MANUAL

HEATING, VENTILATION AND AIR CONDITIONING FOR PLANT BUILDINGS

DEP 31.76.10.10-Gen.

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DESIGN AND ENGINEERING PRACTICE

PREFACE

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The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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TABLE OF CONTENTS

APPENDICES

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the indoor climate of **plant buildings** and for the design and engineering of HVAC systems. It takes into account the requirements for both people and electronic equipment. This DEP is intended primarily to apply to new plant buildings; for "revamps" of existing installations it is intended that this DEP should be followed as far as is practical, in consultation with the Principal.

This DEP is a revision of the DEP of the same number dated April 1994.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this document is confined to companies forming part of or managed by the Royal Dutch/Shell Group, and to Contractors nominated by them (i.e. the distribution code is "C", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants and in exploration and production installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this document as closely as possible.

1.3 CROSS-REFERENCES

Where cross-references are made, the number of the section or sub-section referred to is shown in brackets.

All publications referred to in this document are listed in (6).

1.4 DEFINITIONS

For the purpose of this DEP, the following definitions shall hold:

1.4.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4.2 Specific definitions

Air handling unit (Re-circulation). HVAC equipment through which air is transported and transformed to the required conditions by filtration, heating, cooling (including dehumidification by means of condensation) and humidification. Re-circulation air handling

units may form part of an HVAC ducting system.

Air handling unit (Self-contained). An air handling unit, located in the space which it serves, which re-circulates the air in that space to the required conditions. A self-contained air handling unit does not normally involve a ducting system.

Chilled water unit (Compressor type). A unit similar to a direct expansion (DX) chiller but including a heat exchanger which utilises the vaporising refrigerant's latent heat to cool a chilled water circuit to the required temperature.

Direct expansion (DX) chiller. A unit consisting of a compressor and a condenser. The refrigerant vapour is compressed to a certain pressure, condensed to liquid refrigerant and then vaporised, thus utilising the vaporising refrigerant's latent heat in a cooling coil (separate from the chiller). The vaporised refrigerant is returned from the coil to the compressor.

(Dry-bulb) Temperature. The temperature of the air indicated by an accurate thermometer.

Electronic/Electrical equipment. Indoor electronic and electrical equipment, including microprocessor based control, safeguarding, telecommunication, computer, power supply and switchgear systems.

Fan coil unit. HVAC equipment through which air is re-circulated from the space in which it is located. The purpose of this re-circulation is to cool or heat this air to the conditions required for the space. This unit is normally connected to the chilled water system.

Fresh air ventilation unit. An air handling unit in which the fresh air is handled to the required conditions and used as ventilation air.

Human comfort. Is defined by the environmental parameters of temperature, radiation, humidity and air movement necessary for thermal comfort and depends on the individual's clothing and activity level. In a control building occupants will typically be sedentary or slightly active and wearing indoor clothing.

Humidity (Relative). The ratio of the weight fraction of water vapour present in the air to the weight fraction of water vapour present in saturated air at the same temperature and barometric pressure.

HVAC system. A heating, ventilation and air-conditioning system which maintains the temperature, relative humidity and air quality in a room or building within defined limits.

Interruptible, maintained electrical supply. A source of electrical power which is backed up by a second (emergency) source of power to provide a supply of electricity that may be interrupted for no more than 15 s.

Plant buildings. Buildings such as control buildings, field auxiliary rooms (FARs), analyser houses, electrical substations and others (e.g. dedicated flow metering buildings). Such buildings may contain different types of rooms. HVAC electrical equipment shall be suitable for the applicable hazardous area. Refer to DEP 32.31.50.13-Gen. for further safety requirements for analyser houses.

Uninterruptible maintained electrical supply. A source of electrical power, which is backed up by a second (emergency) source of power to provide a supply of electricity that may be interrupted for no more than 0.5 ms.

Vital electronic equipment. Electronic equipment which, if failing in operation or when actuated, can cause a process upset, an unsafe condition of the process and/or electrical installation, can jeopardise life, or can cause major damage to the installation.

Vital HVAC system. A HVAC system meant for vital rooms only.

Vital rooms. Rooms containing vital electronic equipment (e.g. instrument auxiliary room, electrical auxiliary room, telecommunications room) and continuously manned rooms (e.g. control room).

1.5 SUMMARY OF CHANGES SINCE LAST REVISION

This revision has been primarily editorial, including updating of references. The only

significant non-editorial changes are:

Appendix 3.1, Appendix 3.2:

Clarification of actions to be taken for chillers and chiller pumps during abnormal situations.

2. GENERAL

Plant buildings may require climatic conditioning (i.e. heating, ventilation and/or air conditioning) in order to maintain the temperature, relative humidity and air quality within defined limits. In this way reliable operation of electronic equipment and human working conditions are enhanced.

HVAC systems are generally supplied by specialised Manufacturers as package units or as single components. Standard industrial HVAC equipment should be used.

It shall be ensured that sufficient space in plant buildings is reserved for HVAC equipment and its ducting.

3. DESIGN CONSIDERATIONS

3.1 HUMAN COMFORT

The temperature of rooms continuously occupied by people shall be between 20 and 26 °C, and the relative humidity between 20 and 80%. These requirements, based on ANSI/ASHRAE 55, should enable the majority of occupants to feel comfortable. ISO 7726 and ISO 7730 may also be consulted.

3.2 ELECTRONIC EQUIPMENT

3.2.1 General

Indoor electronic equipment should operate at a room temperature between 18 and 27 °C and a relative humidity between 35 and 75%. Under these conditions reliable and long-term operation of electronic equipment is expected if air contamination is restricted (3.2.2).

The above requirements are mostly congruent with IEC 60654-1, class A1 and IEC 60654-4, class 1.

