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**Erdöl- und Erdgasindustrie –
Offshore-Produktionsanlagen –
Heizung, Lüftung und Klimatisierung (ISO/DIS 15138:2017);
Englische Fassung prEN ISO 15138:2017**

Petroleum and natural gas industries –
Offshore production installations –
Heating, ventilation and air-conditioning (ISO/DIS 15138:2017);
English version prEN ISO 15138:2017

Industries du pétrole et du gaz naturel –
Plates-formes de production en mer –
Chauffage, ventilation et climatisation (ISO/DIS 15138:2017);
Version anglaise prEN ISO 15138:2017

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2017-04-21 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfs besonders zu vereinbaren.

Stellungnahmen werden erbeten

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- oder in Papierform an den DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG), 10772 Berlin, Burggrafenstr. 6, 10787 Berlin.

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Gesamtumfang 135 Seiten

DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG)
DIN-Normenausschuss Maschinenbau (NAM)

Nationales Vorwort

Dieses Dokument (prEN ISO 15138:2017) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“ Subkomitee 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“ (Sekretariat NEN, Niederlande) erarbeitet.

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 der ISO Norm.

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;
- 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.

Nationaler Anhang NA (informativ)

Begriffe und Abkürzungen

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

3 Begriffe und Abkürzungen

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:

- IEC Electropedia: unter <http://www.electropedia.org/>;
- ISO Online browsing platform: unter <http://www.iso.org/obp>.

3.1

aktives System

System mit spannungsführenden Bauteilen

3.2

angemessene Belüftung

Luftaustausch, der gemäß Klassifizierungscode als annehmbar gilt

3.3

Verdrängungslüftung

<Luftverdrängungseinheiten> Luftbewegung im Raum durch kolben- oder stopfenförmige Vorrichtungen

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

3.4

starre Offshore-Anlage

starre Anlage

alle Anlagen, die auf starren Offshore-Bauwerken angebracht sind, und für die Förderung von Kohlenwasserstoffen in Form von Rohöl oder Gas durch Öl- und Gasvorkommen unter dem Meer vorgesehen sind

3.5

starres Offshore-Bauwerk

fest auf dem Grund errichtetes Bauwerk, das alle Tätigkeiten auf den Meeresgrund überträgt

Anmerkung 1 zum Begriff: Schiffe, Bohrtürme usw., die sich auf der Durchfahrt befinden oder für Erkundungs- und Erwartungstätigkeiten verwendet werden, sind von dieser Definition ausdrücklich ausgenommen.

3.6

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 definiert werden, die weder optisch, akustisch noch olfaktorisch, sondern nur mit Blasenprüfungen oder Prüfungen mit ähnlicher Empfindlichkeit festgestellt werden kann.

3.7

offene Fläche

Fläche im Freien, auf der Dämpfe schnell vom Wind weggeweht werden

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

3.8

passives System

System ohne spannungsführende Bauteile

3.9

Not-Zufluchtsort

TR

(en: temporary refuge)

Stelle, an der die Besatzung für eine zuvor bestimmte Dauer Schutz finden kann, während Untersuchungen durchgeführt sowie Notfallreaktionen und die vorläufige Evakuierung geplant werden

3.10

Stagnationsbereich

Bereich mit unzureichender Lüftungsrate

4 Abkürzungen für Begriffe

AC	Wechselstrom (en: alternating current)
AC/h	Luftwechsel pro Stunde (en: air changes per hour)
AHU	Luftbehandlungsgerät (en: air handling unit)
AMCA	Internationale technische Prüfororganisation 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 Klimaanlagebau 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)
CMS	Steuer- und Überwachungssystem (en: control and monitoring system)
CVU	Zwischenüberhitzer mit konstantem Volumen (en: tant-volume terminal reheat unit)
DC	Gleichstrom (en: direct current)
DE	Antriebsseite (en: drive end)
DX	Direktexpansion (en: direct expansion)
EN	Europäische Norm (en: European Standard)

