WINTER TRAINING REPORT ON

DESIGN AND ENGINEERING OF OFFSHORE PLATFORMS AND FACILITIES FOR PRODUCTION,PROCESSING AND TRANSPORTATION OF OIL AND NATURAL GAS

MENTORED BY

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ACKNOWLEDGEMENTS

We sincerely thank Mr. Basudeb Sarkar,CE(P) for taking us under his able mentorship. We also thank specially Mr. Sudip Gupta,CE(P) and Mr. K.C. Deka,CE(CIVIL) for helping us throughout this period .We also give sincere thanks to Mr. P.L.N. Laxminarayan,CE(M) , Mr. Pranjal Sarma,SE(M) , Mr. A. Sezhian,DGM(E) , Mrs. Elizabeth,SE(I), Mr. K. Thakuria,SE(M),Mr. Dilip Mondal,SE(E&T), Mr. Maruti Viswakarma,AEE(E), Mr. V.N. Mathur,DGM(Civil) ,Mr. Samar Das,CE(D) Mr. N.M. Ghavri,Senior Drawing Officer and Mr. R.V. Gawande,EE(M), for giving us their valuable time and sharing their knowledge with us.

We also thank Mr. B.B. Nayak,DGM(P) and Mr. S.R. Chowdhury,CE(P) for guiding us on our visit to the URAN plant.

We also express our gratitude towards Mr. Alok Bali, Supdtg. Geologist and RTI, ONGC(Mumbai) without the help of whom it would not have been possible for us to undergo this training.

We thank Oil and Natural Gas Corporation Limited, Mumbai for giving us an opportunity to have an industrial exposure under the guidance of the experts.

We also thank all of them who have directly or indirectly helped us during the tenure of our training.

Sincerely thanking all of the above once again, we hope to continue to take the guide from the aforementioned in near future. It has been a great experience for all of us.

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CONTENTS

ABSTRACT

We had an opportunity to undergo vocational training for 18 days (20.12.10 to 06.01.2011) in ONGC, Mumbai at the 11 High office. During this period, we had an exposure to various ongoing projects and procedures in different departments of offshore engineering services of the organization. We got an opportunity to discuss and learn a lot about the industrial processing and Development activities of ONGC.

There are basically two divisions under engineering services – Offshore Design Section (ODS) and Offshore Works Division (OWD). During the tenure of the training our focus was mainly on ODS, under which there are seven disciplines-

1. Process
2. Piping
3. Pipelines
4. Instrumentation
5. Mechanical
6. Electrical
7. Structure

Apart from getting the overview of all these disciplines, we have also worked on a small project on PGC, along with a single day visit to the process platform at URAN, and an overview of the basics of drilling processes.

ABOUT ONGC

ONGC Ltd. Is recognized as the Numero Uno E&P company in the world and 25th among the leading global energy measures as per "Platts Top 250" Global Energy Company Ranking 2008. It is the first and only Indian company to figure in Fortune's "World's Most Admired Companies List, 2007".

ONGC Group of Companies comprises of

1. Oil and Natural Gas Corporation Limited (ONGC - The Parent Company)
2. Overseas E&P: ONGC Videsh Limited (OVL – a wholly owned subsidiary of ONGC), ONGC Nile Ganga BV (ONG BV - a wholly owned subsidiary of OVL), ONGC Amazon Alaknanda Ltd. (OAAL) etc.
3. Mangalore Refinery and Petrochemicals Limited (MRPL - a subsidiary of ONGC).
4. Value-Chain: OPAL, OMPL etc.
5. Services: OMESL, Pawan Hans Helicopters Ltd., etc.
6. SEZ: MSEZ, DSL.
7. Power: OTPC.

Oil and Natural Gas Corporation Limited (ONGC) is India's Most Valuable Company, having a market share of above 80% in India's Crude Oil and Natural Gas Exploration and Production. ONGC registered the highest profit among all Indian companies with Rs. 19872 Crores in the year 2007-08. ONGC also produces Value-Added Products (VAP) like C2-C3, LPG, Naphtha and SKO.

ONGC Videsh Limited (OVL) is overseas arm of ONGC, engaged in Exploration & Production Activities. It trans-nationally operates E&P Business in 10 countries, making ONGC the biggest Indian Multinational Corporation. In recent years, it has laid footholds in hydrocarbon acreage in various countries including Ivory Cost and Australia. ONGC Nile Ganga BV is a wholly owned subsidiary of OVL and has equity in producing field in Sudan.

