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Guidance on Practice for Heating, Ventilating and Air Conditioning - Onshore

GP 14-02

BP GROUP
ENGINEERING TECHNICAL PRACTICES

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GP 14-02. This Guidance on Practice (GP) is based on parts of heritage documents from the merged BP companies as follows:

British Petroleum

RP 14-2

Heating, Ventilating and Air-conditioning Onshore

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1. Scope

This Guidance on Practice (GP) provides guidance for the design, construction, and operation of heating, ventilating, and air conditioning onshore. This document takes into account health, safety and environmental legislation, good design practice, and technical and economic considerations. The design information included in this specification is not intended to cover complete details.

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this technical practice. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical practice are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

American petroleum Institute (API)

RP 500B	Recommended Practice for Classification of Locations for Electrical Installations at Drilling Rigs and Production Facilities on Land and on Marine Platforms
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American Society of Mechanical Engineers (ASME)

Boiler and Pressure Vessel Code

American Society of Heating, Refrigerating, & Air-Conditioning Engineers (ASHRAE)

Safety Standards for Refrigeration Systems

BP

GP 12-15	Wire and Cable
GP 12-20	Motors
GP 12-25	Earthing / Grounding
GP 12-60	Hazardous Area Electrical Installations
GP 42-10	Metallic Piping Systems

Chartered Institution of Building Services Engineers (CIBSE)

Guides to HVAC Systems

Engineering Equipment & Materials Users Association (EEMUA)

Design and Construction Specifications and Codes

International Organization for Standardization (ISO)

1940	Mechanical Vibration, Balancing Rotors
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National Electrical Manufacturers Association (NEMA)

Specifications and Standards for Enclosures

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code
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Sheet Metal & Air-Conditioning Contractors National Association (SMACNA)

Specifications and Standards for Sheet Metal and HVAC Fabrication ,
Manufacturing and Installation

3. Symbols and abbreviations

CFC chlorofluorocarbon

ft feet

in inches

kW kilowatt

kPa kilopascals

LEL lower explosive limit

m meter

mm millimetres

ppm parts per million

pH potential hydrogen ions

yd yard

4. General

- a. Design shall be in accordance with international or national standards as appropriate to the specific project. While this GP quotes many standards and practices which will be directly applicable to European and U.K. projects, these shall be replaced with equivalent international or national standards and practices as agreed by BP.
- b. Design and construction of HVAC systems shall meet the following specifications as applicable:
 1. NEMA or equivalent IEC specifications and standards
 2. NFPA 70 National Electrical Code
 3. SMACNA or equivalent specifications and standards
 4. GP 12-15
 5. GP 12-20
 6. GP 12-25
 7. GP 12-60
- c. HVAC systems shall be incorporated in buildings and enclosures as required to provide air conditioning, ventilation, heating, pressurisation, cooling and humidity control for the safety and comfort of personnel, for the protection of equipment and to extend the life of stored products.
- d. External and internal conditions and controls shall be considered at the outset of design in order to develop an appropriate system design solution.



- e. HVAC systems shall be designed to suit the particular application in accordance with the CIBSE and / or ASHRAE Guide Books and shall take into consideration a full assessment of all heat gains, heat storage and heat losses of the buildings or enclosures.
- f. For each application an evaluation shall be made of the standby plant required to maintain the service without detriment to the functional needs of the areas concerned.
- g. On essential services equipment, and where space permits, two 100% duty plants (run and standby) shall be installed. Where space restrictions prohibit this then two 50% capacity machines shall be installed. Consideration shall also be given on motor driven equipment to one duty plant with two motors. Generally on non-essential services one duty machine will be acceptable.
- h. The philosophy for sparing of equipment shall be based on a Risk Analysis Study.
- i. The design shall consider the following issues:
 - 1. Safety
 - 2. Operability
 - 3. Constructability
 - 4. Applicable codes
 - 5. Good engineering practice
 - 6. Minimum Cost
 - 7. Efficient systems operation.
 - 8. Suitability for the application.
 - 9. Practical and economic maintenance provisions
- j. The design shall demonstrate that the selected approach is optimal, by means of appropriate capital and operating cost estimates.
- k. The design of the systems shall include specification and selection of plant and equipment items together with all controls and instrumentation associated with the systems.
- l. The design shall ensure that work is fully coordinated with all relevant and associated work whether or not all disciplines are engaged under the same contract.
- m. The design shall take into account the following influencing factors:
 - 1. Climate
 - a) Arctic
 - b) Temperate
 - c) Arid
 - d) Tropical
 - e) Dry bulb temperatures
 - f) Wet bulb temperatures
 - g) Rainfall
 - h) Wind
 - i) Airborne contaminants
 - 2. Location
 - a) Country
 - b) Latitude