NOTE: The relative humidity shall never exceed 95%, non-condensing.

3.2.2 Air contamination

Extremely low levels of air contaminants (e.g. a few parts per billion) may cause corrosion and affect the reliability of electronic equipment. Combination of contaminants may cause corrosion rates even higher than those expected from the individual components.

NOTES:
1. The application of chemical filters is not recommended for reasons of selectivity, maintenance and cost.
2. Expected air contaminants should be stated to determine any possibility of corrosion. Corrosion tests can be executed locally, based on the reactivity of copper and silver coupons as described in IEC 60654-4, to determine the affect of the expected air contaminants.
3. Humidity control is the first (and only) line of defence against corrosion due to air contamination.

3.3 INDOOR CLIMATE

3.3.1 Temperature and relative humidity

A general overview of required indoor climatic conditions in plant buildings is given in Appendix 1. Recommended climatic conditions for the various plant rooms are given in Appendix 2.

3.3.2 Air quality

Indoor or outdoor air may contain contaminants. These occur in the form of gases, vapours or dust. Acceptable levels of these contaminants are determined by considering human safety and comfort and/or safety and reliability of electronic equipment (3.2.2). ANSI/ASHRAE 62 will give guidance for an acceptable indoor air quality.

Detectors for flammable and toxic gas and their control systems are described in DEP 32.30.20.11-Gen. If the safety level (setting) of such detectors is exceeded, abnormal situations exist and certain actions shall be taken (see Appendices 3.1, 3.2, 3.3 and 3.4).

Ingress and distribution of dust particles in plant buildings shall be avoided by sealing of doors and incorporation of filters in air handling units.

For dusty environments, e.g. desert areas etc., additional measures shall be considered to avoid the entrance of dust into plant buildings. The design implications and deviations resulting from these measures shall be recorded and submitted to the Principal .

3.4 OUTDOOR CLIMATE

For various geographical locations, climatic data such as temperature, humidity, wind,

saline content of the atmosphere, chances of sand and dust storms, micro-climatic variations, etc., can be found in handbooks issued by bodies such as the UK Meteorological Office, London Road, Bracknell, Berkshire.

Such information is normally included in the project specification.

In general, the upper inlet air design temperature (dry bulb) for HVAC systems shall be the higher of the following:
- the highest air temperature that is exceeded for 400 hours per year;
- 4 °C lower than the highest air temperature that is exceeded for 40 hours per year.

The lower inlet air design temperature (dry bulb) for HVAC systems shall be determined from available meteorological data.

3.5 HEATING AND COOLING

3.5.1 Heating

Heating may be required to raise the temperature inside a building to the required level. In the heating capacity calculations the dissipated heat from personnel, lighting and electronic equipment shall not be included. Heat losses through walls, floors and roofs shall be taken into account.

The Contractor shall submit the "heating capacity" calculations to the Principal.

3.5.2 Cooling

Cooling may be required to lower the temperature inside a plant building to the required level.

Cooling capacity calculations should be based on heat gain from sources such as personnel, electronic equipment, lighting, fresh air intake, walls, roofs, windows etc.

The heat gain rates and calculations should be based on the data provided in ASHRAE Handbook "Fundamentals".

The heat gain from electronic equipment requires special attention and shall be based on data provided by the Vendors of the electronic equipment.

The Contractor shall submit the " cooling capacity" calculations to the Principal.

NOTE: Under all stated climatic conditions (3.3.1), condensation on air ducting and chilled water piping shall be prevented. Insulation shall be installed where necessary to achieve this.

3.6 FRESH AIR VENTILATION

3.6.1 General

Fresh air ventilation may be required in order to:

- provide a minimum fresh air intake quantity per unit of time;
- maintain an over-pressure in order to prevent the ingress of contaminants;
- compensate for specific exhausts such as those in a designated smoking area, a battery room or laboratory.

Requirements for fresh air ventilation systems are:

- A positive flow from outdoors to indoors and back shall be accomplished.
- The air flow direction shall be such that the flow is from clean rooms, e.g. control room, instrument auxiliary room, telecommunication room and computer room, to rooms with air polluting (fouling) equipment e.g. battery room, HVAC machine room, laboratory. Air from polluted rooms such as designated smoking areas shall be exhausted to outdoors.

3.6.2 Flow rates

(a) The ventilation flow rate for hydrogen generating batteries shall be as specified in DIN VDE 0510:

Q = 55 x h x I

Where: Q = litres of air per hour
h = number of cells
I = charging current at end of high rate charging, but not less than 25% of rated charge output.

For further details the electrical engineering department of the Principal should be contacted.

(b) The ventilation flow rate for analyser houses shall be as indicated in DEP 32.31.50.13-Gen.

3.6.3 Filtration

(a) Fresh air ventilation units for control buildings shall be provided with a pre-filter for 85% efficiency ASHRAE dust spot and an after-filter for 95% efficiency ASHRAE dust spot (dust spot tests according to ANSI/ASHRAE 52.1).

(b) Fresh air ventilation units for analyser houses shall be provided with a pre-filter for 85% efficiency ASHRAE dust spot test.

NOTES:
1. A dust collector shall be applied if the dust concentration at the fresh air intake is more than 10 mg/m^3.
2. Re-circulation air handling units shall be provided with 65% efficiency ASHRAE dust spot test filters.

3.7 NOISE AND VIBRATION

The Contractor shall confirm that the noise levels directly or indirectly caused by HVAC equipment are 10 dB(A) below the noise limits stated for the relevant rooms in DEP 31.10.00.31-Gen.

