HVAC Design for Oil and Gas Facilities

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A. Bhatia

Continuing Education and Development, Inc.

P: (877) 322-5800
info@cedengineering.com

HVAC for Oil & Gas Facilities

Oil refineries, processing plants, pipelines, storage farms, LPG/LNG plants, and offshore platforms all utilize or produce a wide range of hazardous combustible and toxic gases. In addition, the processes involved in each can produce non-toxic gases which, when accumulated in high concentrations, depletes oxygen causing a hazardous condition to personnel who occupy the area without proper protection.

The first and foremost factor in design and installation of heating, ventilation and air-conditioning (HVAC) services in oil and gas (O&G) facilities is "SAFETY", which overrules any other activity. Two important objectives must be fulfilled:

1. Occupants' survival
2. Continuation of the specific activities carried out in these structures

This aspect is more relevant and important for off-shore platforms as these facilities are prone to toxic gas releases, which can get pumped out along with crude oil or gas, besides the fire hazard, which is relatively easier to comprehend. These two hazards combined together can play havoc with human life besides damaging the costly equipment that will have an effect on operations downstream.

Design Objectives

Considering the occupational hazards, the HVAC systems must be designed, installed and operated with utmost care and thought given to reliability of design and equipment performance. Specific design objectives include:

1. Maintaining environment conditions (temperature and humidity) appropriate to the operating requirements.
2. Maintaining pressurization between hazardous and non-hazardous areas.
3. Dilution and removal of potentially hazardous concentrations of flammable / toxic gaseous mixtures in hazardous areas.
4. Filtration of dust, chemical contaminants and odours through chemical and carbon activated filters.

5. The isolation of individual areas and control of ventilation in emergency conditions, through interface with the shutdown logic of the fire and gas detection and alarm safety systems.

<u>Operation Objectives</u>

The HVAC systems should respond appropriately to the emergency shutdown and provide for operation of essential services during an incident. Specific requirements include:

1. HVAC services to all areas should normally be fan powered, except where it can be demonstrated that natural ventilation can provide adequate safety protection to the Installation.

2. HVAC systems should run continuously. During an emergency, certain parts of the system may still be required to operate.

3. HVAC systems serving spaces where area classification depends on ventilation or where operational aspects require extensive ventilation availability shall have back-up capacity/ adequate standby /redundancy.

4. HVAC systems required for operation during emergency situations shall be powered from dual power sources i.e. main supply as well the emergency power system. The changeover between the normal and main supply shall be reliable and automatic during failure.

5. Due cognizance should be given to fire and smoke control requirements of HVAC services during and after an emergency.

This course will help explain the complexities of designing offshore installations and how to go about carrying out the design and selection of a proper HVAC system and related equipment.

What's so special for Offshore Installation!

Safety Considerations

An offshore platform is uniquely hazardous in that persons are miles out to the sea and surrounded by huge quantities of combustible material and other toxic gases. The size and composition of the crew of an offshore installation will vary greatly from platform to platform. Because of the cost intensive nature of operating an offshore platform, it is important to maximize productivity by ensuring work continues 24 hours a day. This means that there are essentially two complete crews onboard at a time, one for day shift and the other for night shift. Crews will also change out at regular intervals, nominally two weeks.

The nature of the operation — extraction of volatile substances sometimes under extreme pressure in a hostile environment poses significant risks. To give an idea, in July 1988, 167 people died when Occidental Petroleum's Alpha offshore production platform, on the Piper field in the North Sea, exploded after a gas leak. The accident greatly accelerated the practice of providing living accommodations on separate rigs, away from those used for extraction. The toxicity and the danger of Hydrogen Sulphide (H_2S), which is the most commonly, found gas in oil fields is immense. Even an exposure of 10ppm concentration of H_2S for about an hour will bring about loss of sight and damage to the brain. Exposure to 200ppm concentration for duration of less than 5 minutes can result in death.

Since HVAC involves handling air, which can get contaminated with gases, monitoring the air quality is crucial. Adequate care has to be taken to prevent gas ingress into accommodation areas, restrict air flows to prevent spread of gas or fire into surrounding areas and to ensure safe evacuation of personnel.

Labour and Logistical Cost

While the rig is drilling nothing can stop it, because depending on the depth being drilled, you can lose all of the drill and that can costs millions. The HVAC downtime can cause a substantial loss in productivity and can result in the loss of millions of dollars in capital investment.

The cost of offshore installation is prohibitively high in range of 4 to 5 times that of normal work location. The importance of detailed engineering can not be underestimated, prior to taking up the installation. The idea is to reduce offshore work as much as possible, except the final hook-up which can only be done offshore.

Also on the sea, the amount of maintenance possibilities will be limited - and costly. You have to have redundancy, especially with the air conditioning for critical areas such as main control room, switchgear rooms and areas like that.

Space Constraints

The space is at premium on any offshore installation, due to the high cost of structural, protective coating and allied requirements. Since HVAC is only one of the services required for the installation, the HVAC engineer will usually find himself on the defensive on the space aspect as well. Most of the time, the equipment manufacturer's space requirements cannot be made available in a straight forward manner. The HVAC engineer will be required to justify the space requirements for installation and maintenance with proper documentation. In most of the cases, adequate drawings will have to be made to prove that required access space will be available. Since all services are virtually “fighting” for space, the need for proper engineering, co-ordination with other services and clash checking cannot be underestimated.

Constructional Features

The constructional features of any platform will naturally be different from those found onshore, mainly due to the corrosion resistance and fire rating required for the external walls/decks and a number of internal walls/decks. The codes and the statutory requirements for offshore facilities are very stringent.

Majority of the offshore installations are in a classified area and therefore the equipment needs to be certified for compliance with the relevant hazardous area requirement and standards.

Engineering Documentation

Offshore facilities are subject to thorough third party evaluation and certification by agencies such Lloyds, ABS, etc. for compliance to specifications, good engineering practices and statutory codes and standards. Any deviation or compromise will result in costly repair or modification works as any work carried out offshore will be extremely costly. Needless to say, engineering documentation is of utmost importance through all phases of installation. All equipment shall be identifiable with tag numbers, keeping in line with the design and engineering philosophy of the project. These tag numbers should appear in all drawings and documents to facilitate easy and fast reference.

A comprehensive documentation of HVAC systems is essential for a proper and complete evaluation. The documentation should cover design, operation and performance qualifications of the system. The design documentation is likely to include, but may not be limited to following:

1. Identification of various systems, their functions, schematics & flow diagrams, sensors, dampers valves etc., critical parameters & fail-safe positions.

2. Layout plans showing various rooms & spaces and the critical parameters like:

   - Room temperature
   - room humidity
   - Room pressures and differential pressures between room and room and passages
   - Process equipment locations and power inputs
   - Critical instruments, recorders and alarms, if any

3. Equipment performance and acceptance criteria for fans, filters, cooling coils, heating coils, motors & drives.

4. Duct & pipe layouts showing air inlets, outlets air quantities, water flows and pressures.

5. Control schematics and control procedures.

What can HVAC do?

1. Maintain acceptable working and living environment for personnel and for equipment.

   - Offshore facilities are high in humidity, which needs to be controlled to comfortable levels of 50 ± 5%.
   - Comfort temperature range is 75±2°F and low temperature may be required where sensitive equipment is placed. The temperatures are generally not required to exceed 40°C in the electrical substations.

2. Provide air filtration to control airborne particles, dust and toxic odours. The filtration for off-shore facilities may include the activated carbon and chemical filtration.

3. Provide dilution ventilation

- To maintain an atmosphere where the gas/air mixture is kept below lower explosion limit (LEL) during normal operation.
- To reduce the risk from build-up of potentially explosive / toxic gases within these spaces.

4. Maintain room pressure (delta P) – space pressurization per the area classification.

   - To prevent smoke spreading and keep enclosed escape ways free of smoke in case of fire.
   - To prevent ingress of potentially explosive / toxic gas-air mixtures into non-hazardous areas, electrical switch rooms and equipment rooms.

What HVAC can't do?

- HVAC systems are not intended to prevent the catastrophic events such as release of toxic and/or hazardous gases.
- HVAC can not compensate of its own, for the intrinsic safety design features such as structural stability, coatings, area segregation, fire protection systems etc. It only aids the safety process.