- c) Altitude
- d) Inland
- e) Coastal
- 3. Exposure
 - a) Sheltered / city or town
 - b) Exposed / open land
- 4. Orientation
 - a) Sun path
 - b) Prevailing wind direction
 - c) Prevailing wind speed
- 5. Classification
 - a) Non-hazardous
 - b) Hazardous
 - c) Proximity to hazard
- 6. Safety
 - a) Fire detection
 - b) Fire protection
 - c) Fire / Smoke control
 - d) Gas / Vapour detection
- 7. Economics
 - a) Type of system
 - b) Control
 - c) Energy conservation

5. System selection

5.1. General

- a. Selection of the HVAC system shall be based on consideration of the following:
 - 1. Nature of the application and period of usage of the building.
 - 2. Type of building construction.
 - 3. External and internal load patterns.
 - 4. Desired space conditions and control limits.
 - 5. Method of control for minimizing use of primary energy.
 - 6. Opportunities for heat recovery.
 - 7. Economic factors (including probable future cost and availability of fuel).
 - 8. Environment and Health and Safety Legislation.
 - 9. Possible need for dilution of contaminants.
 - 10. Ease and simplicity of operation and control.
- b. Systems suitable for the application shall be selected from the following:



5.2. Natural Ventilation

- a. Shall be selected for unmanned or infrequently occupied buildings where the extremes of weather conditions will not affect the building operation. The buildings will generally require large louvered openings on at least two (opposite) walls together with roof openings or cowls.
- b. To assist the natural ventilation concept and prevent local hot spots and / or gas concentration, specific attention shall be given to using a secondary ventilation system termed "Jet Air."
- c. Design of naturally ventilated buildings shall be in accordance with an appropriate national or international standard.

5.3. Mechanical supply / natural extract.

- a. Shall be selected for buildings which cannot be adequately ventilated by natural means or which need to be pressurised due to proximity to hazardous zone or to prevent the ingress of dust, smoke or fumes.
- b. The system shall comprise a filtered and heated ducted air supply which is designed to relieve pressure to outside through natural leakage paths or pressure control dampers

5.4. Mechanical extract / natural supply.

- a. Shall be selected for buildings in which local extract is essential to prevent the transfer of odours, heat, fumes, or dust produced by the processes contained within the building.
- b. The natural supply or make-up air shall be via louvered openings.

5.5. Combined mechanical supply & extract.

- a. Shall be selected for permanently manned buildings to provide proper control of air movement and reasonable control of comfort conditions.
- b. The system shall comprise arrangements of supply and extract fans, ductwork, dampers, grilles and diffusers (or common supply fan) with fresh air intake on the low pressure side. Interconnections may be included for full or partial re-circulation; the fresh air intake provided with filtration and heating as required.
- c. Positive pressurisation control may be provided for non-hazardous areas or enclosures to maintain the design pressure differentials between hazardous and non-hazardous areas, and / or assist in preventing smoke transfer into escape corridors. Fire and smoke control shall be via a local fireman's panel(s) to operate fire / smoke dampers within the ductwork system.

5.6. Air conditioning system.

Air conditioning systems shall be basically similar to the mechanical ventilation systems but with the facility for heating, cooling, humidifying, and de-humidifying, in order to control temperature and humidity within predetermined limits throughout the year.