EI	Energieinstitut (en: Energy Institute)
ESD	Notabschaltung (en: emergency shutdown)
F&G	Feuer und Gas (en: fire and gas)
GWP	Treibhauspotential (en: global warming potential)
HAZOP	Gefahren und Betriebsfähigkeit (en: hazard and operability)
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)
IEC	Internationale Elektrotechnische Kommission (en: International Electrotechnical Commission)
IMO	Internationale Seeschiffahrtsorganisation (en: International Maritime Organization)
IP	Institut für Erdöl (en: Institute of Petroleum)
LFL	untere Brennbarkeitsgrenze (en: lower flammable limit)
LQ	Mannschaftsräume (en: living quarters)
MODU	Bewegliche Offshore-Bohreinheit (en: mobile offshore drilling unit)
NDE	Nichtantriebsseite (en: non-drive end)
NFPA	Nationale Feuerschutzvereinigung (en: National Fire Protection Association)
NS	Norwegische Norm (en: Norsk Standard (Norwegian Standard))
ODP	Ozonabbaupotential (en: ozone depletion potential)
QRA	Quantitative Risikoanalyse (en: quantitative risk analysis)
r.m.s	Effektivwert (en: root mean square)
TR	Not-Zufluchtsort (en: temporary refuge)
VSD	drehzahl geregelter Antrieb (en: variable speed drive)

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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. 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. 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 meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/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.

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

1 Scope

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

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

This document normally applies 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 of 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*

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*

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

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

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

EN 12900, *Refrigerant compressors — Rating conditions, tolerances and presentation of manufacturer's performance data*

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*

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*

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:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

active system

system that relies on energized components

3.2

adequate ventilation

air exchange that is acceptable with reference to the classification code

3.3

displacement ventilation

«air displacement units» 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.

3.4

fixed offshore installation

fixed installation

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

3.5

fixed offshore structure

structure that is bottom-founded and transfers all actions on it to the seabed

Note 1 to entry: Vessels and drilling rigs, etc. that are in transit or engaged in exploration and appraisal activities are specifically excluded from this definition.

3.6

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.

3.7

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.

3.8

passive system

system that does not rely on energized components

3.9

temporary refuge

TR

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

3.10

stagnant area

area where the ventilation rate is less than adequate

4 Abbreviated terms

AC alternating current

AC/h air changes per hour

AHU air handling unit

AMCA Air Movement and Control Association Inc.

API American Petroleum Institute

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers

BS British Standard

CCR	central control room
CFD	computational fluid dynamics
CIBSE	Chartered Institution of Building Services Engineers
CMS	control and monitoring system
CVU	constant-volume terminal reheat unit
DC	direct current
DE	drive end
DX	direct expansion
EN	European Standard
EI	Energy Institute
ESD	emergency shutdown
F&G	fire and gas
GWP	global warming potential
HAZOP	hazard and operability
HSE	health, safety and environment
HVAC	heating, ventilation and air conditioning
HVCA	Heating and Ventilating Contractors' Association
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
IP	Institute of Petroleum
LFL	lower flammable limit
LQ	living quarters
MODU	mobile offshore drilling unit
NDE	non-drive end
NFPA	National Fire Protection Association
NS	Norsk Standard (Norwegian Standard)
ODP	ozone depletion potential

QRA quantitative risk analysis

r.m.s. root mean square

TR temporary refuge

VSD variable speed drive

5 Design

5.1 Introduction

Clause 5 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. Key functional requirements for HVAC systems applicable to all areas of the installation are the following:

- 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 the 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 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 in the development of a basis of design 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);
- 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 it involves a process of iteration as the design matures and does not take place as the sequential series of steps used in this document to facilitate presentation. The processes outlined here are equally applicable to major redevelopment 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 study (HAZOP) 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. It is the responsibility of the user to assess whether the requirements in this document are acceptable to the local regulator.

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

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 in 5.4.

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.