Noise caused by HVAC installations can be reduced by applying one or more of the following:

- air duct silencers;
- soundproofing of air ducts;
- quiet self-contained equipment;

To reduce vibration from rotating and vibrating items of equipment they shall be isolated from piping, ducting and structures by means of flexible piping, air duct connectors, vibration isolators, etc. For this subject reference is made to ASHRAE Handbook: "HVAC Applications: Sound and Vibration Control".

3.8 INDOOR CLIMATE TO BE MAINTAINED IN ABNORMAL SITUATIONS

The HVAC system design shall cater for abnormal conditions. The required working conditions for the electronic equipment shall be ensured during abnormal conditions.

3.8.1 Abnormal situations

For operation of HVAC during abnormal situations, refer to Appendices 3.1, 3.2, 3.3 and3.4.

3.8.1.1 Equipment in vital rooms

Typically, the following equipment shall stay in operation in all situations:

- all vital electronic process control and safeguarding equipment;
- all plant fire and gas detection and control equipment;
- all plant telecommunication equipment, including CCTV;
- all vital electrical equipment related to the above.

The Contractor shall submit a listing of vital equipment/vital rooms to the Principal, indicating the temperature and/or humidity limits beyond which the safe working conditions cannot be guaranteed.

3.8.1.2 Facilities required

In order to cope with flammable/toxic gases outside the plant building, one or more of the following features may be required:

(a) gas-tight, quick closing, spring-operated dampers in the fresh air intakes and exhausts;
(b) explosion-proof dampers in the fresh air intakes and exhausts;
(c) HVAC emergency shutdown switch(es).

3.8.2 Actions to be taken

For details on manual and automatic actions which shall be taken or occur during abnormal situations for vital and non-vital rooms refer to Appendices 3.1, 3.2, 3.3 and 3.4.

4. HVAC REQUIREMENTS FOR PLANT BUILDINGS

4.1 GENERAL

Fresh air ventilation is normally only required in control buildings and analyser houses. Other plant buildings need no ventilation as they are regularly visited by operation and/or maintenance personnel and normally have sufficient exchange of fresh air, thereby avoiding unacceptable indoor conditions.

HVAC systems shall not contain a CFC refrigerant. HFC or, in special cases, HCFC refrigerants should be used.

4.2 BLASTPROOF CONTROL BUILDINGS

Control buildings contain vital electronic equipment and are continuously manned.

4.2.1 Heating

LP steam or hot water may be considered as a heating medium for the central heating system. The fresh air ventilation unit and the re-circulation air handling units shall, if applicable, be heated through this central heating system.

If steam heating is applied, provisions should be made to avoid freezing of condensate lines and drains.

Vital rooms (e.g. control room, instrument auxiliary room, electrical auxiliary room etc.) should be heated through re-circulation air handling units.

For other rooms heating should be provided by either individual fan coil units, individual electric after-heaters or a central heating system.

4.2.2 Cooling

4.2.2.1 Rooms containing vital equipment

For cooling of rooms containing vital electronic equipment, self-contained air handling units are preferred for economic reasons.

Such units are located inside the rooms they serve.

In order to allow for maintenance and failure of such units, redundancy shall be provided. The capacity of the individual self-contained units shall be such that the normal climatic requirements are met even if one unit fails.

To cater for future extensions, 15 to 20% overall spare cooling capacity shall be included (e.g. take 2 x 115% or 3 x 60% etc. capacity units).

NOTE: The selection of 2 x n% units, with n being less than 100%, **is not permitted** since, if a unit fails, then case calculations are needed to determine both "rates of temperature rise" and "ultimate temperatures".

Also, time durations would have to be specified for the length of time which electronic equipment could be operated under such abnormal conditions without affecting its reliability. This is a complex and dubious method and shall therefore be avoided.

Normally, all available redundant air handling units are to be in operation. Failure of a redundant unit shall be displayed in the control room. Provisions shall be made to isolate units for maintenance purposes.

Self-contained units shall be of the down-flow type where the conditioned air is blown into the plenum under the computer floor. Condensation in the plenum shall not be allowed.

NOTE: Measures are required to prevent damage to the equipment in case of leakage of chilled water.

Humidity control shall be provided (3.2.2) by either the individual self-contained air handling units or by the central re-circulation air handling unit.

4.2.2.2 Control room

Cooling of a control room shall be provided by a central re-circulation air handling unit. Self-

contained air handling units are normally not applied as they usually do not satisfy the noise limit requirements (3.7).

4.2.2.3 Other rooms

Cooling of other rooms shall be provided by individual fan coil units unless the central re-circulation air handling unit can provide the cooling capacity requirements more economically.

4.2.2.4 Centralised chilled water system

If a centralised chilled water system is applied, the cooling capacity of each of the chilled water units shall be such that:

- if two units are installed and one fails the normal cooling capacity is still met;
- if three units are installed and two fail, the **vital** cooling capacity shall be met.

Chilled water systems shall be provided with condensers which should be of the air-cooled type. Water-cooled condensers should not be used as cooling water leakage may cause damage.

4.2.3 Fresh air ventilation unit

The fresh air is directed into the control building via a stack with a rain-proof and wire-screened intake. The concrete penthouse contains the intake safety devices (i.e. explosion-proof dampers and gas-tight dampers) and exhaust fans.

The exhaust systems from polluting rooms such as designated smoking areas, the laboratory and battery room shall be separately routed to the penthouse and be fitted with non-return valves.

The location of the gas detectors in the fresh air intake shall be specified by the Contractor and submitted to the Principal.

NOTE: Provisions shall be made to allow purging of the fresh air intake after gas has been detected.

To reduce the amount of require fresh air intake, the flow direction shall be from clean rooms to polluting (fouling) rooms. To prevent loss of over-pressure the main entrance and exit doors should be provided with air lock systems.