What is expected from an HVAC designer?

The HVAC designer must be skilled and experienced to work on O& G facilities. He/she should be sensitive to the threats posed and should be able to address and incorporate the appropriate detail following appraisal of the various design parameters. He/she should have:

1. Knowledge of Area Classification

   ✓ Potential hazardous gases and their likely sources

   ✓ Segregation of hazardous and non-hazardous areas

   ✓ Pressure differential between segregated areas

2. Knowledge of Fire Safety

   ✓ Fire protection design and its integration with HVAC systems

- ✓ Passive fire protection measures such as compartmentation, zoning, fire proofing, right classification of fire rating materials and pressurization.
- ✓ Smoke and gas control philosophy (i.e. prevention of ingress of smoke or gas into accommodation spaces, control stations, enclosed escape routes or enclosed muster areas).

3. Knowledge of HVAC System & Equipment

- ✓ Equipment selection appropriate to operating conditions (corrosive and saline environment)
- ✓ Orientation of a fixed platform in order to maximize benefit from natural ventilation
- ✓ Standardization of components used in HVAC systems in order to provide interchangeability between systems
- ✓ Equipment redundancy and standby philosophy

4. Knowledge of Control Philosophy

- ✓ Emergency shutdown and emergency power philosophies
- ✓ DCS
- ✓ Field Instrumentation

It is very important that engineering is done accurately the first time, complying with all codes and standards.

HVAC DESIGN CONCEPTS

Area Classification

Area classification enables all parts of the Installation to be identified as one of the following:

1. Zone 0 (Hazardous Areas), in which an explosive gas / air mixture is continuously present or present for long periods.

2. Zone 1, in which an explosive gas / air mixture is likely to occur in normal operation.

3. Zone 2, in which an explosive gas / air mixture is not likely to occur in normal operation, and if it occurs it will exist only for a short time.

4. Non-hazardous areas - manned and un-manned areas in which an explosive gas / air mixture will not occur in normal operation.

As per the practice followed, ventilated space beyond 3 meters from the periphery of a *zone 1* space is considered as *zone 2*. Similarly, ventilated space beyond 3 meters from the periphery of *zone 0* spaces is considered as *zone 1. Zone 0* is obviously the area in which a source of such flammable gas exists. (Caution: the above is only a guideline, not a definition.)

Typically, the majority of HVAC equipment equipped with electrical motors or actuators in most of the offshore installations should be suitable for ***Zone 2*** requirements. In *Zone 1* areas, electrical equipment is generally avoided, as far as possible. HVAC equipment should not be installed in *Zone 1* areas, except for very essential exhaust equipment, on say, well head structures.

Fans and electrical components that are likely to operate during an emergency shutdown and/or exposed to hazardous environment during normal operation would need to be suitable for Zone 1 area classification and connected to an emergency power supply. Fans and electrical components located within non-hazardous enclosures, such as living accommodation, need not be rated for Zone 1 provided the HVAC system is arranged to shut down and isolate when gas is detected at the system air intake.

And in *Zone 0* areas, no electrical equipment, and hence no HVAC equipment, is considered at all, except works associated with instrumentation, which will invariably be provided through IS barriers. (Intrinsically Safe barriers limit the energy fed to a circuit to prevent explosions)

It should be noted that this area classification deals only with risks due to flammable gases and vapours and by implication flammable mists. It does not deal with dusts.

Classification of areas of the installation into hazardous and non-hazardous shall be in accordance with a recognized international standard or code for the protection of electrical apparatus and conductors both inside and outside of enclosed areas. These include:

- API RP 500B(9)
- BS 5345 Part 1, 1976(4) Part 2, 1983(5)
- I.P. Model Code of Safe Practice Parts 1(6) and 8(7)
- MODU Code(8)
- SOLAS

Access Openings

The access openings between hazardous and non-hazardous enclosures should be avoided. Generally entry/exit points on each deck level are provided with air locks from which return air will NOT be taken back to the Air Handling Unit (AHU). In such cases, the air supply requirement into the air lock will be governed more by the leakage area of the external door of the air lock, rather than the inside conditions, as inside conditions are not important for air locks, as no one stays in these rooms for long. *Air locks are small rooms with controlled airflows acting as barriers between spaces.*

Access openings into or between Zone 1 and Zone 2 hazardous areas would need to be protected by an appropriate airlock(s) or gastight door(s). Three alternative situations are possible:

a. Zone 1 area opening into a Zone 2 area

b. Zone 2 area opening into a non-hazardous area

c. Zone 1 area opening into a non-hazardous area

Preference should be given to using an airlock for each of the three alternative situations referred to above. However, when an airlock is not practicable, gastight self-closing doors may be used for situations a) and b).

Situation c) would need to be fitted with a double door airlock whenever possible. If this is not practicable the HVAC system provided to maintain pressure differential would need to be upgraded from a single fan normally used for arrangements a) and

b) to include two 100% duty fans, one running and one standby. Controls would need to automatically start the standby fan on failure of the duty fan or upon prolonged loss of pressure differential, when both would run simultaneously.

The following important points may be noted:

1. Where practicable doors should be positioned so that they do not face a source of hazard.

2. All electrical equipment located within an airlock should be certified as suitable for use in a hazardous area of equal or greater hazard rating as that external to the airlock.

3. Hinged doors for normal access between hazardous and non-hazardous areas should open into the non-hazardous area. Emergency hinged doors should open in the direction of escape. The exceptions to this are sliding doors when fitted.

4. Barriers on the access openings shall have sufficient fire endurance to remain effective throughout a fire exposure. All doors should be gastight self-closing type without any hold-back device. Gastight doors should be capable of being demonstrated gastight under normal operating conditions.

Pressurization

Maintenance of a pressure differential between hazardous and non-hazardous areas (generally in the range of 30 to 70 Pa) is essential to prevent ingress of toxic or hazardous gases like H_2S or CO or CO_2. Hazardous areas (zone 0 and zone 1) shall be at negative pressure whereas the non-hazardous zones shall be at positive pressure. Positive pressurization is achieved by dumping more outside air (filtered) than it is exhausted from the spaces. Requirements include:

1. Living accommodation should be located in a non-hazardous area and shall be at a positive pressure with respect to outside ambient.

2. The access corridors and escape routes shall be maintained at a pressure above that of adjacent cabins.

3. Mechanically ventilated enclosed escape ways shall have overpressure against neighboring areas.

4. All process areas such as mud storage, mixing, chemical storage rooms, shale shakers and pump rooms should be at negative pressure with respect to adjacent lower classification zones. Arrangements shall be made to enclose the various mud handling processes within hoods, booths or enclosures so as to trap fumes, dust and gas at source and exhaust to a safe point of discharge to the outside atmosphere.

5. All areas housing hazardous equipment such as battery rooms shall be maintained at negative pressure.

The pressure differential caused by wind blowing across the installation should be considered at the design stage.

Dilution & Purge Systems

Accidental releases of flammable gas on offshore installations can lead to a build-up of gas with the potential for ignition and, depending on the circumstances, hazardous events such as fire and explosion with potentially severe consequences. Mechanical ventilation can help to mitigate such incidents and gas detection systems play an important role in reducing risks from gas releases by early detection allowing appropriate mitigation to take place.

Dilution is used to maintain acceptable gas and particulate concentrations in a zone subject to smoke/gas infiltration from an adjacent space. A space can be considered reasonably safe with respect to smoke/gas obscuration, if the concentration of contaminants in the space is less than *about 1%* of the concentration in the immediate fire area. It is obvious that such dilution would also reduce concentrations of toxic smoke components.

Dilution is sometimes referred to as purging or extraction. Requirements include:

1. All electrical equipment located in hazardous areas which are not compatible with the appropriate zone requirements should be provided with a purge system.

2. Purge systems should use inert gas or air as a purge medium. Flammable gas should not be used.

3. Purge systems should normally be separate from general HVAC systems serving enclosed or open areas.

4. Air for purge systems should be drawn from a non-hazardous source and appropriate controls provided to prevent ingestion of hazardous gases.

5. The purge medium would need to be treated prior to discharge into the purged equipment to avoid risk of condensation or other forms of contamination.

6. Adequate standby or redundancy would need to be provided, with purge system controls integrated with the control system of the equipment or space served and overall safety systems of the Installation.