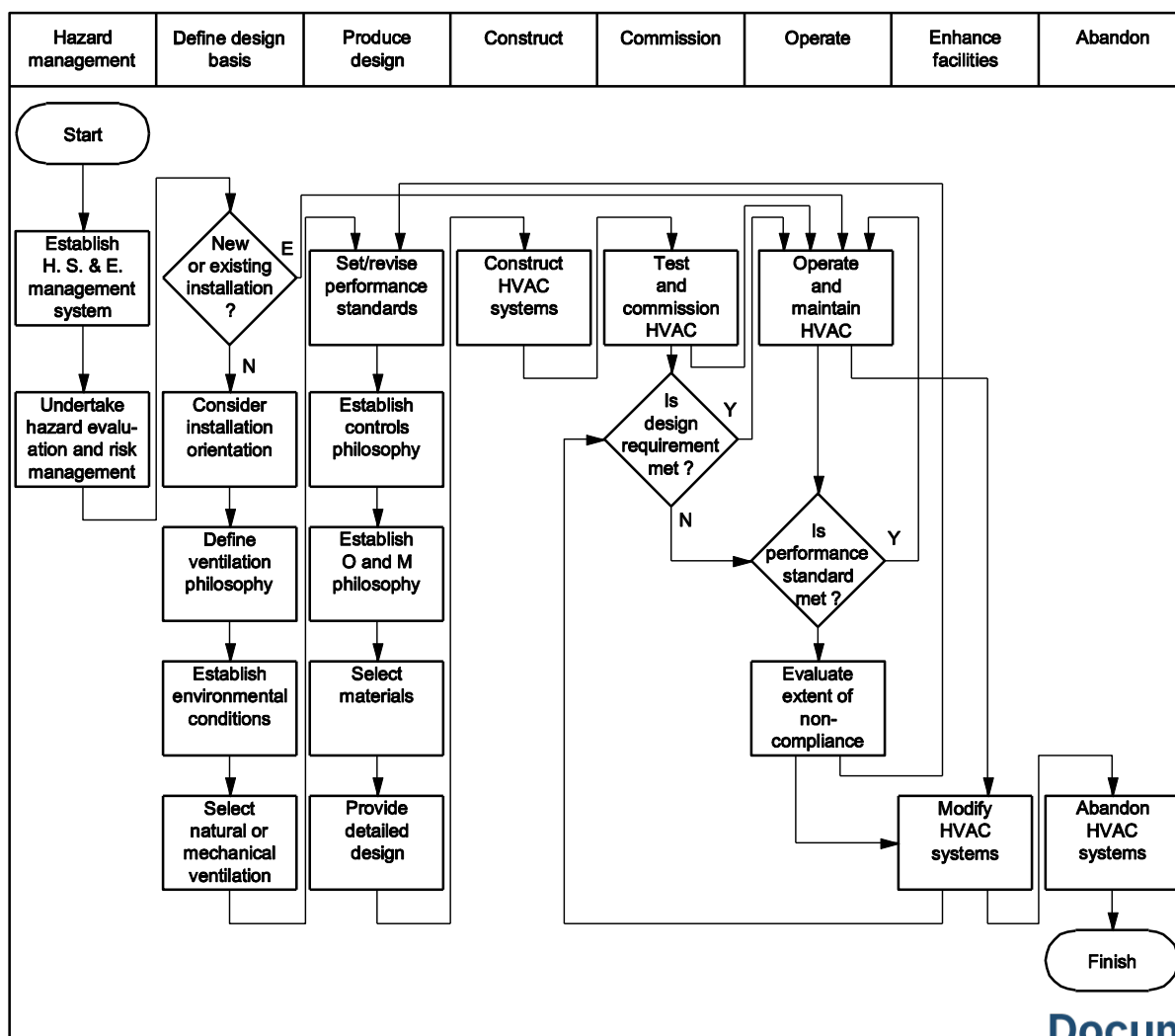


Figure 1 — Application of this document to a project life cycle

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, 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 whilst 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 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.