The fresh air heating capacity and the fresh air humidification, if applicable, shall be handled by the fresh air ventilation unit.

The fresh air ventilation unit should be provided with redundant fans to enable maintenance during normal operation.

4.2.4 Air distribution

All ducting required for fresh air ventilation and air re-circulation shall run along the ceiling.

Ducting shall not be installed inside the plenum under computer floors.

Air diffusing equipment shall be selected and installed so that it provides adequate air diffusion but prevents draughts in occupied rooms (i.e. air velocities of more than 0.2 m/s at a height of 2 m above floor level). For air diffusing equipment in the various rooms the following guidelines apply (see also Appendix 2):

- control room: cold air and exhaust diffusers should be installed on the ceiling;
- equipment rooms such as instrument auxiliary, electrical auxiliary and computer room: cold air diffusers should be installed on the computer floor (space permitting) and exhaust diffusers should be installed on the ceiling.

To prevent the spreading of smoke in case of fire, the air distribution systems shall consist of separate systems, to isolate the affected air distribution system by smoke/fire dampers. Certain rooms may in this respect be combined. NFPA 90A shall apply.

4.2.5 HVAC machine room

Main HVAC equipment such as the fresh air ventilation unit, the re-circulation air handling

unit for the control room, the chilled water generator, the hot water generator and relevant control panels/cabinets shall be located in the HVAC machine room.

In order to reduce the amount of ducting, the HVAC machine room shall be located as close as possible to those rooms which are served by the re-circulation air handling units.

NOTE: Condensers shall be located outside the control building on ground level.

4.3 NON-BLASTPROOF CONTROL BUILDINGS

The HVAC requirements for such a building are similar to those specified in (4.2) with the exception that explosion-proof dampers are not required;

NOTE: If the control building forms part of the administration area, the control building HVAC system may be combined with the administration area HVAC system provided that there is a facility to isolate the non-vital rooms from the control building HVAC system.

4.4 FIELD AUXILIARY ROOMS ("FARs")

FARs contain vital electronic instrument equipment and therefore shall be air-conditioned

The rooms in FARs are generally limited to instrument auxiliary rooms, electrical auxiliary rooms, battery rooms and HVAC rooms.

The HVAC system for a blastproof FAR is similar to that for blastproof control buildings (4.2) except that fresh air or pressurisation equipment and devices such as air intake stack, penthouse, gas-tight dampers, explosion proof dampers etc. are normally not required.

The HVAC system shall therefore comply with the requirements as specified in (4.2.1, 4.2.2 and 4.2.5).

For a non-blastproof FAR the same guidelines as for non-blastproof control buildings are to be applied. The HVAC system shall comply with the requirements as specified in (4.3).

4.5 ANALYSER HOUSES

Analyser houses may contain vital equipment and are normally unmanned. Although it is preferred that they be located in non-hazardous areas, they are sometimes located in or near a Zone 2 area (note also that the existence of the analyser house may itself cause the adjacent area to be classified as hazardous).

Analyser houses shall be provided with a forced fresh air ventilation unit (4.5.2) to prevent internally-released gases from forming explosive mixtures and to prevent the ingress of gases from outside.

NOTES:
1. The intake of fresh air shall always be from a non-hazardous location.
2. Installed equipment shall be suitable to operate in moderately contaminated air (IEC 60654-1, class 2).

4.5.1 Heating and cooling

If steam heating is applied provisions should be made to avoid freezing of condensate lines and drains.

Separate cooling facilities shall only be applied when the heat dissipation cannot be removed economically by the fresh air ventilation unit.

Direct expansion chillers or chilled water can be applied as a cooling medium.

4.5.2 Ventilation

The ventilation system shall comply with the requirements of DEP 32.31.50.13-Gen.

The fresh air ventilation unit shall be provided with a filter having an 85% efficiency ASHRAE dust spot test. Redundancy (e.g. double fans) should be provided.

The fresh air shall blow from ceiling-mounted diffusers and exhaust via a combined system of flush-mounted upper and lower wall diffusers. Sufficient dilution of the total space is required. Stagnant layers and/or corners shall be prevented in analyser houses.

NOTE: Light gases leave the space via the ceiling-mounted diffusers and heavy gases leave via the bottom diffusers.

The location of gas detectors, if required, in the fresh air intake shall be advised by the Principal.

HVAC electrical equipment shall be suitable for the applicable hazardous area. Refer to DEP 32.31.50.13-Gen. and DEP 32.30.20.11-Gen. for further safety requirements.

NOTE: HVAC equipment (chillers, air handling units, fan coil units, etc.) may not always be suitable for a Zone 2 or Zone 1 area classification. Therefore the location of such equipment shall be carefully chosen.

To facilitate installation and maintenance, HVAC equipment shall be located at ground level or in a basement.

4.6 ELECTRICAL SUBSTATIONS

Electrical substations are normally unmanned; they should not be provided with fresh air ventilation units.

NOTE: Cooling by means of fresh air ventilation may only be applied if the substation is located so that the likelihood of problems caused by dust, flammable, toxic or corrosive gases is negligible (e.g. when substations are located in administration areas).

4.6.1 Substations with fresh air ventilation

When permitted (see note under 4.6), fresh air intake ventilation should be provided by natural (non-forced) air circulation. Ventilation apertures shall exclude rain, snow and windborne debris.

If sufficient cooling cannot be achieved through natural ventilation, forced ventilation may be applied provided that this is more economical than cooling through air re-circulation units.

4.6.2 Substations without fresh air ventilation

Heating, if required, shall be provided by means of electric heaters which shall be thermostatically controlled and have totally enclosed heating elements.