ONGC envisages organizing Import/International Sale of Crude Oil and Export of Petroleum Products through Tendering Procedure for all the Group Companies. However, it would be restricted to the Companies/ Firms/ Vendors registered with ONGC on its approved Vendor Lists.[1]

1. PRELIMINARIES OF OIL AND GAS PRODUCTION

There are mainly four steps involved in the production of crude oil and gas. They are:

1. Exploration
2. Gas and Crude Oil Production
3. Processing
4. Transportation.

1.1 EXPLORATION:

Exploration means a scientific search set by the geologists and geophysicists for locating the probable regions of oil and gas. In general terms this refer to the entire gamut of search for hydrocarbons with the help of geological and geophysical surveys integrated with laboratory data backup, selection of suitable locations of exploratory test-drilling and testing of such wells.

Geophysical technology greatly reduces the risk of drilling. Wells are drilled to test a geological theory or model that is generated in the Wide Area Geological Review and validated by seismic data. The relative position of rock layers can be imaged from the patterns of acoustic sound waves that are reflected from subsurface formations. For two-dimensional (2D) seismic operations, field crews run parallel lines of sound recorders at wide intervals to cover large areas in a relatively inexpensive manner. Once a field is discovered, 3D seismic can be run in a grid pattern with close sound recorders to delineate the most attractive places to drill additional wells and determine the areal extent of a formation.[2]

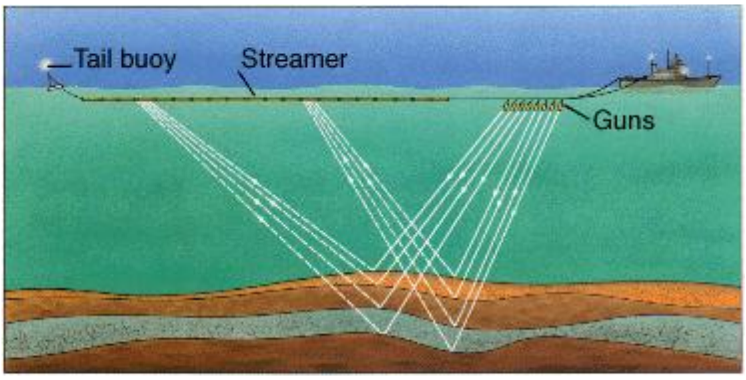


Fig 1.1 Seismic Survey for offshore

1.2. GAS AND CRUDE OIL PRODUCTION:

According to generally accepted theory, Crude Oil is derived from ancient biomass. It is a fossil fuel derived from ancient fossilized organic materials. More specifically, crude oil and natural gas are products of heating of ancient organic materials (i.e. kerogen) over geological time. Three conditions must be present for oil reservoirs to form: a source rock rich in hydrocarbon material buried deep enough for subterranean heat to cook it into oil; a porous and permeable reservoir rock for it to accumulate in; and a cap rock (seal) or other mechanism that prevents it from escaping to the surface. Within these reservoirs, fluids will typically organize themselves like a three-layer cake with a layer of water below the oil layer and a layer of gas above it according to their densities, although the different layers vary in size between reservoirs. Because most hydrocarbons are lighter than rock or water, they often migrate upward through adjacent rock layers until either reaching the surface or becoming trapped within porous rocks (known as reservoirs) by impermeable rocks above. However, the process is influenced by underground water flows, causing oil to migrate hundreds of kilometers horizontally or even short distances downward before becoming trapped in a reservoir. When hydrocarbons are concentrated in a trap, an oil field forms, from which the liquid can be extracted by drilling and pumping.[3]

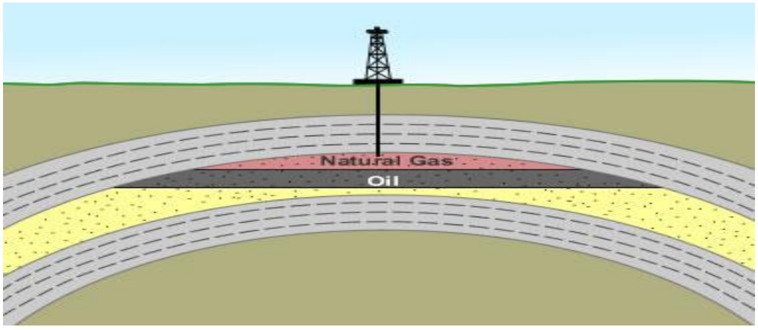


Fig1.2: Hydrocarbon trapping in an anticline structure[4]

Prospects must be well defined in order to obtain oil and gas leases from landowners prior to the drilling of a wildcat well after the necessary land work has been completed, the drilling rig is moved on site and crews work 24 hours a day to drill a hole for the calculated depth.