7. Where appropriate, purged equipment should be maintained at a pressure of at least 50 Pa above that of the surrounding area in which it is located. Loss of over-pressure would need to initiate an audible / visual alarm at a normally manned station after a suitable delay which, it is suggested, should not exceed 30 seconds. Seals on equipment would need to ensure a low rate of leakage of purge medium.

8. A safety relief system would need to be provided so that discharge of the purging medium is direct to the outside atmosphere in a non-hazardous area.

Ventilation & Exhaust

Adequate ventilation is important to prevent personnel being exposed to levels of air-borne toxic substances in excess of the occupational exposure limits. Ventilation systems shall be designed to provide a continuous airflow pattern from non-contaminated areas of the building to potentially contaminated areas, and then to normally contaminated areas.

1. In all manned areas, HVAC systems should provide a minimum of 20 CFM of outside air per person. Fresh air requirement is worked out not only on the basis of occupancy or exhaust requirements, but more importantly on the pressurization requirement of the area concerned. Highest of the values worked out on these various parameters shall be chosen as the fresh air requirement for any area.

2. The airflow shall be toward areas of hazardous material contamination. The process areas that use hazardous materials shall have ventilation systems designed to ensure that the airborne hazardous material concentrations do not exceed the limits referenced in statutory codes and are as low as reasonably

achievable (ALARA) in the workplace environment. Effective loss-of-ventilation alarms shall be provided in all of these areas.

3. The process areas should be provided with mechanical ventilation systems capable of continuously providing at least 12 air changes per hour. Air change rates would need to be based upon the empty volume of the space served with no allowance made for equipment.

4. Open or partially enclosed hazardous areas would need to be ventilated by natural means to achieve at least 12 air changes per hour for 95% of the time. This may be augmented, where necessary, by mechanical systems to meet the same design criteria as enclosed hazardous areas.

5. In areas of high process heat gain, the ventilation rate may need to be increased in order to limit the temperature rise in the space to 40°C.

6. Similar to the fresh air requirements for various areas, exhaust requirements from areas (such as laboratories, kitchen, toilets, battery rooms etc.) shall be finalized considering various codes of practice. This will help in the preparation of a proper air balance chart for all the areas of any system, which in turn will facilitate further engineering and drawing works.

Safety in ventilation design

The design of a confinement ventilation system shall ensure the desired airflow characteristics when personnel access doors or hatches are open. When necessary, air locks or enclosed vestibules shall be used to minimize the impact of this on the ventilation system and to prevent the spread of airborne contamination within the facility. The ventilation system design shall provide the required confinement capability under all credible circumstances including a single-point failure in the system.

Equipment in ventilation systems shall be appropriately qualified to ensure reliable operation during normal operating conditions and anticipated operational occurrences. Components of safety class ventilation that require electric power to perform their safety functions shall be considered safety class loads. Ventilation system components and controls that require electric power to perform safety functions shall be supplied with a safety class uninterruptible power supply (UPS) and/or emergency power supply as required by a systems design/safety analysis.

The use of downdraft ventilation within occupied process areas shall be considered as a means to reduce the potential inhalation of contamination for high-density process material.

Fire/Smoke Ventilation

The HVAC design shall comply with the requirements of NFPA 90A. Typical requirements include:

1. Gas detection of flammable and toxic gases shall be provided at all fresh air inlets, upstream of gas dampers of mechanical fresh air supply systems. Detection of gas shall initiate alarm protective sequences dependent upon the percentage lower explosion limit (LEL) gas in the air concentration.

2. Fire / gas control dampers shall be provided at fresh air intakes, air outlets and air transfer penetrations of fire barriers to maintain integrity. Fire dampers shall be installed in the air ducts passing through the firewalls and where the duct crosses the areas of different classification.

3. Blast proof dampers (explosion proof valves) shall be installed on all the fresh intakes as well as on all the air outlets of HVAC systems of blast protected (blast resilient and blast resistant) structures.

4. In the event of a positive detection, the fire and gas detection and alarm system shall provide signals to the HVAC to initiate the following actions:

   - Closure of fire or gas dampers installed on the fresh air intakes or on the air outlets of the buildings.

   - Electrical Isolation

   - Stopping of HVAC system and/or shifting to smoke exhaust system

The fire and gas (F&G) detection systems shall send shutdown commands to the HVAC system via hardwired links.

5. Particular care would need to be taken to ensure that HVAC systems do not destroy the fire protection provided by gaseous extinguishing media which may be used in certain areas. Appropriate controls, should be considered with local and remote control facilities provided to enable the HVAC system to help with

recovery and removal of pollutants after an incident. Locations where gaseous extinguishing media are stored should be ventilated.

6. Where foam fire protection systems are provided, provision should be made for venting the protected space whilst foam is being introduced.

Battery Room Ventilation

In any offshore installation the battery room is essential to ensure emergency power in the event of a power breakdown. Apart from keeping the most essential services running without any break, emergency lighting and ventilation systems have to be fed with emergency power to aid safety operation, if need arises. Though cooling may not be required in emergency periods, continuous ventilation must be ensured for safety against hydrogen built up and potential explosion.

The risks from hydrogen evolving from certain types of batteries should be recognized, and the HVAC systems shall be arranged to reduce the hazard from this source. Design of the battery room shall meet the requirements of NFPA 70, article 480. Basic design parameters are:

Battery Room Exhaust Fan Sizing

1. Size the battery room ventilation system to prevent hydrogen concentration in the room from exceeding *2 percent* by volume.

2. Work out the hydrogen emission rate of the batteries - the ventilation equipment should have a capacity more than the hydrogen emission rate, after allowing for percentage of hydrogen in the air. This is done either based on the data given by the battery supplier or worked out using the formula:

   $$Q = 0.054 \times I \times N$$

   Where:

   - Q = required ventilation rate in ft^3/s.
   - I = 0.21 x (capacity of the largest battery to be charged in ampere-hours) or 0.25 x (the maximum obtainable amperes from the charger), whichever is greater.

- N = (number of batteries to be recharged at one time) x (number of cells per battery).

(Note: A single cell is normally two volts DC. Therefore, a six volt battery normally has three cells and a 12 volt battery normally has six cells.)

3. In event the battery data is not available "maintain at least 12 air changes per hour".
4. The battery rooms shall have 100% duty plus standby explosion proof exhaust fans, with automatic change-over in event of failure of main fan. Upon loss of main power supply, the battery room ventilation fans and their controls shall be powered from the emergency source. Each fan shall have an independent failure alarm.
5. The battery room ventilation system shall be equipped with a signaling device that transmits a trouble signal to the control room when the concentration of H_2 in the room exceeds the control limit. The ventilation system shall include sensors for initiating alarm signals to the central control room in the event of ventilation system failure.
6. The hydrogen (H_2) ventilation system for the battery room shall be separate from ventilation systems for other spaces. Air recirculation in the battery room is prohibited.
7. The fan motors must be outside the duct and battery room. Each fan shall have a non-sparking construction.
8. Consideration should be given to addressing whether low humidity levels could be present during differing weather conditions with the risk of ignition by static spark.
9. Sealed batteries are less tolerant of high temperatures than are wet type (i.e., vented) batteries. If average daily temperatures in the battery room exceed 92°F, consideration should be given to using only wet type batteries.

<u>Fuel storage area ventilation</u>

Provision shall be made for adequate ventilation of fuel storage areas prior to entering for inspection or repair. Ventilation for fuel storage areas shall comply with NFPA 30, Flammable and Combustible Liquids Code, NFPA 37, and NFPA 110.

Air Distribution

A well-designed air distribution system shall result in an efficient air conditioning system. A low-velocity duct system is practical in facilities where space is of secondary importance and a high-velocity duct system is often most practical in a facility where space is at a premium.

1. Due to space constraints and considering the air flow requirements in offshore service, the designer may have to go for high pressure ducting. The pressure drop in supply air ducting will be in the range of 1000 to 1500 Pa and that in return air ducting will be in the range of 500 to 1000 Pa.

2. Ducts that may carry contaminated air or run through areas that may become contaminated shall be gas tight. Duct systems shall be designed within prescribed limits of available space, friction loss, noise level, heat loss or gain, and pressure containment.