In the absence of any performance standards set by the local aviation authority, a maximum allowable air temperature rise above the surface of the helideck for helicopter operation shall be agreed by the party that initiates the project.

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 ^[12], 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 IP Code, Part 15 ^[31] 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,
- 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

In the absence of local regulations, the requirement for shelter shall be evaluated, which can reveal a subsequent need for an HVAC system.

The design of the HVAC systems shall be based on local regulations or design codes. 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.

Wind velocity data are usually reported at a standard 10 m height, but can be recorded at a different height on an installation. The corrections 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 m	Duration of gust		Sustained mean wind duration		
	3 s	15 s	1 min	10 min	1 h
10	1,33	1,26	1,18	1,08	1,00
20	1,43	1,36	1,28	1,17	1,09
30	1,49	1,42	1,34	1,23	1,15
50	1,57	1,50	1,42	1,31	1,22
60	1,59	1,52	1,44	1,34	1,25
80	1,64	1,57	1,49	1,39	1,30
100	1,67	1,60	1,52	1,42	1,33
120	1,70	1,63	1,55	1,46	1,36
150	1,73	1,66	1,58	1,49	1,40
Exponent (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 $24 \text{ m/s} \times 1,42 \times 34 \text{ m/s}$.

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):

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

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

$$v_{10} = 7 \text{ m/s} \times (100/122) = 5,378 \text{ m/s}$$

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 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 [13] 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 °C	Maximum temperature °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	Measures shall be taken if noise limit is exceeded.
	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	
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	

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.

Sound power generated by, or transmitted through, the HVAC systems shall not contribute to exceeding the levels stated in local regulations, recognized standards or the 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.

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.

Note that many of these factors are controlled by local legislation, which should be consulted for implications.

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

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, and, of necessity, require outside air supply to meet the extract air requirements of the tanks and shakers. Under normal circumstances, these requirements are met by a powered supply system to provide adequate air distribution to the general space. The exception to this requirement is where the modules are of a semi-open nature where air can be drawn in from a variety of openings. Under these circumstances, natural ventilation 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).

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, fire/gas damper status shall be indicated at the F&G panel in the CCR.

Control panels supplied as part of packaged equipments 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 fire and gas 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

— start	All fans
— stop	All fans
— automatic changeover switch with selector	For each run/standby fan set (including shut-off dampers)
— open + close	All fire/gas dampers, as required by the F&G philosophy

b) Indicators

— run	All fans
— stop	All fans
— tripped	All fans
— filter dirty	Each filter (not separate vane sections)
— on/tripped	Each heater

— lamp test	
— on/tripped	Each package equipment item
— open	Each fire/gas damper protecting fire-rated bulkheads or providing boundary isolation to a TR
— close	Each fire/gas damper protecting fire-rated bulkheads or providing boundary isolation to a TR
— loss of pressurization	Any area requiring pressurization, and each gas turbine hood

c) Alarms

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

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

5.2.5.3.3.2 Local control of fans

An emergency stop station such as 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 EN 378 (all parts) ^[16].

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:

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

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

Local, remote, manual or automatic functioning 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.

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.

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

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.

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, 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 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.
- 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, etc.;
- specify inherently corrosion-resistant materials;

- make use of corrosion-resistant coatings; or
- use corrosion allowances to extend the period before replacement.

Stainless steels are usually preferred as a means of minimizing corrosion. Other materials, such as aluminium and composite, offer mass savings and corrosion-resistant capabilities. As a general caution, 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 ^[13], CIBSE ^[15] 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 $\pm 10\%$ at the projects 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.

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 ^[13] or CIBSE ^[15]. 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 velocity).

The final selection shall be checked for wind gusts producing velocities with a 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 (CFD) 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,
- 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 (CFD) — 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 CAD files in a neutral format, such as 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, etc., 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 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 CFD — 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 r.m.s 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 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.