6. Safety

- a. The HVAC systems shall be designed for inherently safe operation under all normal and emergency conditions.
- b. All systems shall incorporate a smoke control philosophy in their design. Such a system shall principally pressurise corridors and stairways to a level higher than the surrounding areas to prevent smoke ingress and to permit personnel escape.



- c. For smoke removal, areas having mechanical extract systems shall be at a lower pressure than adjacent areas.
- d. Air conditioning or ventilation systems incorporating air recirculation shall, on detection of smoke, automatically close recirculation dampers and fully open the fresh air and extract air dampers to exhaust the smoke to atmosphere.
- e. Where the possibility exists for toxic or ignitable gas to be drawn into ventilation air intakes, gas detectors shall be provided to automatically shut down the system and close isolation dampers.
- f. Fire and gas isolation dampers shall be provided at air inlet and exhaust penetrations and fire dampers wherever fire rated structures are penetrated. In specific applications fire and gas dampers shall be remotely controllable.
- g. Shut-down of designated fans or fire and gas dampers shall be initiated either automatically by the facilities fire and gas detection system prior to extinguisher release, or manually by the operator's personnel by means of local Fireman's Panels during an incident.
- h. Blast dampers shall be fitted in air inlets and discharge locations of blast protected buildings.
- i. Access shall be provided for satisfactory implementation of plant and equipment maintenance procedures.
- j. Optimum use of space available shall be considered with respect to plant and equipment layout arrangements. Where possible, duplicated components requiring dismantling or withdrawal for maintenance shall make use of the same access space.
- k. Particular attention shall be given to hazardous area classification and the provision of equipment suitable to operate in the designated areas. Reference shall be made to GP 12-60 for the requirements of electrical equipment for use in classified areas.
- l. To reduce the reliance on normal and emergency electrical supplies, hazardous areas shall be naturally ventilated to create airflow through the areas to provide purging requirements. Locations where gas pockets could form shall be reconfigured to eliminate the problem or provided with mechanical ventilation such as a "jet air" system.
- m. Where natural ventilation is inappropriate, areas shall be mechanically ventilated and / or pressurised preferably by means of a system which optimises air circulation by induction methods.
- n. Air intakes for pressurising or purging the hazardous areas shall be located in non-hazardous areas remote from the hazard source. The positions of chimneys or flues and the prevailing wind direction shall also be considered when determining the location of air intakes.
- o. Specific attention shall be given to locating air discharges where they will not create problems due to an extension of the hazardous area or contamination of air intakes by toxic materials, smells, or odours.
- p. Air inlets shall be located at least 6 m (19.6 ft) from any ventilation exhaust and 8.0m beyond any hazardous area limit.
- q. Segregation of air inlets and exhausts shall be such that cross contamination caused by recirculation is prevented.

Buildings or enclosures in non hazardous areas are not required to be positively pressurised but it is recommended that simple pressurisation be provided as a minimum to prevent the ingress of the external environment, dust, and odours.



7. Mechanical design

7.1. General

- a. For worldwide applications, reference shall be made to the CIBSE Guide.
- b. Air conditioning systems shall be designed to:
 1. Meet daily and annual variations in outdoor temperature, humidity, and solar radiation.
 2. Meet internal load variations due to movement of people and operation of lighting, machinery, and equipment.
 3. Meet maximum heating and cooling loads and potential load conditions including nights and weekends and providing frost protection if required.
 4. Meet sensible and latent load ratios that may be different from (and more onerous) than those occurring at maximum load condition.
- c. Provide adequate ventilation without drafts or stuffiness and with noise and vibration below the established design conditions.
- d. Calculations shall be produced to support all system and equipment selection and sizing and shall include:
 1. Building fabric heat exchange (gains / losses).
 2. Internal heat gains.
 3. Duct and piping flow rates, pressure drops and sizing.
 4. Equipment electrical power consumption and motor kW.
 5. Equipment utilities consumption: air, water, steam.
 6. Weight estimate for major equipment, and bulk materials.
- e. A comprehensive survey of the internal load shall be made. A list of occupancy, lighting, instruments, machinery, rectifiers, and other equipment releasing heat shall be prepared including use factor, load factor, power input, calculated heat release, location arrangement, and other specific requirements.
- f. Infiltration gains or losses shall not be included when the areas are internally pressurised, unless the infiltration pressure exceeds the controlled pressure.