3. Circular ducting (machine fabricated by using GS strip bands of 100 or 150 mm width) is recommended, as the helically wound longitudinal joints provide adequate mechanical strength.

4. Ductwork connections to the outside atmosphere and through fire barriers would need to be provided with fire / gas dampers rated to that of the fire barrier penetrated.

5. Ducts shall be constructed in accordance with applicable Sheet Metal and Air Conditioning Contractors National Association (SMACNA) standards.

6. Special attention shall be paid to ductwork connections to fan inlets and outlets in order to maximize the fan performance. See AMCA publication 201.

7. Flexible ducting shall be kept to a minimum and be used only for vibration damping or thermal expansion purposes.

8. Return air shall be ducted to get a proper air balance. Many contractors have used return air plenums above a false ceiling, which results in unbalanced

operations within a short period of commissioning, as the space above the false ceiling is being used for other services too and the maintenance staffs of HVAC looses control over the performance of the plant.

9. Re-circulation of air from the hazardous space shall not be made except where required during phased, partial or non-production periods.

10. The extract ducts from areas exposed for pollution, such as mud tanks, shall be fitted with inspection doors, suitable for complete clean out of the ducting. Doors shall be provided in all ductwork for inspection and cleaning and in some cases to gain access for a person into the duct. All inspection doors in heavy gauge ductwork (duct class A and D) shall be hinged.

Air intakes and outlets

1. Supply air intakes would need to be located in non-hazardous external zones. The separation between air intakes and extract outlets should be a minimum of 4.5m, but greater where practicable.

2. Care should be taken when siting supply air intakes to ensure that products of combustion from fuel burning equipment or toxic / hazardous discharge from process / equipment vents and similar outlets are not drawn into the HVAC system.

3. Where practicable, ventilation outlets from non-hazardous areas should not discharge into a hazardous area. Where such an extract does discharge into a hazardous area from a non-hazardous area, precautions would need to be taken to automatically prevent backflow of air from the hazardous into the non-hazardous area.

4. The air intakes shall where possible be located underneath the installation.

5. Systems for hazardous and non-hazardous areas may have common air intake if means are provided to prevent the spreading of gas from hazardous to non-hazardous areas. Consideration shall be taken to possible contamination sources such as:

    - Ventilation extract outlets

    - Turbine and diesel engine exhaust outlets

- Mud burning smoke
- Gas leakage from hazardous areas

6. The air intakes shall where possible be upstream of the prevailing wind. The wind influence on the air intake must be studied and documented
7. Outlets from hazardous areas should be located at high level

Air extract

1. From hazardous areas extract shall be arranged at both high and low level in order to take care of both light and heavy gases.
2. Spot extract shall be used wherever suitable to avoid spreading of dust, fumes, heat etc. and to reduce the amount of general ventilation.
3. HVAC ducts should avoid passing through areas of differing classification. However, where unavoidable, fire protection of ducts to the same standard as that of the enclosure would need to be provided.
4. Where necessary ducts of welded, gas-tight construction would need to be used. The air pressure differential inside the duct relative to its surroundings should be appropriate to the situation.
5. The air intakes and outlets from the various HVAC systems should be protected from wind-driven rain, snow and wave entry which might inhibit performance or hazard the Installation.

Air Cleaning and Filtration

Air cleaning is the process of removing airborne particles from the air. Air cleaning can be classified into air filtration, which essentially involves the removal of airborne particles present in the conditioned air. Air cleaning is a wider term that besides filtration, involves the removal of dust and gaseous contaminants from the space air exhaust air, and flue gas for air pollution control.

Fresh air inlets to air handling units should have coalescing filters/demisters capable of separating salt laden moisture particles to reduce corrosive effects within the air handling units. The norms generally followed are (i) to reduce the salt in air concentrations to 0.05ppm by weight from an input of 3.6ppm, based on NGTE

(National Gas Turbine Establishment, USA) Standard 30 knot aerosol and (ii) dust particle removal efficiency of 98% at 6 microns to BS 540 Part I or equivalent.

Most of the airborne particles removed by air filtration are smaller than 1 mm, and the concentration of these particles in the airstream seldom exceeds 2 mg/m^3. The purpose of air filtration is to benefit the health and comfort of the occupants as well as meet the cleanliness requirements of the working area.

In Offshore facilities, corrosive gases and particles from vats, scrubbers, and similar equipment in gloveboxes must be neutralized. A*ctivated carbon and chemical filtration (example Purafil) are* widely used to remove objectionable odors and irritating gaseous airborne particulates, typically 0.003 to 0.006 mm in size, from the air stream by adsorption. *Adsorption* is physical condensation of gas or vapor on the surface of an activated substance like activated carbon. Activated substances are extremely porous. One pound of activated carbon contains 5,000,000 ft^2 of internal surface.

Where spaces, such as a control room, are to be occupied during abnormal events, safety class filtration systems shall be provided on the air inlets to protect the occupants. If room air is recirculated, at least one stage of HEPA filtration shall be provided in the recirculation circuit. The design shall include redundant filter banks and fans that shall be located based on the results of the safety analysis. Consideration shall be given to providing roughing filters or pre-filters upstream of a HEPA filter to maximize the useful life of the HEPA filter.

Air-filtration units shall be installed as close as practical to the source of contaminants to minimize the contamination of ventilation system ductwork.

Workplace Noise

Feasible engineering controls, including sound-insulated equipment, attenuators and control rooms shall be employed to reduce the average noise level in normal work areas. Plant equipment should be well maintained to minimize noise levels. The noise levels must be restricted below 82 dB (A) at 3ft.

Ductwork and fan mounts should be carefully designed. Ducts will be connected to fan and filter inlets and outlets by means of butyl rubber or butyl coated nylon cloth materials. Main supply fans should be remote from occupied areas and provided with resilient sound-absorbing bases. Noise due to high velocity ducts, abrupt turns, and rigid connections to fans will all be considered. Where high-velocity minimum-size equipment must be used, an adequate acoustical and vibration treatment will be employed.

Corrosion Resistance

Provision would need to be made to protect HVAC equipment from harmful effects from particulate contaminants and salt aerosols carried by wind / sea spray.

Coastal or marine environments are characterized by the abundance of sodium chloride (salt). Salt-laden seawater mist, combined with the harmful emissions of the process itself, can accelerate corrosion and pose a severe threat to HVAC equipment life. Consideration should be given to using components and materials specifically developed for the application. Where possible, materials inherently resistant to marine corrosion should be used and coatings, where applied, would need to be heavy duty marine standards. Items likely to suffer damage from corrosion prior to being made operational shall be suitably protected with appropriate coating.

Static Discharge

HVAC systems and their components should be adequately earthed in order to avoid build-up of electrostatic potential which might cause ignition of a flammable gas / air mixture.

Consideration should be given to controlling humidity in order to minimize the risk of static discharge in any area where flammable gas and a dry atmosphere may be present, such as battery rooms and sick bays.

Anti-Blast Requirements

The HVAC design must withstand the blast load – i.e. the load (or force) exerted on an object when the outward pressure of an explosion strikes it and moves around it. It results from both the static overpressure and the dynamic pressure.

Any opening is always a vulnerable part of a structure. It is essential that the number and size of openings are reduced to a minimum to limit the total exposure risk. For HVAC installations, it is necessary to protect all the openings in structures against penetration by the blast. This protection is provided in the form of (anti-)blast valves, which closes automatically in response to the blast wave alone without use of a detector or electrical contacts. A small fraction of the wave, or a slight “let-through impulse", will pass through the valve before the disc is fully closed. The overpressure resulting from the let-through impulses, behind the valve, shall never exceed <u>500 Pa.</u>

Anti-blast valves can be divided into two groups: one designed to protect against a long-duration load (repeated explosions) and the other to protect against a conventional, short-duration load. The main characteristic of blast valves intended for long-duration loads is their ability to withstand very strong impulses, whereas those intended for short-duration loads are designed to reduce the impulses created by strong overpressure peaks lasting a short time.

Quick-closing "blast valves" are designed to eliminate the damaging effects of the blast wave inside the building and to ensure that the ventilating capacity will not be affected. They shall protect the internal systems against high amplitude impulse loads, of both short and long duration.

All the blast valves for offshore facility shall be designed to withstand a minimum of six consecutive blast loads with no degradation of their performance.