Once the hole has been drilled to the target formation, the well is logged with electronic downhole measurement tools to record the characteristics of the subsurface rock formations. If logging indicates the well is productive, it is cased with steel pipe and a wellhead of shutoff valves is installed to prepare for production. The well is completed by perforating holes in the casing at the depth of the producing formation. Once a successful test well or series of wells has been drilled, the economic potential of the hydrocarbon discovery must be determined. This step includes estimating how much oil and gas is present (reserves), the probable selling price, the cost of continuing the exploration effort as well as the cost of full field development, and the taxes, royalties, and other expenses associated with producing the oil field. If the venture looks promising, the final step is taken—development of a newly discovered field.[3]

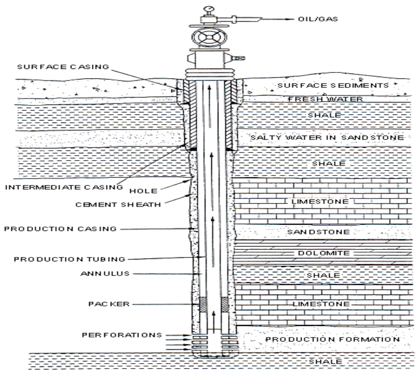


Fig1.3: Typical oil and gas Well Configuration [4]

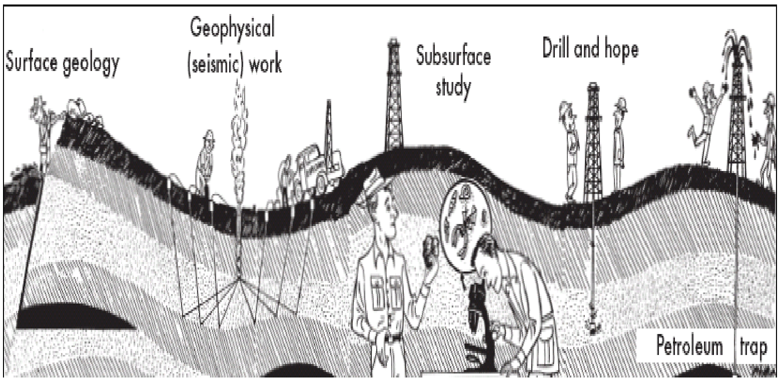


Fig1.4: Overview of Oil and Gas Production [2]

1.3. PROCESSING:

Offshore productions consists of a number of operations that allow the safe and efficient production of hydrocarbons from the flowing wells. The key operations that will be conducted at the offshore platform include:

- Produced Hydrocarbon Separation
- Gas Processing
- Oil and Gas Export
- Well Testing
- Produced Water Treatment and Injection
- Utillities to support these processes