7.2. Ventilation

- a. Natural ventilation calculations shall consider both wind pressure differentials and stack effect created by thermal gradients.
- b. The natural ventilation wind effect component shall be calculated to provide the minimum air change requirements based on a wind speed of 0,5 m/s (1.64 ft/s) and the room or enclosure shall have louvers or openings on at least two opposite or adjacent faces.
- c. Ventilation rates shall be based upon:
- d. Occupancy - the minimum fresh air rate required per person in enclosed areas as given by CIBSE Guide.
 1. Odour control.
 2. Condensation control
 3. Hazardous Areas - 12 air changes per hour.
 4. Non-hazardous Areas - 6 air changes per hour.



- e. The air changes quoted are recognised minima and shall be subject to increase as necessary to offset space heat gains / losses and to provide aspiration air for equipment in relevant areas. If these rates cannot be achieved by natural ventilation (as demonstrated by calculation) or where particular hazards dictate, mechanical ventilation (in whole or in part) shall be provided.
- f. Air change rates shall be based on full space volume without reduction being made for contained equipment.

The requirement for 12 air changes per hour for hazardous areas is derived from "Adequate Ventilation" in accordance with API RP 500B. However, it should be recognised that the empirical approach cannot fully account for the significant local influences on air flows within any ventilated space. Where stagnant regions are possible it may be necessary to carry out a detailed flow analysis. The design approach should be based on an appropriate standard and the philosophy documented accordingly.

The requirement for 6 air changes per hour for non-hazardous areas is to ensure comfort and safety of personnel and to prevent the ingress of toxic or ignitable gas.

It should be noted that efficient ventilation and purging of a space will only be achieved if the air flow is evenly distributed throughout.

7.3. Pressurization

Pressurisation of rooms or areas via the HVAC system shall be employed to:

1. Achieve pressurisation differentials to give the required segregation for area classification.
2. Prevent infiltration of the external environment and consequent heat gain or loss to the enclosure.
3. Provide a means of smoke control by pressurising escape routes.
4. Minimise the transfer of odours, smells and contaminants from one area to another, e.g., kitchens, galleys, and toilets.

Two types of pressurisation may be used:

- *Simple - achieved by designing supply and extract air flows to be in excess of one another to obtain the design pressure differentials.*
- *Fully Controlled - achieved by means of automatic duct mounted pressure control dampers or, fan inlet radial vane dampers, to modulate air flows in response to monitored room pressure conditions compared to a pressure reference point and thereby maintain pressure differentials.*

7.4. All-air systems

- a. All-air systems shall cater for total heating and cooling loads by controlling the supply air condition. The system shall incorporate a re-circulation facility where a proportion of the air is extracted and the remainder mixed with fresh incoming air.

All-air systems may employ high or low velocity supply air ductwork distribution systems.

- b. Shall be categorised as follows:
 1. Constant volume all-air systems shall be used in locations which operate with a reasonably constant load throughout the year. They may be either low or high velocity systems.



2. Low velocity systems generally include unitary systems with multi-zone units (with hot and cold deck mixing) a particular example.
 3. High velocity systems shall employ single or dual duct supply to terminal units; dual duct systems mixing hot & cold air supplies at the correct proportion to provide temperature control as dictated by room or space thermostats.
 4. Variable volume all-air systems shall be used in locations which operate at partial loads for most of the year. Prime energy consumption will be reduced by reducing the supply air volume (and corresponding extract) under low load conditions.
- c. Specific attention shall be given to ensure that satisfactory air distribution, space humidity control and adequate fresh air quantities are provided at all times.

