

# HVAC&R Applications for Oil & Gas Offshore Installations



Photo 2: Drillship

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Operating a drillship 24X7 with very expensive engineers and technicians in hazardous offshore locations involves keeping the crew safe and comfortable and all equipment functioning trouble free. The HVAC&R system design and installation must meet several international codes, standards and certifications, and equipment may be required to function in temperatures down to  $-40^{\circ}\text{C}$ .

Oil and gas are considered among the world's most important resources. The oil and gas industry plays a critical role in driving the global economy. Petroleum itself is used for numerous products, in addition to serving as the world's primary fuel source. The processes and systems involved in production, transportation and storage, marketing and distribution of oil and gas are highly complex, capital-intensive and require state-of-the-art technology.

While the oil and gas industries

provide significant opportunities for developing economies, at the same time, they bring substantial risks that need to be managed and mitigated by governments, investors, and communities. The depleting nature of oil and gas resources make it particularly important that governments and economic policies ensure that the benefits of their exploitation contribute to the development of the human, social, and physical capital needed for sustainable development.

## **Focus on India's Oil & Gas Offshore Business**

Oil & Gas exploration in India has grown dramatically in the last decade through the New Exploration Licensing Policy (NELP) program. With its first open exploration round in 1997, India is currently conducting its eighth bidding round for exploration & development opportunities on and offshore the South Asian country.

NELP VIII is offering 70 Indian blocks

## **About the Author**

**Pradeep K. Suman** is a mechanical engineer from Delhi College of Engineering with 14 years HVAC experience with Samsung, ABB & SRP Enviro. He has been involved in the design of a variety of land-based HVAC installations and also in the design of a Russian Semi Submersible Floating Drilling Rig (SSFDR) and an ONGC platform, drillships and Floating Production Storage and Offloading (FPSO) projects. He is a member of ASHRAE and ISHRAE, lives in Delhi and can be contacted at [pradeep77123@rediffmail.com](mailto:pradeep77123@rediffmail.com)



Photo 1: Jack-Up Rig

for exploration and production, of those 62 are located offshore. After the planned IX bidding round, India hopes that 80% of its sedimentary basin will be under exploration.

The growth in exploration is reflected in the increasing number of offshore rigs working off the coast of India. Look back to June 2000 there were only 12 rigs contracted for work in the water offshore India. That number has grown to 44 rigs currently contracted for work in the water surrounding the country. Out of 44 rigs, 34 Jack-up Rigs, 7 Drillships and 3 Semi-submersible Rigs(SSFDR) are currently performing drilling operation.

#### Offshore Installations for Oil & Gas Industries

Various types of offshore installations are being used for oil & gas exploration, drilling, production, processing, storage and transportation. These are mainly categorized as follows:

**Drilling Rigs:** These types of offshore installations, are used for oil and gas exploration, drilling and production, depending on the oil & gas well water depth. These are further categorized as:

- Jack-Up Rigs (max. 180m water depth) - Photo 1
- Drillships (max. 3000m water depth) – Photo 2
- Semi submersible floating drilling rig, SSFDR (180m to 10000m water depth) – Photo 3
- Submersible rigs (max. 350m water depth)

**Oil & Gas Production Installations:** These type of installations are used for oil & gas processing or production and are further



Photo 4: Floating Production Storage and Offloading (FPSO)



Photo 3: Semi Submersible Floating Drilling Rig (SSFDR)

categorized as:

- Fixed Platforms (steel jacket, concrete gravity structure, compliant tower)
- Floating Structure (tension leg platform, semi-submersible, FPSO, floating LNG etc.)

**Oil & Gas Storage & Transportation:** These are used for oil & gas bulk storage and transportation from production area to various clients. See:

Oil & Gas Tankers – Photo 5

LNG Carrier etc. – Photo 6

#### HVAC & R System Design

For any oil & gas offshore installation the main objectives of the HVAC & R system design are:

1. Occupants survival & comfort
2. Safe and satisfactory operation of specific activities carried out in these installations.

These offshore installations are prone to toxic gas release, which can get pumped out along with crude oil and gas, besides the fire hazard, which is relatively easier to comprehend. These two hazards combined together can play a dangerous scenario with human life beside damaging the equipment that will have an effect on operations downstream. The various applications of HVAC & R in offshore installation are:

#### Comfort Air Conditioning

Air conditioning is provided for occupants survival and comfort mainly in living quarters, driller cabin, main control room, technical workshop, laboratories etc. Generally, direct expansion and chilled water-based mechanical refrigeration systems are used with an air distribution system.

#### Mechanical Ventilation

Mechanical ventilation is provided mainly in all the enclosed areas, such as engine/generator rooms, pump rooms, electrical rooms, battery room, local equipment rooms, thruster rooms, stores, machinery spaces and area of occupants movement. Generally, these types of ventilation systems require large amounts of air flow, so axial flow, and centrifugal fan units are used with a proper air distribution system. Wherever possible, natural ventilation is also used with proper feasibility study.