Standby Equipment

Nothing can fail on the rig.

All important equipment particularly, rotating machinery, shall have adequately installed standby equipment. Spare parts should be easily available in the stores of the user, at least, in the onshore base, if space problems inhibit storage offshore.

Consideration should be given to providing dedicated HVAC systems to serve concrete support legs, steel jackets and similar spaces where personnel access is restricted to entry from one end only, so that dangerous concentrations of flammable / toxic gas do not accumulate.

Supporting of equipment

HVAC equipment, large pumps or exchangers shall be mounted on pads that absorb a large amount of the energy emitted when the blast wave and (or) the shock wave strikes the building.

All piping must be connected to the machines via flexible systems.

Service cable and pipe penetrations

Service cables and pipes are typically fed into installations through the outside walls, or through the various gas-tight blast walls. These penetrations shall be done with transit sleeves. As the number and type of pipe or cable penetrations are not exactly known during the initial building design, margins must be taken to estimate the number and type of sleeves. The sleeves shall be embedded in the concrete during the building construction phase. Pipes and cables shall be installed with suitable cable glands or packing to meet the blast-proofing, liquid tightness and gas tightness requirements.

The sleeves may be selected for single or multiple cables or pipes. They shall be able to withstand an unlimited number of loading at an overpressure of 5MPa. The transit inlets shall be delivered in the dimensions appropriate for the cables or pipes they will accommodate. The penetrations themselves shall be of blast, gas and fire resistant design.

Structural soundness

AT A MINIMUM, a building's structural system should be able to withstand the force of blasts originating at the edge standoff distance. The extent of these measures varies depending on the amount of standoff distance available, the building's size and location, and other factors.

HVAC control system

The HVAC system shall as a minimum have the following control provisions:

1. Auto/manual operation selecting facilities
2. Start/stop of fans
3. Fan and damper status/alarm
4. Alarm for loss of pressurization/flow
5. Auto/stand-by selecting facilities for fans
6. Temperature status/alarm for temperature sensitive areas
7. The system logic shall be equipped with manual reset
8. Controlled shutdown

9. Emergency shutdown and facilities for safe re-start after an incident

The control of pressurization is very important. The extent of executive action taken after loss of ventilation or pressurization differential would need to be considered and appropriate arrangements made to avoid compromising the safety of the installation. In general, status indication should prove that ventilation is performing its intended function, in particular air flow and fire / gas damper operation. Where standby plant is provided, it would need to be arranged to change over automatically and alarm or indicate on changeover.

Loss of pressure differential (more than 20 Pa) should initiate an audible / visual alarm at a normally manned station after a suitable delay period which, it is suggested, should not exceed 30 seconds.

Loss of pressure differential in a non-hazardous space, coincident with the detection of gas at any location, would need to initiate automatic disconnection and de-energizing of all electrical equipment.

A safe scheme of pressure relief venting from the space should be provided to ensure that doors can be opened and closed during normal and emergency operations.

SYSTEM LAYOUT

Careful consideration should be given to the location and layout of HVAC systems and associated plant and components to enable adequate routine inspection testing and preventative and breakdown maintenance to be carried out without prejudicing safety of the installation.

1. Suitable access platforms and routes for entry and removal of expendable components or failed equipment should be provided.

2. Access doors into plant and ductwork would need to be of sufficient size to enable servicing to be adequately carried out.

3. HVAC systems should be laid out with safety aspects in mind. They should be kept clear of areas prone to damage from normal operations. Where practicable, hydrocarbon fuel lines and main power and signal cables would need to be kept clear of HVAC systems.

4. HVAC systems in hazardous areas would need to be laid out to scavenge the space of gas and heat accumulation, and prevent build-up of pockets of flammable or toxic gases which may be lighter or heavier than air. It should be noted that an even distribution of air within an area is as important as the quantity of air supplied.

5. The air intake should be provided with chemical filtration and equipment for mist and droplet collection.

All plant, leading components and utility supplies should be clearly labeled /tagged with appropriate unique identification.

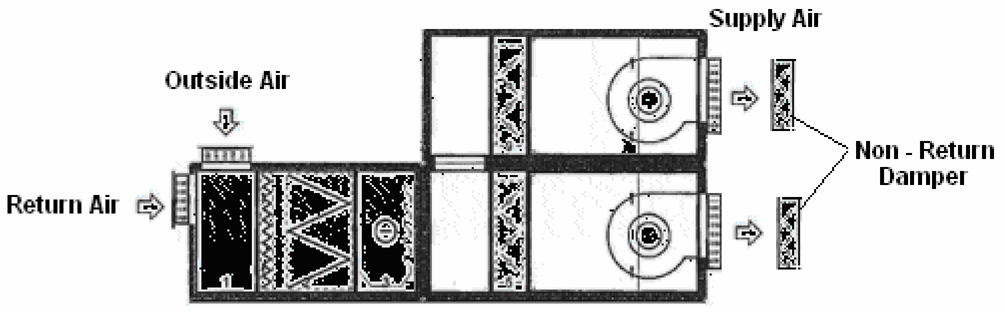
Section – 2 HVAC EQUIPMENT AND MACHINERY

HVAC equipment and machinery for offshore facilities shall be suitable for saline corrosive atmosphere. In addition to high relative humidity, some systems may be subjected to wide temperature variations from freezing conditions to high ambient radiant heat.

Air Handling Units and Fans

Due to the importance of pressurization, air handling units are considered to be the most important HVAC equipment, particularly in installations in hazardous areas or where toxic gases can be present.

Since standby equipment is essential for more critical equipment such as air handling units, (particularly where pressurization is involved) battery room exhaust fans etc., one often comes across a scenario, where there is no space available for installing two air handling units. Since filters, cooling and heating coils etc. are stationary equipment, air handling units can be considered with dual fans, as shown in figure below, one operating and one standby, with shut off and non return dampers at the inlet and outlet. Shut off dampers have to be provided at the inlet to the fans to ensure non-short circuiting of air flow. These dampers are best provided with pneumatic actuators as instrument air supply will be usually available on such platforms. Pneumatic actuators are preferred, as zone classified electric motor driven dampers will be costlier and more cumbersome to operate and maintain.



DOUBLE DECK AIR HANDLING UNIT

Specialist manufacturers of such air handling units are: FlaktWoods, Direct Engineering (Australia), Heinen and Hopman (Netherlands).

In case of an installation comprising of more than two decks, it is preferable to go for individual air-handling units for each deck. In case a common air handling unit is selected for serving more than one deck, there will be ducts penetrating fire rated decks, necessitating provision of fire dampers. Of course, this is a point where the overall size of the installation will be the deciding factor for the selection of number of air handling units. Duty and standby exhaust fans shall also have non return dampers, either gravity operated or electric/ pneumatic actuated, at the outlets. Type of actuation shall be based on the control philosophy.

Constant Volume Systems

The most reliable system for offshore facility is constant volume system. This is because; ensuring constant pressure gradient between the adjacent areas is of prime importance. The constant volume systems often require terminal reheat to heat the air before terminal discharge in response to the space thermostat. This can waste energy, since air is cooled and then reheated. Many energy codes prohibit this practice for comfort applications, however, where close control of temperature and humidity is required for process areas the energy conservation requirement is waived. The advantages of reheat systems are that humidity is always controlled (since dehumidification always takes place at the cooling coil) and each space or zone that needs temperature control can easily be accommodated by adding a reheat coil and thermostat. Another advantage of constant volume system is that airflow is constant, which makes balancing and pressurization easier to main maintain. A reheat system is probably the simplest and easiest of all systems to understand and maintain.

Variable Air Volume Systems

A variable air volume (VAV) system is generally not used in offshore installation. The VAV system works by delivering a constant temperature air supply to spaces with reductions in airflow as cooling loads diminish. This eliminates the energy used for reheat and saves fan energy, because the total amount of air moved is reduced.

Fans & Fan Drives

The fan material, as well as the fan type, must be selected to withstand corrosive attack. For example, in corrosive environments fans can be constructed with expensive alloys that are strong and corrosion resistant, or they can be less expensively constructed with fibreglass reinforced plastic or coated with a corrosion resistant material. Because coatings are often less expensive than super-alloy metals, fan types that work well with coatings (for example, radial fan blades because of their simple shape) are widely used in corrosive applications; however, wear will reduce the reliability of coatings. Alternately, materials such as reinforced fibreglass plastics have been developed for fan applications and function effectively in many corrosive environments. However, there may be size and speed limitations for composite materials and plastic materials.