If cooling is required it shall be provided by internal re-circulation air handling units having at least two direct expansion (DX) chiller units. One outdoor compressor/condenser unit shall be provided for each DX unit. The location of the DX units shall be such that:

- blowing of cool air directly into the switchgear will not occur;
- condensate shall not leak onto the switchgear. Condensate shall be drained to the outside of the building and, if relevant, measures shall be provided to prevent freezing;
- maintenance shall be possible without damaging the switchgear.

NOTE: The number and rating of DX units shall be such that the temperature inside the substation shall not exceed the normal conditions when one DX unit is out of operation (4.2.2.1).

To remove the heat gain from large variable speed drive systems (VSDS) chilled water may be required as a cooling medium. In such cases the chilled water system may also be applied for total substation cooling.

NOTES:
1. To avoid loss of the VSDS equipment in case of failure of a chilled water unit, certain redundancy measures may be required, for example 2 x 100-115% chilled water units and 2 x 100-115% chilled water pumps.

2. Measures shall be taken to avoid damage due to chilled water leakage.

5. CONTROL AND ELECTRICAL REQUIREMENTS

5.1 CONTROL, ALARMING, LOGGING AND MICROPROCESSOR-BASED CONTROL SYSTEMS

5.1.1 Control and alarming

HVAC control and alarm systems shall be in line with the HVAC vendor's standards. HVAC control systems should at least include the following:

(a) Temperature control

- for constantly manned rooms (e.g. control room, shift supervisor room);
- for certain rooms which are less frequently used (e.g. meeting rooms, mess rooms etc.);
- for equipment rooms and buildings (e.g. instrument auxiliary room, electrical auxiliary room, computer room, electrical substations and FARs).

(b) Humidity control

- for all rooms and buildings where vital electronic equipment is installed;
- for continuously manned rooms where the outside climate is so extreme that the humidity requirements of (3.1) are not reliably achieved without humidity control.

Control systems shall normally operate in automatic mode but manual operation shall be possible.

HVAC alarms shall be individually displayed on local HVAC panels. Common HVAC alarm signals generated by the HVAC control system and displayed on the DCS screen in the main control room shall be routed either via potential-free contacts and interface boxes or via software links. First failure alarm detection is not required. "Mimic" type alarm display panels (ADP) are not required.

Control signals coming from an HVAC control system cabinet and going to an HVAC motor control centre (power) cabinet shall pass via an interface box. The HVAC control/alarm cabinet and the motor control centre (power) cabinet shall be physically separated. For central air handling units, both cabinets should be located in the HVAC machine room.

5.1.2 Logging

For rooms in which vital electronic equipment is installed, permanent long-term monitoring of temperature and relative humidity is required if specified by the Principal.

5.1.3 Microprocessor-based control systems

Microprocessor-based control systems such as Programmable Logic Controllers (PLCs) should be used.

For buildings containing both the control room(s) and administration offices, the integration of HVAC control systems and the Building Automation System shall be considered.

For engineering requirements of both PLC and Building Automation Systems the Principal shall be consulted.

5.2 ELECTRICAL POWER SUPPLY AND ELECTRICAL SAFETY

5.2.1 Electrical power supply

The electrical power supply for vital HVAC systems (units) shall be either AC interruptible maintained or AC uninterruptible maintained, as follows:

vital HVAC control systems and local panels:	AC uninterruptible maintained electrical supply
vital re-circulation air handling units (including ventilators, pumps and chilled water system):	AC interruptible maintained electrical supply

For a typical single-line diagram for a HVAC electrical power supply system refer to Appendix 4.

5.2.2 Electrical safety

The type of protection for the electrical apparatus installed shall comply with the requirements defined in IEC 60079-14.

5.3 INSTRUMENT AIR SUPPLY

Pneumatic instrumentation shall be connected to the "priority instrument air header". Refer to DEP 31.37.00.11-Gen.

5.4 HUMIDIFIERS

When humidification is required, steam humidification shall be employed and the humidifiers should be connected to the drinking water system. The water quality shall be checked with respect to the humidifiers applied.

Precautions shall be taken to avoid excessive fouling of humidifiers.

5.5 TEST EQUIPMENT

Unless otherwise specified by the Principal, the Supplier of the HVAC system shall provide all test equipment required to commission and maintain the whole HVAC system. Test equipment may include gauge manometers, anemometers, Pitot tubes, hygrometers, thermometers, tachometers, sound analysers, vibration meters, recorders (for tuning control loops), etc.

The Contractor/Supplier shall submit a proposed list of test equipment to the Principal.

5.6 HAND-OVER DOCUMENTS

The final documentation shall at least include:

- engineering flow schemes ('as built');
- design criteria and data summary;
- layout and location drawings for each plant building;
- calculation sheets for ventilation rates, pressurisation, normal and abnormal cooling, heating load etc;
- control and alarm schemes;
- electrical power supply and distribution drawings;
- hardware/software related drawings for control, alarm and shutdown functions;
- start-up, shutdown, trouble shooting and regular maintenance procedures;
- operating manuals;
- technical data books and spare parts listings;
- certification or declaration that all electrical equipment is suitable for use in hazardous areas (where applicable).

The Contractor/Manufacturer/Supplier shall submit a listing of hand-over documents to the

Principal.

6. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEPs and standard specifications	DEP 00.00.05.05-Gen.
Noise control	DEP 31.10.00.31-Gen.
Instrument air supply	DEP 31.37.00.11-Gen.
Fire, gas and smoke detection systems	DEP 32.30.20.11-Gen.
On-line process stream analysis: Analyser houses	DEP 32.31.50.13-Gen.

AMERICAN STANDARDS

ASHRAE Handbook: "Fundamentals".