Photo 5: Oil & Gas Tankers

### Refrigeration

In oil and gas offshore installations living quarters, pre-fabricated cold rooms are used for food storage for long periods. The cold rooms are categorized based on the type of product to be stored and its temperature range varies from 5°C to -20°C. Mechanical refrigeration systems are used for maintaining cold room temperature.

### Specific Requirements For HVAC & R System Design

#### Codes & Standards

Generally, codes and standards to be followed for HVAC & R design are mentioned in the contract ITB (Invitation to Bid) documents and these requirements reflect the local and global best practices in oil and gas offshore HVAC design. These are ISO, NORSOK, SOLAS, RMRS, ASHRAE, CIBSE, NFPA, BS, SMACNA, AMCA etc.

#### Certification

The HVAC & R design and installation needs to be certified by third party certification agencies like Lloyds, ABS, RMRS, DNV, IMR etc.

#### HSE Considerations

Health Safety and Environment considerations are well taken care of in HVAC & R system planning, designing, installation, commissioning and operation stages. These considerations are cross-checked at various stages of designing through the following studies:

HAZID: Hazardous and Operability Study



Photo 7: An offshore installation in the North Sea zone



Photo 6: LNG Carrier

HAZOP: Hazardous Identification Study

CRA: Conceptual Risk Analysis Study

An offshore installation is uniquely hazardous, in that the persons living and working on these are miles out to 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 installation to installation. Because of the cost intensive nature of operating an offshore installation, it is important to maximize productivity by ensuring work continuity 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, normally every two weeks.

HVAC involves handling air, which can get contaminated with gases, hence 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.

#### Noise Prediction Report

In oil and gas offshore installations, a Noise Prediction Report needs to be prepared to study the noise level in all the areas with all the possible combinations of operations of various machines and systems. Based on this report, action must be taken to correct the system design to obtain the required noise level. In HVAC & R systems, all the noise reduction measures to be used such as use of proper vibration isolators, proper air velocity selection, low noise fan, use of sound attenuators, and proper structural and architectural material with acoustic properties. Generally, in living quarter cabins 40 db noise level is to be maintained.

#### Use of Available Utilities

In all oil & gas offshore installations various utilities are available in the facility for serving various machines or processes. We always try to use the available utilities as far as possible for maximum utilization:

*continued on page 82*

continued from page 80



Photo 8: Pre-fabricated spiral ducts

### Electrical Power

The HVAC&R equipments should be designed as per the available voltage and frequency available in the facility.

### Fresh water

Generally, fresh water is available for cooling purposes so a water-cooled condenser should be used for the main HVAC plant, local packaged AC units and for cold room refrigeration system.

### Sea water

Sea water or combination of sea water and fresh water can be used for the AHU cooling coils.

### Instrument Air

Instrument air is available for using in all pneumatic-based HVAC equipment controls.

### Steam

Steam is also available for heating purpose, so steam-based heater or heating coil can be used.

### Winterization requirement

For designing oil & gas offshore installations for cold climates like the North Sea, Barents Sea etc., temperature may fall down to  $-40^{\circ}\text{C}$ . The HVAC&R system for such areas should be designed accordingly. Generally, we try to avoid any HVAC&R equipment being placed outside, open to atmosphere. If at all any equipment or system is placed outside, it should be properly insulated. If a fan is placed outside, then its blades must be heat traced and the motor must have a space heater. The fresh air louvers must also be heat traced and designed with minimum air velocity like 2-3 m/sec to avoid the entry of ice particles in the fresh air.

### Global Warming Potential (GWP), Ozone Depletion Potential (ODP) & energy efficiency

HVAC&R systems used for oil & gas offshore installations should use zero ODP and low GWP refrigerants like R-134a, R-404a and systems must be energy efficient so that use of reheating, pre-cooling, pre-heating recovery system can be handled by the avail-

able utilities. Also, to make the system environment-friendly, we try to use natural ventilation wherever possible.

### Integration of HVAC&R system

The HVAC&R system must be integrated with the platform instrumentation configuration and control system (ICMS). These ICMS systems operate, control and monitor all the utility systems of the platform. This ICMS system can be web-controlled through communication links.

### Latest Trends & Technologies are Used in HVAC & R Systems

#### Wind-tunnel and computational fluid dynamics (CFD) modeling:

A modeling program, either CFD and/or a wind-tunnel test, shall be undertaken to predict:

- The air flow distribution pattern inside a room
- Natural ventilation rates and frequencies
- Wind pressure distribution around the installation to determine air inlet and outlet positions
- Requirements for secondary ventilation
- Gas build-up inside hazardous modules
- Weather protection for the working environment

To ensure sufficient air movement (distribution) throughout a naturally ventilated module, it may be necessary to provide secondary ventilation. If the area cannot be sufficiently ventilated by natural means, it shall be provided with mechanical assistance, or be enclosed and provided with fully mechanical means to achieve the required ventilation rate.