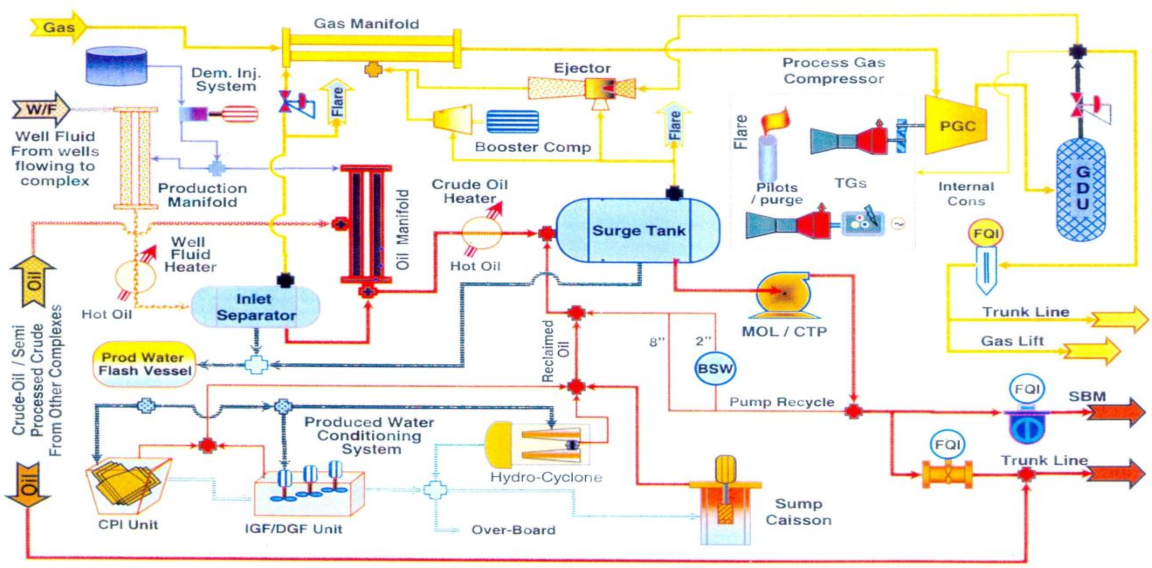


Fig1.5: Schematic Diagram of an Offshore Process Complex[4]

The Pipelines and Risers facility uses Subsea production wells. The typical High Pressure (HP) wellhead at the bottom right, with its Christmas tree and choke, is located on the sea bottom. A production riser (offshore) or gathering line (onshore) brings the well flow into the manifolds. As the reservoir is produced, wells may fall in pressure and become Low Pressure (LP) wells. This line may include several check valves. The choke, master and wing valves are relatively slow, therefore in case of production shutdown, pressure before the first closed sectioning valve will rise to the maximum wellhead pressure before these valves can close. The pipelines and risers are designed with this in mind. Short pipeline distances is not a problem, but longer distances may cause multiphase well flow to separate and form severe slugs, plugs of liquid with gas in between, travelling in the pipeline. Severe slugging may upset the separation process, and also cause overpressure safety shutdowns. Slugging might also occur in the well as described earlier. Slugging may be controlled manually by adjusting the choke, or with automatic slug controls. Further, areas of heavy condensate might form in the pipelines. At high pressure, these plugs may freeze at normal sea temperature, e.g. if production is shut down or with long offsets. This may be prevented by injecting ethylene glycol. Check valves allow each well to be routed into one or more of several Manifold Lines. There will be at least one for each process train plus additional Manifolds for test and balancing purposes. The Check valves systems have been not included in the diagram to avoid complexity of the diagram. The well-stream may consist of Crude oil, Gas, Condensates, water and various contaminants. The purpose of the separators is to split the flow into deable fractions. The main separators are gravity type. As mentioned the production choke reduces the pressure to the HP manifold and First stage separator to about 3-5 MPa (30-50 times atmospheric pressure). Inlet temperature is often in the range of 100-150 degrees C. The pressure is often reduced in several stages, three stages are used, to allow controlled separation of volatile components. The purpose is to achieve maximum liquid recovery and stabilized oil and gas, and separate water. A large pressure reduction in a single separator will cause flash vaporization leading to instabilities and safety hazards. An important function is also to prevent **gas blow-by** which happens when low level causes gas to exit via the oil output causing high pressure downstream. The liquid outlets from the separator will be equipped with **vortex breakers** to reduce disturbance on the liquid table inside. Emergency Valves (EV) are sectioning valves that will separate the process components and blow-down valves that will allow excess hydrocarbons to be burned off in the flare. These valves are operated if critical operating conditions are detected or on manual command, by a dedicated Emergency Shutdown System There also needs to be enough capacity to handle normal slugging from wells and risers. Other types of separators such as vertical separators, cyclones (centrifugal separation) can be use to save weight, space or improve separation There also has to be a certain minimum pressure difference between each stage to allow satisfactory performance in the pressure and level control loops.The second stage separator is quite similar to the first stage HP separator. In addition to output from the first stage, it will also receive production from wells connected to the Low Pressure manifold. The pressure is now around 1 MPa (10 atmospheres) and temperature below 100 degrees C. The water content will be reduced to below 2%. An oil heater could be located between the first and second stage separator to reheat the oil/water/gas mixture. This will make it easier to separate out water when initial water cut is high and temperature is low. The heat exchanger is normally a tube/shell type where oil passes though tubes in a cooling medium placed inside an outer shell. The third stage basically uses a **Flash-Drum**. Further reduction of water percentage is done in the **GDU (Gas Dehydration Unit).** On an installation such as this, when the water cut is high, there will be a huge amount of produced water. Water must be cleaned before discharge to sea. Often this water contains sand particles bound to the oil/water emulsion. The environmental regulations in most countries are quite strict, It also places limits other forms of contaminants. This still means up to one barrel of oil per day for the above production, but in this form, the microscopic oil drops are broken down fast by natural bacteria. Various equipments are used, First sand is removed from the water by using a sand cyclone. The water then goes to a hydrocyclone, a centrifugal separator that will remove oil drops. The hydrocyclone creates a standing vortex where oil collects in the middle and water is forced to the side. Finally the water is collected in the water de-gassing drum. Dispersed gas will slowly rise to the surface and pull remaining oil droplets to the surface by flotation. The surface oil film is drained, and the produced water can be discharged to sea. Recovered oil in the water treatment system is typically recycled to the third stage separators. The gas train consist of several stages, each taking gas from a suitable pressure level in the production separator's gas outlet, and from the previous stage. Incoming gas is first cooled in a **heat exchanger** and goes into the compressors. For the compressor operate in an efficient way, the temperature of the gas should be low. The lower the temperature is the less energy will be used to compress the gas for a given final pressure and temperature. Temperature exchangers of various forms are used to cool the gas, The separated gas may contain mist and other liquid droplets. Liquid drops of water and hydrocarbons also form when the gas is cooled in the heat exchanger, and must be removed before it reaches the compressor. If liquid droplets enter the compressor they will erode the fast rotating blades for which gas is passed through a scrubber and reboiler system to remove the remaining fraction of water from the gas. When the gas is exported, many gas trains include additional equipment for further gas processing, to remove unwanted components such as hydrogen sulphide and carbon dioxide. These gases are called **sour gas** and **sweetening** /acid removal is the process of taking them out.