When space is not a factor, centrifugal fans with backward curved and air-foil type blades shall be used for maximum efficiency. Vaneaxial fans are used when space is at a premium and non-turbulent inlet conditions can be obtained. The use of inlet vane straightness for this purpose in recommended. Following guidelines should be noted:

1. Fans shall have spark proof construction and be driven by motors designed for classified areas. Remember, cooling/ heating takes only the second preference.

2. The fans used on the installation should have non-overloading, non-stall performance characteristics.

3. Adequate performance margins to cope with adverse design wind speed would need to be provided.

4. Fans would normally be electrically driven. However, compressed-air-driven fans and ejectors may occasionally be employed for emergency use or as a means of overcoming electrical zoning or power supply constraints. Such arrangements would need to include a pressure / air flow switch local to the fan or ejector to alarm on loss of ventilation air.

Dampers

In air moving systems, dampers are used to: 1) balance airflow, 2) control airflow, 3) resist the passage of fire, or 4) resist the passage of smoke. Balancing dampers are used in ducts to adjust the airflow to the design values.

Fire Dampers - Fire dampers are designed to close automatically upon detection of heat, to restrict the passage of heat or flame. Generally, fire dampers are installed in duct penetrations through walls that have been designed to meet a specific level of fire resistance. In United States, fire dampers are usually constructed and labelled in accordance with standard UL 555 (1990). Generally, multi-blade fire dampers are held open by a fusible link and are spring loaded. In a fire situation, hot gases cause the link to come apart allowing a spring to slam the blades shut. In place of fusible links, some manufacturers use other heat responsive devices.

For offshore applications, use of frangible bulbs is recommended, which can be easily replaced through the control box without having to open up the dampers. Fusible linkages are not recommended, as the same cannot be replaced easily through an access door, unless the access door is very large.

The dampers shall be preferably of pneumatic type as instrument quality air will be generally available on platforms. Further, electric actuation will be costlier, due to the zone-rating requirement of any electric component. All fire dampers shall have limit switches or at least proximity switches to enable monitoring of the status of the fire dampers on Fire and Gas control panel.

Within the framework of adhering to the specifications, one can still try to reduce the cost, by reducing the number of fire dampers by providing fire rated ducts. There will be some locations, where the same duct crosses two fire rated walls within a short distance, without any branch take off. In such locations, a fire damper need be provided only in one location with a fire rated duct extending up to the next fire rated wall. Fabrication of fire rated ducts and providing fire rated insulation will work out to be cheaper than providing a fire damper and associated cabling, instrument tubing and ancillary works.

Needless to say, the construction of fire dampers shall meet with the fire-rating requirement, using materials that can meet the duty and certification requirements. It will be cheaper to go for stainless steel dampers.

Smoke Dampers - In HVAC systems without smoke control, smoke dampers close upon detection of smoke to restrict the passage of smoke. In United States, fire dampers are usually constructed and labelled in accordance with standard UL 555S (1983). These dampers are classified as 0, I, II, III and IV leakage rated at ambient or elevated temperatures of 250F or at higher in increments of 100F above 250F.

The maximum leakage rate for different classifications is tabulated below:

Classification	At 0.249 kPa (1.0 in H_2O) L/(s m^2)	cfm/ft^2	At 0.995 kPa (4.0 in H_2O) L/(s m^2)	cfm/ft^2
O	0	0	0	0
I	20	4	41	8
II	51	10	102	20
III	203	40	406	80
IV	305	60	610	120
	At 1.99 kPa (8.0 in H_2O)		At 2.99 kPa (12 in H_2O)	
Extended Static Range	L/(s m^2)	cfm/ft^2	L/(s m^2)	cfm/ft^2
O	0	0	0	0
I	56	11	71	14
II	142	28	178	35
III	569	112	711	140
IV	853	168	1067	210

<u>Class 0 dampers with zero leakage and/or Class I dampers are commonly used in O & G facilities.</u>

Dampers would need to be capable of withstanding temperatures and pressures for the rating of the barrier, and also of responding automatically to alarms, with provision for local and remote operation and indication to meet the emergency shutdown logic of the Installation.

1. Dampers would need to have the minimum leakage practicable for the particular application involved. These must comply with UL 555S and should be minimum class I construction for O & G facilities.

2. Dampers required to control supply of combustion air to engines (rig savers) would need to be of the same robust construction as fire / gas dampers.

3. Controls and damper actuators should be inherently non-sparking and appropriate to the area classification.

4. Actuators would need to be capable of rapidly closing and opening the dampers against airflow pressure within the duct. Controls would need to be arranged to 'fail safe' in the event of loss of power or breaking of fusible or frangible link(s).

These links should be positioned where they will be able to detect fire or over temperature. The arrangement of links required to provide adequate protection would need to be analyzed for each application to ensure that the barrier is correctly protected.

Pneumatic actuation is preferred over electrical actuation. It is easier to provide zone-classified solenoid valves for pneumatic actuation, as compared to electrical actuation.

Balancing and Volume Control Dampers

Adequate number of balancing and volume control dampers shall be provided to facilitate balancing of airflow, as pressurization gets precedence over inside conditions in most of the cases. Material of construction of these dampers shall be compatible with the ducting material to which the damper is fixed. In case of dissimilar materials used for the duct and the dampers, proper gaskets have to be provided to prevent galvanic action.

Air-Cooled Condensers

For small size plants, say of less than 50 ton capacity, air-cooled condensers are preferred, mainly due to the cost factor and space constraints.

The condenser coils shall be of copper tubes and copper fins, electro tinned after assembly, or with ARCACLAD or equivalent coating to reduce the impact of corrosive atmosphere. Aluminium fins are not recommended due to poor corrosion resistance in a marine environment.

Air-cooled condensers installed in hazardous areas shall have to be suitably rated.

Water Cooled Condensers

A water-cooled condenser is preferred only if adequate sea water is available from the sea water pumping system available on the platform. To provide a dedicated sea water circulation system only for the HVAC system will not be worthwhile, due to the high cost involved. Hence inputs from the platform designer will be required to decide on this point.

In case a water-cooled condenser is chosen, it will be preferable to go for a plate heat exchanger with sea water on the primary side and fresh water on the secondary side. Though, additional equipment in the form of a plate heat exchanger is used, the additional space requirement will be negligible. Plates of the plate heat exchanger shall be of titanium of suitable grade.

Compressors

For systems to be installed in safe areas, selection of compressors can follow the parameters generally applied for any typical installation onshore. However, for installations in *zone 2* classified areas; open compressors will be the most acceptable choice, as only then can the electrical requirements be met.

Direct driven compressors are preferred, though belt drive is also acceptable, if anti-static drives are selected.

All control elements such as pressure switches, crankcase heater termination, solenoid valves etc shall comply with, at least zone 2 requirements. Some project specifications insist on flameproof enclosures for these control elements, (like Shell) though the same is more than what is required for an application in zone 2 areas.

Interestingly, some of the US specifications prepared by companies like Mobil, accept semi-sealed compressors for machines of capacity less than 7.5 ton, for classified areas comparable to *zone 2* (US classifications of hazardous areas are based on divisions based on gas groups), even though the terminal box of a semi-sealed compressor will not meet with the *zone 2* requirements.

Wherever the chillers or condensing units can be installed in pressurized areas, compressors of any type can be installed, provided it is ensured that the compressors will function only when the space is pressurized.

Refrigerant Piping

Carefully review current Federal regulations prior to selecting mechanical refrigeration equipment. Current and anticipated future restrictions limit or prohibit using ozone-depleting substances. All design shall comply with ASHRAE 15.

Copper piping can be used for refrigerant piping, with protective coating, to withstand corrosive marine atmosphere, in line with the project painting specifications, which is an important document on any offshore project.

Control System

With the developments that have taken place in the microprocessor-based controls, during the last decade, it has become far easier to carry out the engineering hook up with the platform control system, so as to monitor the operation of HVAC plant, with particular reference to the fire dampers, as they form an integral part of the platform safety system. Starting and stopping of the HVAC system shall be done with the help of a PC through the central control system. Selection of the HVAC equipment has to be done keeping in view this requirement.