#### Pressure Drop & Noise Calculation Report

The ductwork must be designed to reduce pressure drop and also to reduce noise level by selecting a proper air distribution system. A combined report must be prepared for HVAC pressure drop and noise calculation to verify the air distribution system design. This report is produced by the sound and acoustic professional consultants.

#### 3-Dimensional Modeling of all HVAC Equipments & Systems

In oil & gas offshore installations lot's of services are used like piping, electrical, instrumentation, structure etc. Hence for multidiscipline coordinated layout planning and space management

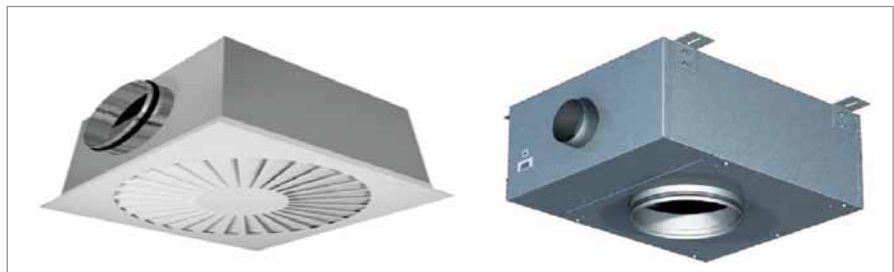


Photo 9: Supply air terminal units

*continued from page 82*

these services are actually modeled in 3D software to check the constructability, routing, clashes and space availability for maintenance and operation purposes, including the complete HVAC&R system with ducting, refrigeration piping, chiller, AHU, air distribution products, equipments and duct supports etc. This will provide a complete visualization of all the services before the installation using 3D software like PDMS, PDS.

### **Type of Equipment Used**

#### **Spiral Duct, pre insulated**

This type of ducting system installs in about half the time, reducing downtime for installation.

Today, more and more companies are switching from rectangular to spiral round rigid duct work. Why is this? What advantages do spiral systems have over rectangular? The fact is that such ducts are energy efficient, cost less to install, often require less space, need less hangers, operation costs are lower, more noise-free, installation simplified, cleaning less complicated, airflow measurement easier and light in weight.

#### **Modularization in HVAC& R systems**

In oil & gas offshore installations like living quarters for personnel, the typical type of one-man and two-man cabins used in 100 to 400 numbers depends on the size of living quarters, so this type of modular construction concept is used for economy, flexibility and ease of use. In HVAC&R also, we try to use maximum modularization of systems such as use of typical terminal units (a combination of an acoustic plenum, terminal diffuser, re-heater and thermostat), prefabricated and pre-insulated spiral ducts, packaged air conditioners that combine all essential components in a single unit including multiple hermetic scroll compressors which ensure continuous smooth operation.

#### **Type of compressors preferred**

Since such Installations are complex in nature (structure and layouts), generally we use DX type air conditioning system with semi-hermetic type compressor. If the system is installed in a hazardous area, then explosion/ flame-proof compressor and electrical connection box is used as per application requirement and to meet the code and standards requirement.

#### **Type of condensers preferred**

Since such installations are in a



*Photo 11: Sturdily built double-skin AHU*

harsh environment, air-cooled condenser are not preferred and water-cooled condensers are used with common fresh water available from the fresh water treatment plant in the installation. Water cooled condensers also require less space and space is always a constraint.

#### **Type of evaporators preferred**

Because of complex space management, DX type coils are preferred. This DX coil is made of copper tube and copper fins to avoid corrosion from environment effect.

#### **Type of AHUs used**

Generally, double skin type is used and is built up on a sturdy bedframe made of steel and includes all sections required to suit every individual specification. It is manufactured in different sizes with air capacities ranging from 0.53 to 13.61 cu.m/s.

The air handling unit is specially designed for marine installations. Each section is designed as a modular system and consists of a rigid framework made of square pipes with specially assembled corners. The sections are made of galvalume\* steel sheet and internally insulated. Galvalume is an aluminum-zinc alloy coated steel sheet produced by a continuous hot dip process. (\*55% aluminum, 43.4% zinc and 1.6% silicon)

Equipment such as fans, motors and filter mats can be simply removed from its section through inspection doors fitted to ensure easy maintenance.

The condensed water from the cooler, humidifier and water eliminator drops into a drip pan and drains out through a drain pipe. The unit can be hooked up by means of eye-plates mounted in each corner of the bed frame. Each component comprising an air handling unit is of high quality, designed for marine application.

Generally, three modes of operation are used in HVAC – Normal mode, Emergency mode and Free-cooling mode. The AHU is operated in free-cooling mode when outside temperature is lower or equal to the design temperature (22°C) when 100% fresh air is used and each AHU component is accordingly designed and sized. OEM's for these type of AHUs are Haier, Carrier, Flakt & Halton etc.

### **Conclusion**

Designing and installing an HVAC&R system on board oil and gas offshore vessels calls for painstaking care, attention to detail and knowledge of design and standards / equipment / software required as per international norms. ❖



*Photo 10: Modular HVAC packaged unit*