ASHRAE Handbook: "HVAC Applications": Sound and Vibration Control

Method of testing air-cleaning devices used in general ventilation for removing particulate matter	ANSI/ASHRAE 52.1
Thermal environmental conditions for human occupancy	ANSI/ASHRAE 55
Ventilation for Acceptable Indoor Quality	ANSI/ASHRAE 62

Issued by:
American Society of Heating, Refrigeration and Air-Conditioning Engineers Incorporated
1971 Tullie Circle NE, Atlanta, GA 30329, USA.

Standard for the installation of air conditioning and ventilating systems	NFPA 90A

Issued by:
National Fire Protection Association
470 Atlantic Avenue
Boston, Massachusetts, MA 02210, USA.

GERMAN STANDARD

Specification for electric storage batteries and battery plants	DIN VDE 0510

Issued by:
Deutsche Institut für Normung e.V.,
Beuth Verlag GmbH
Burggrafenstrasse 4 - 10
1000 Berlin 30
Germany.

INTERNATIONAL STANDARDS

Electrical apparatus for explosive gas atmospheres

Part 14: Electrical installations in hazardous areas (other than mines)	IEC 60079-14

Industrial-process measurement and control equipment; operating conditions

Part 1: Climatic conditions	IEC 60654-1
Part 4: Corrosive and erosive influence	IEC 60654-4

Issued by:

International Electrotechnical Commission
Central Office (Sales Department)
P.O. Box No. 131
3 Rue de Varembé
1211 Geneva 20
Switzerland.

Thermal environments – Instruments and methods for measuring physical quantities	ISO 7726
Moderate thermal environments – Determination of the PMV and PPD indices and specification of the conditions for thermal comfort	ISO 7730

Issued by:
International Organisation for Standardisation
1 Rue de Varembé
CH-1211 Geneva 20
Switzerland

Copies can also be obtained through the national standards organisations

APPENDIX 1 GENERAL OVERVIEW OF CLIMATIC CONDITIONS IN PLANT BUILDINGS

Building type	Temperature °C		Relative Humidity %	
	Human Comfort	Equipment	Human Comfort	Equipment (1)
Control building	20-26	18-27	20-80	35-75
Field auxiliary room	-	18-27	-	35-75
Analyser room	-	18-27	-	35-75
Electrical substation	-	5-35	-	35-75

NOTE: (1) Requirements are dictated by mechanical devices such as printers, video copiers, disk drives etc.

APPENDIX 2 CLIMATIC CONDITIONS FOR VARIOUS PLANT ROOMS

Space	Normal (1) DB Temp.		Normal (19) % RH		Ventilation		Over-pressure	Filter Specification		Condition of Room	Internal Air Recirculation		Type of Air Distribution (20)	
	Min. °C (16)	Max. °C (16)	Min. % RH	Max. % RH	Required	Rate (18)	Pa (14)	Fresh Air %	Recirc. Air %	(2)	Required	Separate	Fresh Air blown from	Used Air Removal from
Control Building														
Control Room	20	26	35	75	Yes	10 l/s m^2 (3)	30	95 (4)(5)	65 (4)	Clean	Yes	Yes (6)	Top	Top
Instr. Aux. Room	18	27	35	75	No	-	-	-	65 (4)	"	"	" (7)	Bottom	"
Electr. Aux. Room	18	27	35	75	No	-	-	-	65 (4)	"	"	" (7)	Top (8)	"
Telecom. Room	18	27	35	75	No	-	-	-	65 (4)	"	"	"	Bottom	"
Computer Room	20	26	35	75	(13)	10 l/s m^2 (3)	30 (13)	95 (4)(5)	65 (4)	"	"	"	"	"
Telemetry Room	18	27	35	75	No	-	-	-	65 (4)	"	"	"	"	"
First Aid Room	20	26	20	80	(13)	10 l/s pers.	10 (13)	65 (4)	-	"	No	No	Top	"
Office	20	26	20	80	(13)	"	10 (13)	65 (4)	-	"	"	"	"	"
Meeting Room	20	26	20	80	(13)	17 l/s pers.	10 (13)	65 (4)	-	"	"	"	"	"
Mess Room	20	26	20	80	(13)	"	10 (13)	65 (4)	-	"	"	"	"	"
Laboratory	20	26	35	75	(13)	(9)	10 (13)	95 (4)(5)	-	Foul	"	"	"	"
Battery Room	18	27	35	75	(13)	(10)		65 (4)	-	"	"	"	"	"
HVAC Mach. Room (15)	18	27	20	80	(13)	1 l/s m^2	10 (13)	65 (4)	-	Clean	"	"	"	"
Corridor	15	26	20	80	(13)	"	10 (13)	95 (4)(5)	-	"	"	"	"	"
Staircase	15	26	20	80	(13)	"	10 (13)	65 (4)	-	"	"	"	"	"
Toilet	20	26	20	80	(13)	5 l/s m^2	10 (13)	65 (4)	-	"	"	"	"	"
Wash/dressing Room	20	26	20	80	Yes	"	10	65 (4)	-	"	"	"	"	"
Shower Room	20	26	20	80	Yes	10 l/s m^2 (11)	10	65 (4)	-	"	"	"	"	"
FAR														
Instr. Aux. Room	18	27	35	75	No	-	-	-	65 (4)	Clean	Yes	Yes (7)	Bottom	Top
Electr. Aux. Room	18	27	35	75	No	-	-	-	65 (4)	"	"	" (7)	Top (8)	"
Battery Room	18	27	35	75	(13)	(10)	-	-	-	Foul	No	No	"	"
Analyser House	18 (17)	27 (17)	35	75	Yes	12 ACh or 6 l/s anal.	25	85 (4)	-	Clean (12)	No	-	Top	Top and Bottom
Electrical Substation	5	35	35	75	No	-	-	-	-	Clean	Yes	-	Top	Top

NOTES: (1) The Control Point (= Set point) shall be adjustable within the 'normal' temperature range stated. The Control Point is normally set at 22 °C; the Control Point Tolerance shall not exceed +/- 2 °C.