Heater Elements

Consideration should be given to ensuring that the surface temperature of heater elements used in HVAC systems and unit heaters is below 200°C or the ignition temperature of any flammable gas likely to be present in the area.

Controls would need to be provided to ensure safe surface temperatures when air flow over the heater elements is restricted or stopped.

Duct heaters shall be suitable and classified per the area classification OR shall be installed in pressurized areas, without having to go for hazardous area classification, since the operation of the heating element will be interconnected to ensure the switching on of the heaters only when the area surrounding the heaters is also pressurized.

Humidifiers

These find application generally in North Sea installations. The cost involved in providing humidifiers, complying with the corrosion resistance specifications does not justify provision of humidifiers in tropical zones, as they will be functional only for very short duration in a year.

Duct Work

Material of Construction of Ducts

Ducts and other HVAC components can be made of materials that will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. While steel is the most common non-combustible duct materials, others include aluminium brick, clay tile, concrete, copper, iron and masonry blocks.

General practice is to use galvanized steel sheets with relatively heavier deposition of zinc (not less than 270 gms/m^2, as per Table 9 of BS 2989 coating mass or weight) for internal ducting and stainless steel grade 316L for external ducting. “A60” fire rated ducts, even indoors, shall be of minimum 5mm thick stainless steel grade 316L.

Fabrication of Ducts

SMACNA or DW 144 or any other recognized fabrication standard can be followed. Wherever lock forming is resorted to, all such joints shall be applied with asbestos-free duct sealant. Fire rated ducts shall be of welded construction, with a minimum thickness of 5 mm for the mild steel sheets used. Ductwork is classified with respect to operational conditions.

Duct classes

Class	Material	Thickness	Operating Conditions
A	Stainless steel UNS S31603	3mm	High strength ductwork. Ductwork exposed to weather and saliferious atmosphere Fire rated ductwork
B	Stainless steel UNS S31600	Supplier standard (Light Gauge)	Internal ductwork in corrosive environments, such as laboratories, battery rooms etc.
C	Stainless steel UNS S31600 UNS S31603	0,8 mm for ØD ≤ Ø200 mm. 1,0 mm for 200 <-ØD < 400 mm. 1,25 mm for 400≤ ØD < 800 mm. 1,5 mm for 800 mm ≤ ØD (Note1)	Internal ductwork in production and utility Areas. External ductwork protected from mechanical strain.
D	Carbon steel painted or hot dipped galvanized. (Note 2)	4mm	High strength ductwork Fire rated ductwork
E	Pre-galvanized sheet Steel	Supplier standard (Light Gauge)	Internal ductwork in controlled environments such as LQ

Notes

- For rectangular ductwork the referenced size is the longest side.
- Galvanizing to be in accordance with ISO 1461 Metallic coatings – Hot dip galvanized coatings on fabricated ferrous products – Requirements
- Alternative duct class or duct material shall be qualified.

Pressure testing of Ducts

The ductwork inclusive equipment shall be pressure tested after installation. All materials such as duct, stiffeners, gaskets, bolting etc., intended as part of the final installation, which are damaged during testing shall be replaced.

All ductwork shall meet the requirements for Air Tightness Class B.

A minimum of 10% of the ductwork shall be tested, and it shall be selected by the company. If this ductwork does not pass the test, then the whole ductwork system shall be tested to the satisfaction of the company. All test devices shall be removed after the tests have been performed.

The section of the ductwork to be tested shall be prepared by blanking off duct outlets etc.

All dampers in the tested ductwork shall be left in open position. Testing shall be satisfactory completed before insulation or enclosure of the ductwork and before terminal units is fitted.

Earth Bonding of Ducts

The structure of the platform provides a common earth point for various types of electrical and instrumentation power. From the point of view of safety, ducting should be earthed. All flanged duct joints shall be bonded with double earthing with insulated yellow/green loops with lugs at either end and bolted to the flanges, in visible, preferably diametrically opposite corners of the ducting.

Duct Hangers and Supports

Ductwork supports shall be arranged to prevent any movement and shall be adequately sized for mechanical loads, wind loads and to accommodate the shipment and tow-out of the platform.

Where ducts are conveying conditioned air, packing blocks shall be installed between duct and support when externally insulated. The blocks shall be of sufficient insulating value to prevent condensation.

Ductwork in and close to noise-sensitive areas shall have a resilient support to prevent structural noise.

Duct Penetrations in Fire Rated Walls/Decks

Wherever any duct crosses a fire rated wall or deck, fire dampers are required to be provided. Fire dampers constitute a major component of the safety system on any offshore installation along with other systems such as deluge system, sprinklers etc. Since fire dampers come under the scope of HVAC discipline, the HVAC engineer will be responsible for this portion of the safety system.

Duct Insulation & Finishes

All ductwork handling treated air, including return air, should be properly insulated and vapour barrier treatment provided. Insulation materials shall be non-hygroscopic.

- Fibreglass blankets or rigid boards are not preferred, as they are hygroscopic. Mineral wool is preferred.
- Isocynurates or polyurethane materials are not permitted, due to toxic gases they can generate in the event of a fire.

Aluminium foil backup over the insulation as a vapour barrier is not adequate for an offshore installation, due to the fact that achieving a successful vapour barrier is dependent on manual labour due to aluminium tape overlapping. There will also be a time gap between the day the insulation is carried out and the day, the plant is commissioned. During this time interval, there could be temperature variations resulting in peeling off of the tapes and entrapping of air within the insulation. Further, installation activities such as cable pulling etc. can damage the aluminium tape vapour barrier. Hence, an additional vapour barrier treatment by using 6 ounce (minimum) canvass or glass cloth coated with asbestos free vapour barrier products, similar to the well known Foster compound 30:80 is essential. In addition, insulated ducts exposed to outside conditions shall be applied with two coats of tough flexible fire resistive elastomeric finish similar to the well-known Foster Monolar coating 60:95 and 60:96. Many consultants insist that the first coat of this product shall be with 60:95, white colour and the second coating shall be with 60:96, gray colour. This is to ensure application of two coats.

In addition to the above treatment, ducts exposed to view and installed external to the building module shall be clad with stainless steel sheets preferably of minimum thickness 0.5 mm, to provide mechanical protection against damage or misuse.

Provision of such treatment is well justified, though there will be a cost impact, as any slackness on quality vapour barrier treatment could result in costly and time consuming replacement of insulation as well as replacement of products of other services, such as explosion proof light fittings, in case any damage is proved due to the moisture falling from ducts. Since a very costly oil production process is involved, every agency will be very alert about reasons and fixing responsibility, in case a mishap or shut down of the plant occurs. Hence every agency has to be very careful in not compromising on the quality of work.

For ductwork insulation, the following table shall be used as a guideline.

Ductwork Insulation

Insulation Service	Insulation		Jacketing Note 5, 6, 7			Purpose
	Material	Thickness	Material	Thickness		
				OD≤ 1200	OD> 1200	
Heat conservation, hot	Mineral Wool or other suitable material	External ductwork. Min. thickness 50 mm. One layer. Internal ductwork. Min. thickness 50 mm. One layer.	Stainless steel	0,5	0,7	To reduce heat losses
			Aluminium alloy	0,7	0,9	
Cold conservation, cold	Cellular glass or other suitable material Mineral wool w/ vapour barrier	Temperature difference to surroundings. Max. 10°C, thickness 25 mm. Above 10°C, thickness 50 mm	Stainless steel	0,5	0,7	To maintain low temperature
			Aluminium alloy	0,7	0,9	
Fire Proofing A60	Mineral wool of "Rock" type, 110 kg/m^3	75 mm.	Stainless steel	0,5	0,7	To prevent accident escalation due to rupture of ducts during fire
			Aluminium alloy	0,7	0,9	

Fire Proofing H0	Ceramic fibre, 128 kg/m^3	2 x 25 mm	Stainless steel	0,5	0,7	To prevent accident escalation due to rupture of ducts during fire
Fire Proofing H60	Ceramic fibre, 128 kg/m^3	2 x 38 mm	Stainless steel	0,5	0,7	To prevent accident escalation due to rupture of ducts during fire
External conden-sation, cold	Cellular foam, Cellular glass or other suitable material Mineral wool w/ vapour barrier	Temperature difference to surroundings. Max. 10°C, thickness 25 mm. Above 10°C, thickness 50 mm	Stainless steel	0,5	0,7	To prevent external condensation on ductwork
			Aluminium alloy	0,7	0,9	
Acoustic insulation, ductwork internal	Mineral Wool	Design according to noise reduction requirements	Galvanised, perforated (30%) carbon steel sheet (Inside duct towards air flow	0,5		To reduce noise

Notes

- If alternative materials are proposed, the insulation capability shall be equivalent to or better than the capability for the specified material and thickness

- No insulation shall have an "open" surface allowing fibers to break off and pollute the surroundings. Factory applied cover shall be preferred to seal the insulation.

