is required. It is accepted that space temperatures can go above design maximum for short periods during peak outside conditions. Designs shall ensure that sufficient ventilation air is provided to control heat gains from equipment and heat transmitted through the walls of the space(s) served.

It can be necessary, where heat gains are excessive, to use room air-conditioning units mounted within, or local to, the space(s) served, such as in the CCR and emergency switch rooms.

5.4.2 Living quarters

5.4.2.1 Objective

The objective is to provide a controlled environment for personnel.

5.4.2.2 Functional requirements

HVAC systems shall be designed to maintain acceptable internal-air conditions at maximum and minimum outside air conditions, taking into account detectable and latent loads from lighting, personnel and other sources.

Ventilation rates shall be established from requirements for heating or cooling and the need for pressurization and personnel comfort.

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.

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5.4.2.3 Detailed requirements

5.4.2.3.1 General

The requirements given in 5.2.3 shall apply. During periods in summer or winter when outside conditions exceed the maximum and minimum design values, it is accepted that the inside temperature might not be to specification.

As a default condition, a minimum flow rate of 8,4 l/s of outdoor air per person shall be supplied to each occupied space as recommended by ISO 7547[4].

Single-duct systems are generally the most cost-effective and shall be provided to

— cabins;

— public areas;

— emergency areas;

— galley.

The main supply system(s) shall be either a fixed, 100 % outdoor air plant or an outdoor air/recirculated air plant that can require automatic temperature- or enthalpy-controlled changeover from full outdoor air to part recirculation. System operation with 100 % recirculation shall be evaluated for only emergency operation.

The main supply, extract/recirculation and cooling plant should be located in a plant room. The supply should be a ducted system connecting to CVUs or balancing dampers. Air may be supplied through ceiling diffusers or through air-displacement units. The reheating should comply with the supply principle chosen, i.e. reheating terminal boxes in conjunction with ceiling diffusers or wall-mounted panel heaters, together with air-displacement units.

5.4.2.3.2 Extract system

Extract ventilation systems in the LQ shall be provided to serve the following areas.

— General extract ventilation from cabins, offices, recreation areas, dining room, locker room, toilets (provided with some protection to prevent cross-contamination) and corridors through a centralized, ducted system.

— Dedicated extract systems from the galley and associated stores, laundry, toilets (unless provided with some protection to prevent cross-contamination), sick bay, rooms fitted with toxic-gas extinguishing systems and battery rooms. No recirculation from these areas is allowed.

The dedicated extract systems shall have their own fans, located either within an internal plant room or external to the LQ module, discharging the exhaust air to atmosphere.

The individual, dedicated extract systems serving the galley, laundry, toilets, sick bay, workshops (and electronic equipment rooms) shall exhaust air to atmosphere.

5.4.2.3.3 Heating, cooling and humidification

Where applicable, heaters (steam, water or electric) and/or cooling coils may be located in the main air handling unit (AHU) in order to raise or lower the air temperature to the required design supply level.

Recovery from extract air may be used for heating/cooling of supply air.

Cooling coils and evaporators shall be supplied with cooling medium from a dedicated refrigeration plant or from the seawater cooling system.

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All refrigeration systems shall be designed to use a zero-ozone-depleting, environmentally acceptable refrigerant or a refrigerant with a low global-warming effect. Phase-down and phase-out of high and medium global warming potential (GWP) refrigerants shall be considered.

Humidification, if fitted, shall comply with the requirements in A.6.

5.4.2.3.4 Galley systems

The galley supply system shall be designed to induce a flow of air from the dining room and across the serving area to the galley, in order to prevent cooking odours from entering the dining room. Alternatively, an air curtain may be provided around individual items of equipment, such as fryers, to improve the local working environment. Boost outdoor-air supply and exhaust systems, in addition to normal systems, may be considered for the peak heat loads in the galley, so that excessive loss of conditioned air is avoided.

Supply ductwork to the galley shall be connected to the main supply duct outside the galley boundaries. Supply ducting to other areas shall not be taken through the galley areas. Consideration shall be given to locate the supply outlets away from food-preparation areas.

A dedicated extract system for the galley shall be provided.

Galley extract systems and terminal reheat boxes in the LQ supply-air system shall also incorporate sufficient access to permit full system and component cleaning.

The galley shall be provided with canopies or hoods over all cooking equipment, which shall be fitted with cleanable grease filters and/or an automatic filter washing system.

Provision shall be made for fire detection and protection in the hoods, exhaust ductwork and fat-fryer systems.

NOTE For example see NFPA 96.

Exhaust canopies or hoods should also be installed over dishwashers and any other heat-producing items of equipment.

5.4.2.3.5 Laundry systems

To minimize the risk of inadequate filtration permitting the build-up of lint and consequent risk of fire, the following design principles shall be adopted for the warm-air clothes-drying machines.

a) Position filters as close as possible to the drying-machine outlet.

b) As far as is reasonably practicable, avoid vertical duct runs.

c) As far as is reasonably practicable, avoid concealed ductwork.

d) Include adequate access doors for complete cleaning and inspection of the system. Provide specific means for quick removal and replacement of system components.

e) Include high capacity filters that are disposable (or easily cleanable).

f) Provide a differential pressure gauge provided across filters.

g) Minimize length of extract duct from laundry machine to atmosphere.

h) Use suitably fire-rated ducts.

5.4.2.3.6 Temporary LQ modules

Supply and extract ventilation systems using the methods described above shall be provided to achieve the required air change rates. Mechanical supply is required to the main area to create the desired air distribution and pressurization, and all toilet areas shall be provided with mechanical extract.

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