Variable volume all-air systems may incorporate high velocity supply air ductwork arrangements with either single duct or dual duct terminal units.

- d. The diffuser from each variable volume unit serving a perimeter zone shall be sited at an optimum distance from the window. The maximum distance shall be 1 m (3.2 ft) subject to review with the diffuser designer and the supplier.

7.5. Air Water systems

Air-water systems comprise a central plant providing all necessary ventilation air and part of the total conditioning load with main and final control provided by water coil terminals (either fan coil or induction units) located within the conditioned space.

Two, three or four pipe water circulating systems are available, depending on the degree of control required.

With two pipe systems, single flow and return pipes circulate hot or chilled water as required to provide heating or cooling on a seasonal, manual change over basis.

Three pipe systems allow for separate supply of chilled and hot water with common return.

Four pipe systems have separate hot and chilled water supply and return arrangements.

Fan coil units may be provided with direct fresh air connection or with ducted conditioned fresh air supply combined with mechanical extract.

Induction units rely on high velocity primary air stream forced through jet nozzles within the unit to induce room air through the unit and over the heating or cooling coils.

8. Energy conservation

- a. Energy conserving or recuperative features shall be adopted wherever these can be justified by an acceptable pay-back period against capital expenditure.
- b. The maximum use of outside air for cooling purposes shall be considered particularly where internal upper temperature limits are above maximum external ambient temperature.
- c. In locations with extreme external ambient conditions of temperature and humidity, outside air quantity shall be minimised in order to reduce heating, cooling and dehumidification loads.

9. Noise and vibration

- a. GP 14-01 shall be applied with regard to noise control.



- b. All machinery shall be isolated from foundations and fixed piping and ductwork by means of vibration isolators and flexible piping / ductwork connectors, including sound proofing and ductwork silencers if applicable.
- c. The effect of noise levels on all buildings and from equipment housed in buildings shall be investigated and taken into account during detail design.
- d. In order to provide acceptable living or working environments, sound levels due to the systems shall comply with the recommended design criteria given in the CIBSE Guide. Specific attention shall be given to the selection of fans (including those for condensers and cooling towers) motors, fan coil units, terminal units, grilles, diffusers, the internal finish, arrangement, and air flow velocities of distribution ductwork in order to achieve the required noise levels.

Acoustic louvers or screening may be required around air-cooled condensers or cooling towers to reduce noise transmission to surroundings.

- e. Noise level information for the above equipment, based on octave band analysis data together with the reference level and testing technique shall be provided for BP approval.
- f. Sound attenuators shall be sized and / or acoustic lining provided in the ductwork, as required for design noise levels.
- g. Where necessary, duct sizes shall be increased to maintain the same cross sectional area.
- h. Acoustic insulation shall also be applied to ductwork externally to prevent noise transfer where an intrusive noise from any source is unacceptable and where duct mounted sound attenuators are not sufficient.
- i. Rotating assemblies shall be balanced in accordance with ISO 1940.
- j. All air conditioning units, ventilation fans, pumps, compressors and water chilling units shall be mounted on anti-vibration mountings of the metal to rubber bonded in shear type so that all units are mechanically isolated from the main structure.
- k. Where large amplitude is required, spring isolators incorporating rebound damping shall be provided.
- l. Anti-vibration mountings, which shall have means of levelling, shall be selected for the particular application of machinery and location, providing not less than 95% isolation from the disturbing force.

10. Equipment

10.1. General

- a. Equipment shall be selected with due consideration to the location of the installation (coastal sites being far more severe on the life expectancy of plant than inland installations) and the particular application.
- b. The equipment supplied shall be of robust construction of a proven design suitable for the specified hours of operation.
- c. All equipment shall be suitable for its intended purpose and provide safe use under all known operating conditions including overload if anticipated.
- d. Protective devices shall be incorporated where necessary for personnel safety.

10.2. Ductwork and fittings

There are two main categories of ductwork systems.