(2) "Clean" means : Clean conditions are required, the generation of fouling (polluting) substances is not expected.

"Foul" means : Fouling (polluting) substances may be generated.

(3) or at least 0.5 air changes per hour.

(4) Efficiency ASHRAE dust spot test, according to ASHRAE 52.

(5) Pre-filter for 85% and an after-filter for 95%. Both efficiencies according to Note 4.

(6) Separate air re-circulation system is required to cope with spread of smoke in case of fire in the control room.

(7) Air re-circulation system may be combined.

(8) If a raised floor is available, from the bottom.

(9) User to specify. The air is exhausted via the fume hoods.

(10) See DIN VDE 0510.

(11) At least 20 l/s per shower head.

(12) Refer to Appendix 3.3.

(13) Principal to confirm.

(14) (Over)pressure control is not required.

(15) Temperature and humidity determined if applicable by control (electronic) equipment.

(16) Minimum temperature in principle holds for heating capacity calculation (at minimum outdoor temperature).

Maximum temperature in principle holds for cooling capacity calculation (at maximum outdoor temperature).

To be verified with Principal.

(17) To be verified with Principal.

(18) Units:

l/s	=	litres per second
l/s pers.	=	litres per second per person
l/s m^2	=	litres per second per square metre
ACh	=	number of air changes per hour
l/s anal.	=	litres per second per analyser

(19) The Control Point (= Set point) shall be adjustable within the 'normal' Relative Humidity range state.

The Control Point is normally set at 45% Relative Humidity (RH); the Control Point Tolerance shall be +/- 5% RH.

(20) The air circulation shall have a mean air velocity of less than 0.2 m/s.

APPENDIX 3.1 BLASTPROOF and NON-BLASTPROOF CONTROL BUILDINGS (VENTILATED)

(Actions to be taken, or occurring, during Abnormal Situations)

Description Equipment		ABNORMAL SITUATIONS				
	Normal	Gas Detection in Fresh Air Intake	Gas/Fire/ Smoke (4) Detection in the Building	External Explosion	Mains Power Failure	Failure of (one) vital HVAC Unit
Fresh Air Ventilation Unit	Run	Stop & close dampers	Run (1)	Run (1)	Stop & close dampers	Run if redundant fan available
Air Handling Units (re-circulation or self-contained)	Run	Run	Run	Run	Run or Stop (2)	Redundant unit(s) run
Water Chillers	Run	Run	Run	Run	Run or Stop (2)	Redundant unit(s) run
Chiller Pumps	Run	Run	Run	Run	Run or Stop (2)	Redundant unit(s) run
Heating System	Run	Stop	Stop	Run	Stop	No redundancy
HVAC Control System	Run	Run	Run	Run	Run (3)	Run

NOTES:

1. The HVAC ESD switch is for stopping the fresh air handling unit and closing the air intake and exhaust.

2. Cooling should be stopped if the electronic equipment can withstand temperatures up to 60 °C and humidity up to 85 % for a period of 30 minutes (safe down period of the plant). Calculations shall cover the worst case scenario (scenarios with partly running equipment may be taken into account). If power is required, it should be obtained from an interruptible power supply (e.g. the available diesel generator).
   If the electronic equipment cannot withstand these conditions the HVAC system shall continue to run.

3. If the cooling stops, temperatures and humidity shall be recorded during the shut down period of the plant. The HVAC control system shall have a stand-alone back-up battery or shall be connected to the UPS system.

4. For measurements to air distribution, see (4.2.4).

APPENDIX 3.2 BLASTPROOF AND NON-BLASTPROOF FIELD AUXILIARY ROOMS (NON-VENTILATED)

(Actions to be taken, or occurring, during Abnormal Situations)

Description Equipment	Normal	ABNORMAL SITUATIONS				
		Gas Detection in Fresh Air Intake	Gas/Fire/ Smoke (4) Detection in the Building	External Explosion	Mains Power Failure	Failure of (one) vital HVAC Unit
Fresh Air Ventilation Unit	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Air Handling Units (Re-circulation or self-contained)	Run	N.A.	Run	Run	Run	Redundant unit(s) run
Water Chillers	If applicable, Run	N.A.	Run	Run	Run or Stop (1)	Redundant unit(s) run
Chiller Pumps	Run	N.A.	Run	Run	Run or Stop (1)	Redundant unit(s) run
Heating System	Run	N.A.	Run	Run	Stop	No redundancy
HVAC Control System	Run	N.A.	Run	Run	Run (2)	Run

NOTES:

1. Cooling should be stopped if the electronic equipment can withstand temperatures up to 60 °C and humidity up to 85 % for a period of 4 hours (safe down period of the plant and equipment). Calculations shall cover the worst case scenario (scenarios with partly running equipment may be taken into account). If power is required, it should be obtained from an interruptible power supply (e.g. the available diesel generator).
   If the electronic equipment cannot withstand these conditions the HVAC system shall continue to run.

2. If the cooling stops, temperatures and humidity shall be recorded during the shut down period of the plant. The HVAC control system shall have a stand alone back-up battery or shall be connected to the UPS system.

3. If electronic equipment does not comply with temperature and humidity requirements as mentioned under 1), the HVAC shall be designed to ensure the working conditions of the electronic equipment. The Contractor shall check the working conditions of the electronic equipment.