1.4. TRANSPORTATION:

The gas pipeline is fed from the High Pressure compressors. Oil pipelines are driven by separate booster pumps. For longer pipelines, intermediate compressor stations or pump stations will be required due to distance or crossing of mountain ranges.

2. OFFSHORE DESIGN SECTIONS

There are basically two divisions under engineering services – Offshore Design Section (ODS) and Offshore Works Division (OWD). During the tenure of the training our focus was mainly on ODS, under which there are seven disciplines-

1. Process
2. Piping
3. Pipelines
4. Instrumentation
5. Electrical
6. Mechanical
7. Structure

2.1 PROCESS

This discipline lays out the initial specifications required for the process platform in the offshore. Any process platform is the gathering and distribution point for all the pipelines i.e. well fluid lines, lift gas lines and oil export line for tanker loading. All the processing facilities i.e. separation, produced water treatment, gas compression and dehydration, gas sweetening is installed on this platform. In addition there are testing facilities for testing of production coming from individual platforms.

Therefore, using many softwares like ASPEN HYSYS, SMARTPLANT etc. the process discipline under ODS drafts out the basic plans for any offshore process platform. The various diagrams like PFDs (Process Flow Diagram) and P&IDs (Piping and instrumentation diagram) are being designed by the people of this discipline. After the process design is completed the feasibility study for the designed process is carried out for future bidding and finalisation for the design.

2.2 PIPING

The piping discipline under ODS looks after the pipes on the process platform. Plant layout and design of piping systems constitutes a major part of the design and engineering effort. Basically the following are the main tasks carried out by this discipline:

- Piping and instrumentation diagrams (P&IDs)
- Piping design and engineering principles
- Terminology, symbols and abbreviations used in piping design
- Piping materials
- Piping specifications and piping codes
- Components of piping systems - fittings, flanges and valves[5]

The main base for all the calculations is Hoop Stress for all the stress calculations and wall thickness. Wall thickness selection is one of the most important and fundamental tasks in design of offshore pipelines. While this task involves many technical aspects related to different design scenarios, primary design loads relevant to the containment of the internal pressure

This discipline uses various software and standard codes for the design purposes. Among the standard codes, ONGC follows the ASME B31 code for pressure piping of a number of individually published sections. The codes used are B31.3 (Process Piping), B31.8 (Gas transportation and distribution piping system) and B31.4 (Pipeline transportation systems for liquid hydrocarbons and other liquids)