Identification of Ducts

All ducts should be identified after insulation, cladding and installation, using an accepted colour coding system, in line with the fabrication standard followed, showing clearly the air flow direction for each duct in all visible locations, for ease of maintenance. The ductwork shall be marked and the identification symbols shall be placed on:

- o Ducting in ceiling behind access points
- o Either side of major components (fans etc.)
- o All ducting in HVAC plant rooms
- o Ducting in shafts behind access doors and panels

- o Ducting entering and leaving modules
- o Ducting entering or leaving local equipment/control rooms in open modules/areas
- o Both sides of fire walls where the duct penetrates
- o Each leg of a branch duct where the destination is not immediately obvious

Pressure Relief Dampers

Pressure relief dampers shall be installed generally in air locks, to ensure that the space is not over-pressurised. In case air locks are not provided near large areas covering an entire deck, then pressure relief dampers shall be installed on walls of such rooms. This is required to limit damage to external doors and to facilitate easy operation of the doors. These dampers can be either spring type or preferably weight operated type.

Supply air and Return air Outlets for Technical Rooms

For technical rooms, where provision of false floor is generally available, (mainly due to the requirement of laying and managing a very large number of cables) it is preferable to supply air into the space below the false floor which will act as a plenum. Floor grilles can be provided on this floor. Part of the supply air can be permitted to rise to the space through the switch gear and control panels in these technical rooms. Return air can be collected by means of diffusers in the false ceiling. This system has the advantage of more uniform distribution, besides the added benefit of avoiding chances of any condensation droplets falling on the switchgear and control panels.

This is a very important factor, as the relative humidity in the surrounding areas of the platform will be generally very high and there are chances for such condensation droplets, as the heat emitted out from the switchgear panels can vary through a large band. The supply air flow rate is naturally derived by considering total equipment load at peak conditions. Generally the manufacturers of the switchgear will be reluctant to commit any diversity factor and the HVAC engineer plays it safe by considering no diversity, resulting in excess air supply most of the time. Hence prevention of condensation droplets is a very important advantage gained by using supply air distribution through false floors.

Water Piping

There is nothing special in the practice followed, except for carrying out radiography tests on welded joints with a view to reduce chances of failures or leakages later after commissioning and anti-corrosive treatment adhering to painting specifications of the project, with materials of construction suitable for marine applications.

- For chilled water circulation, MS heavy-duty seamless pipes are used.
- For sea water, either cupronickel 90:10 or GRP pipes shall be used.

Insulation for chilled water piping shall be carried out with pipe sections of mineral wool, with proper vapour barrier treatment for which the comments made above for duct insulation, will apply after adapting the same for piping.

Wherever any piping penetrates any fire rated wall or deck, these penetrations have to be filled with gas/ smoke tight and fireproof plugs to maintain fire integrity (similar to the application of fire dampers in the case of ducting). Recommended material – CSD plugs, by CSD Sealing Systems of Netherlands. (CSD stands for Conduit Sleeve/Drilled hole sealing systems).

Vent Piping

In order to reduce the risk of pollution, consideration should be given to terminating drains, vents, cold vents and engine and fuel burning exhausts well away from air intakes and discharges of HVAC systems and open areas where personnel normally work. The possible adverse effect on HVAC systems from flaring would need to be considered.

Hazardous vent piping should not cross or pass through ducts or openings to the outside nor should they terminate inside HVAC systems.

ELECTRICAL INSTALLATION

What distinguish electrical installations for offshore HVAC systems from normal onshore installations is basically the wiring specifications for hazardous area equipment wherever it is relevant. The specifications that are followed onshore for hazardous area applications like refineries can be followed here too.

Cables

Fire retardant and fire resistant cables shall be used and shall be halogen free. All cables shall be properly identified as per the cable schedule, with tag numbers as per the project specifications. Wherever the cables cross fire rated walls/ decks, multicable transits shall be used, with identification tags for cables on either side of such transits. Colour coding shall be adhered to, strictly, with a view to reduce down time for any maintenance activity. Power and instrument cables shall be laid in separate cable trays keeping a specified distance of a minimum of 450 mm to prevent chances of fault and nuisance signals disrupting operation of the systems. Clash checking shall be conducted during preparation of drawings keeping this point in view.

Cable Glands

Cable glands shall be suitably rated matching with the cables for which the glands are intended to be used. (Explosion proof and fire rating)

Cable Penetrations

Whenever any cable crosses a fire rated wall or deck, multiple cable transits (MCTs) shall be provided to maintain the integrity of the wall/ deck being penetrated. While designing the transits, care should be taken to provide a minimum of 25% spare blocks for each size of block, to take care of future modifications or upgrading. Further, spare blocks shall have to be kept in the stores too for easy availability.

Earthing

Double earthing shall be provided for all electrical equipment, with earthing wire size to comply with the latest revisions of International Electrotechnical Commission (IEC). Power and instrumentation earthings (both clean and unclean) have to be separate.

Installation of Control Panels

While switch gear and control panels are usually installed in pressurized rooms, there may be cases where some control panels, such as that of chillers cannot be installed in pressurized rooms. In such cases, the control panels can be made 'safe' by using purged and pressurized enclosures for such panels. (Ref: NFPA 496 Standards for purged and pressurized enclosures). Adequate safe guards shall have to be provided in such cases.

COMMISSIONING

Acceptance of the HVAC-plant shall not take place until satisfactory commissioning has been completed. The commissioning shall take place after mechanical completion of the plant.

Documents detailing the procedures for installation, pre-commissioning and commissioning are to be prepared and got approved, with the following in view:

1. To ensure that the installation is carried out as per the specification and complying with good engineering practice.
2. To ensure proper co-ordination with various specialist agencies working on the platform simultaneously.
3. To ensure proper documentation on all aspects of the installation for reference at a later date, to achieve minimum down time in case of any breakdown in future, as production losses will be very high in such cases
4. To ensure a safe working environment.

(In onshore installations, though the above factors are relevant, the costs associated with the activities do not compare in such a high proportion to the production costs, as in an offshore field, resulting in not getting as much priority for such documentation)

DOCUMENTATION

Consideration should be given to providing permanent records of initial testing and commissioning at the time of first setting the HVAC systems to operate, and after modification of the system. During the commissioning period, records shall be prepared and maintained for all activities and shall include but not limited to the following:

- Air-quantities
- Temperatures
- Pressures
- Sound levels

Other records likely to include the following data: · Flow diagrams, ducting and instrumentation diagrams and data sheets showing test points and design and actual values achieved during testing.

- Ductwork index and branch resistance head design calculations
- Equipment schedules listing components and performance data
- Set of ‘as built’ record drawings
- Utilities data schedule for supplies to HVAC systems

This is very important aspect of any offshore installation, as final payment will not be settled till 'as built' documentation is completed to the entire satisfaction of the client and user. Since operating personnel keep changing offshore due to socio-economic factors, one has to ensure that it takes the least time, even for a new comer to the platform for maintenance and operation, to get familiarized with the installation. Another important factor is, as mentioned earlier in this write-up, the knock on effect on the operations and the cost involved in case of a plant shut down.

CONCLUSIONS

This course has illustrated some of the key features that distinguish an offshore installation from a standard installation onshore. This course by itself cannot be considered as a reference point. Relevant codes and standards will need following in detail, while undertaking an offshore installation. As mentioned in the beginning of this course, the prime and foremost consideration for any offshore installation is safety. Every action while undertaking an installation offshore shall be audited keeping this factor in mind.

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