4. For measurements to air distribution, see (4.2.4).

APPENDIX 3.3 ANALYSER HOUSES (VENTILATED)

(Actions to be taken, or occurring during Abnormal Situations)

	Normal	ABNORMAL SITUATIONS				
		Flammable Gas Detection in Fresh Air Intake	Toxic Gas Detection in Fresh Air Intake (4)	External Explosion	Mains Power Failure	HVAC Redundancy if QMI is vital
Fresh Air Ventilation Unit	Run	Run (1)	Run (1)	Run	Stop	Yes
Air Handling Units (3) (Re-circulation or self-contained)	N.A.	N.A.	N.A.	N.A.	N.A.	Yes
Chilled Water System (If applicable)	Run	Run	Run	Run	Stop	No
Heating System	Run	Stop	Run	Run	Stop	No
HVAC Control System	Run	Inactive standby	Run	Run	Stop	No

NOTES:

1. Actions to be taken shall be subject to the safety measures defined in DEP 32.31.50.13-Gen.

2. Inside the analyser house, electrical apparatus which is required to run in case of a ventilation failure shall have a type of protection in compliance with IEC 60079-14 (zone 1).

   Outside the analyser house, electrical apparatus shall have a type of protection in compliance with IEC 60079-14 suitable for the particular area classification (typically zone 2).

   Hot surfaces shall comply with the appropriate temperature class.

3. Typically located outside the analyser house.

4. Actions to be taken if gas is detected **inside** the analyser houses are specified in DEP 32.31.50.13-Gen.

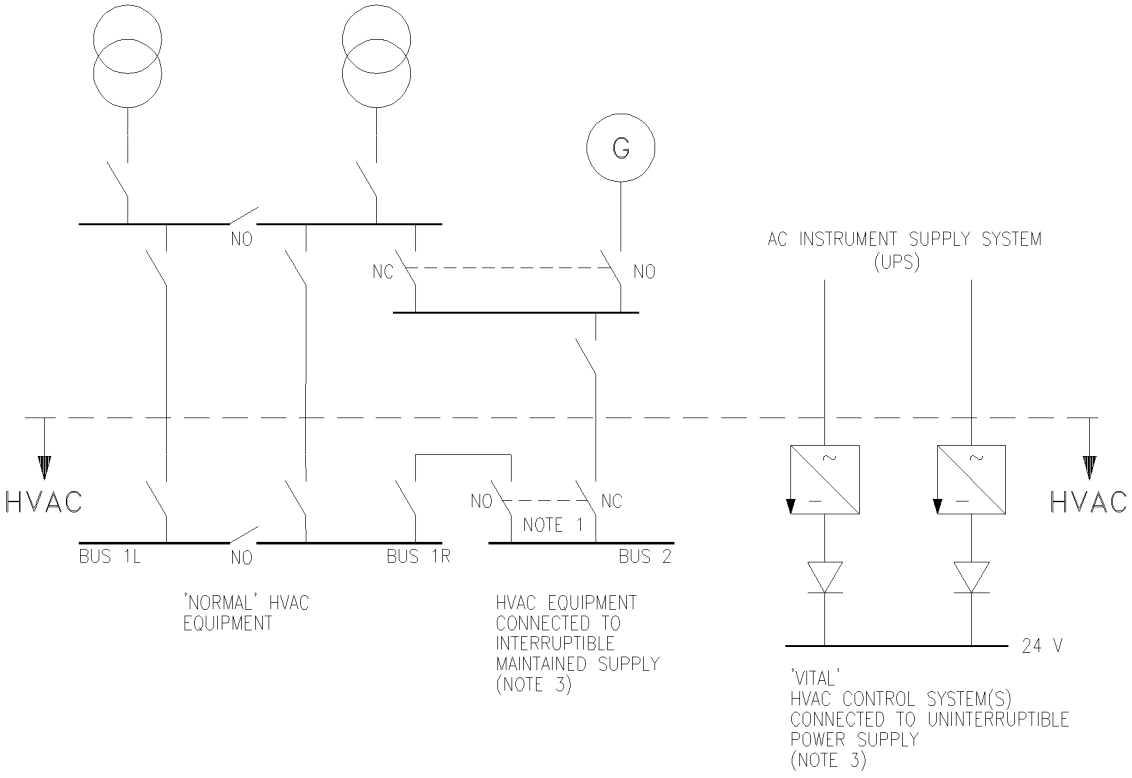
APPENDIX 3.4 ELECTRICAL SUBSTATION (NON-VENTILATED)

(Actions to be taken, or occurring, during Abnormal Situations)

		ABNORMAL SITUATIONS					
	Normal	Gas Detection in Fresh Air Intake	Gas/Fire/ Smoke Detection in the Building	External Explosion	Mains Power Failure	Failure of one HVAC Unit (no redundancy)	Failure of one HVAC Unit (with redundancy)
Fresh Air Ventilation Unit	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Air Handling Units (Re-circulation or Self-contained)	Run	N.A.	Run	Run	Stop	Stop	Redundant unit(s) Run
Heating System	Run	N.A.	Stop	Run	Stop	Stop	Run
HVAC Control System(1)	Run	N.A.	Run	Run	Run	Run (1)	Run

NOTE : 1. If the cooling stops, temperatures and humidity shall be recorded during the shut down period of the plant. A separate battery package should be provided to power the HVAC control System.

APPENDIX 4 TYPICAL SINGLE LINE DIAGRAM FOR (HVAC) ELECTRICAL SYSTEM



NOTES:

1. CHANGE-OVER SHOULD ONLY OPERATE IN CASE OF UNDERVOLTAGE AT BUS 2, WITH THE VOLTAGE ON BUS 1R PRESENT.
2. ALL ABNORMAL SWITCH POSITIONS SHALL BE ALARMED.
3. NOT APPLICABLE FOR HVAC IN AN ELECTRICAL SUBSTATION.