2.3 PIPELINES

Pipelines are used for a number of purposes in the development of offshore hydrocarbon resources These include e.g.:

- Export (transportation) pipelines
- Pipeline bundles.
- Flow lines to transfer product from a platform to export lines
- Water injection or chemical injection flow lines
- Flowlines to transfer product between platforms, subsea manifolds and satellite wells

The design of pipelines is usually performed in three stages, namely;

- Conceptual engineering,
- Preliminary engineering or pre-engineering,
- Detail engineering.[6]

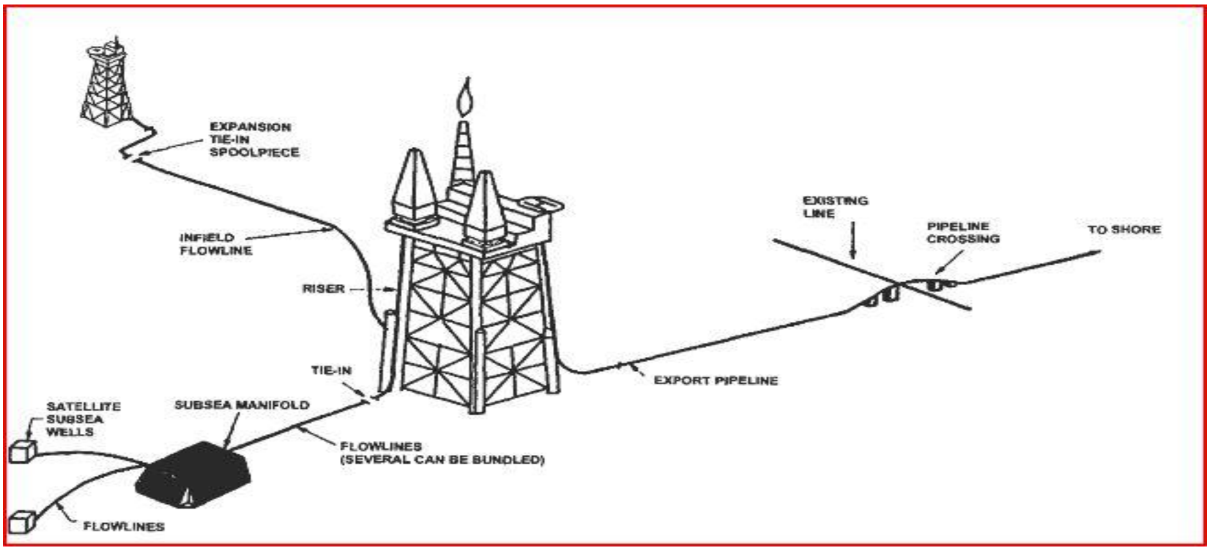


Fig 2.1 The pipeline control for any offshore platform

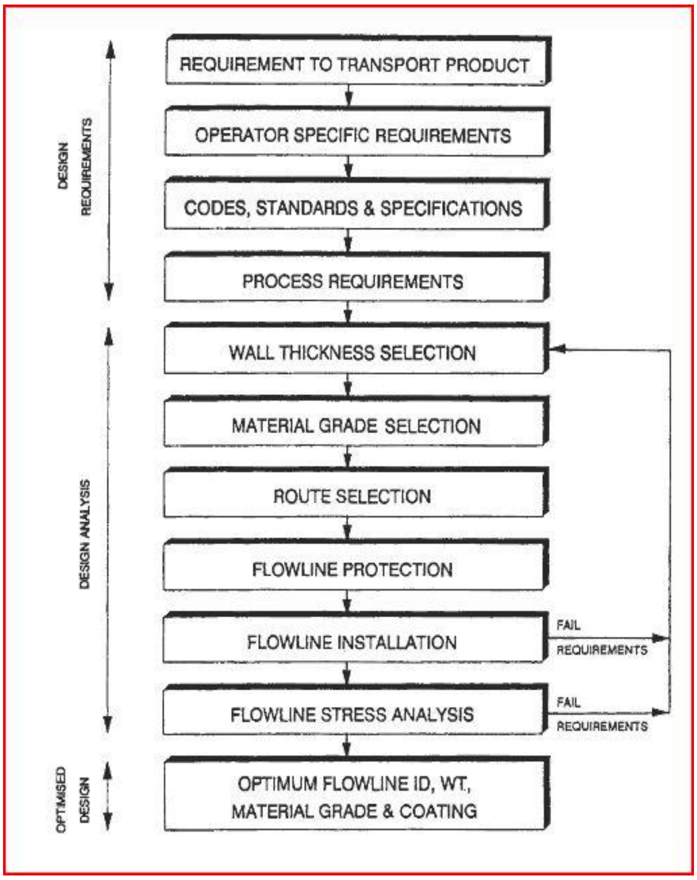


Fig 2.2 Flowline design process

Fig. Below shows the laying of the subsea pipeline, a number of pieces of pipes are welded on the barge and the assembly is made to shift slowly, the assembly acts as a thread and lay down on the seabed

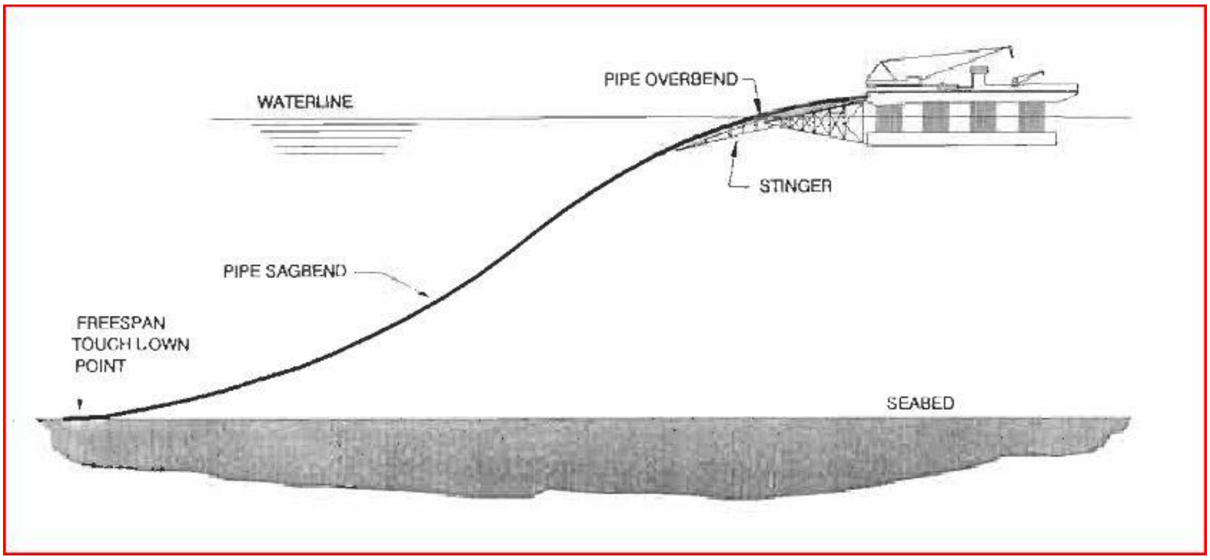


Fig 2.3 Laying of Subsea pipeline on the seabed.

2.4 INSTRUMENTATION

Instrumentation discipline comes into play after the process platform has been designed by the process design section with the help of a P&ID. This discipline helps in controlling and automating all the process parameters involved in the offshore as well as in the onshore process platforms.

The various controlling instruments looked after by this discipline may be either pneumatic or electronic. It deals with the measurement of pressure, temperature, flow-rates with the help pressure transducers, temperature sensors (RTD, Thermocouples etc.) and flow meters respectively. Instrumentation discipline also takes care of the “Shut Down Panel” which shuts down all the processes in case of an emergency.

2.5 ELECTRICAL

Every power plant needs one or the other way electrical power for its proper functioning. For an offshore platform it requires huge electrical power to run all the mechanical devices employed, living quarters electrical consumption and also some power to run various instruments.

For any general platform of ONGC, it requires about 20-25 MW or more power to run the system. To produce such large amount of power is challenging. For this ONGC has its own power production unit where power is generated by a portion of the natural gas produced. There are huge Gas Turbine Units (GTU) for power production. Also the circuit breaker station is installed on the platform itself. For some other purposes which may require small power say few KWs, power is generated by the renewable sources of energy like solar energy, wind energy etc.

2.6 MECHANICAL

The Mechanical devices such as Turbines, Compressors, Pumps, Heat Exchangers etc. are the basics for a plant to operate and such devices are included under the Mechanical discipline for both running and maintenance of the same. A small introduction about the main mechanical units operating in a offshore process platform is given below

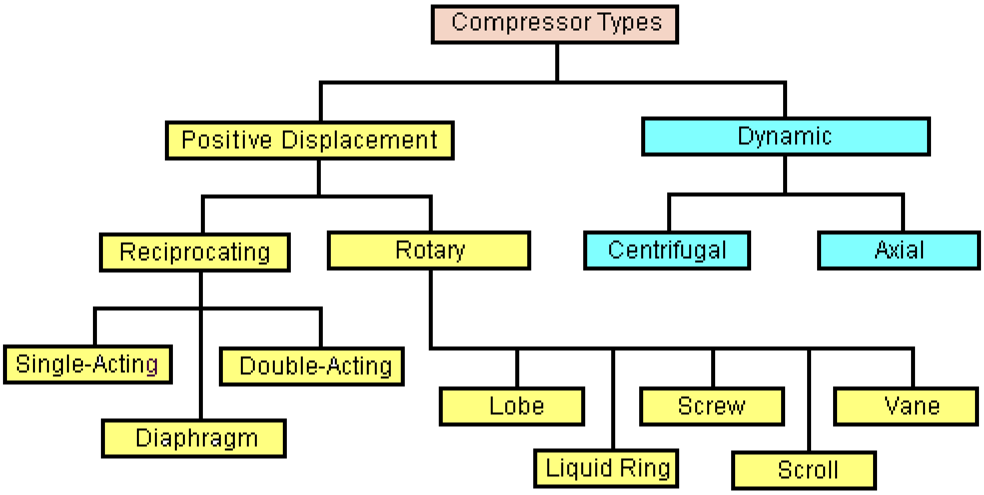
2.6.1 Gas Turbines

Gas Turbines are used for the power production by rotation of the turbine shaft by steam generated due to heat generated by burning a portion of natural gas produced. An efficient gas turbine used in a power plant produces about 10-15 MW of power under optimized conditions. Special care is taken for the inlet gas entering into the turbine as wet gas may corrode the blades of the turbine and also reduces the efficiency furthermore due to corrosion it may cost economic loss to the plant.

2.6.2 Gas Compressors

A **gas compressor** is a mechanical device that increases the pressure of a gas by reducing its volume. Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible, while some can be compressed, the main action of a pump is to pressurize and transport liquids. Normally a three stage compression system is applied in a gas based power plant.[7]

Below are the different types of gas compressors:



The centrifugal types are mostly used in gas plants.

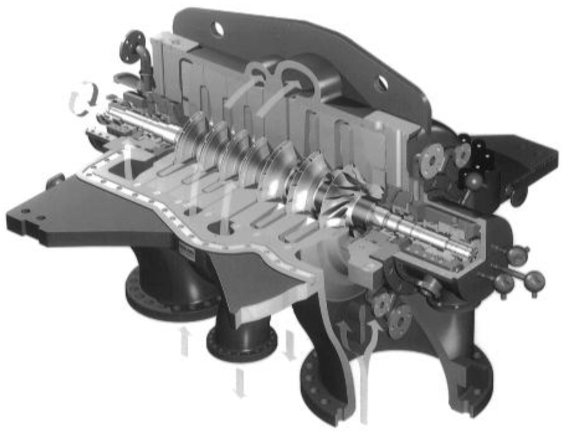


Fig 2.4 Multi Stage Compressor[8]

2.6.3 Heat Exchangers

Heat Exchangers exchanges heat between two fluids, In ONGC heat exchanger used is the tube and shell type. Mainly these units are used during crude oil components separation in which a portion of the crude oil is heated and passed through tubes and other portion is passed through shell in this way exchange of heat takes place reducing the viscosity of the fluid which is necessary to avoid vortex formation and maintain almost laminar flow within the pipes which helps in avoiding condensate formation. Also since compressors require the temperature of the entering gas to be low for its efficient working temperature exchangers of various forms are used to cool the gas.

2.6.4 Knock Out Drums (KOD)

The knock out drums is used for the separation of gas and oil from the saline water. Mainly the principle involved is the gravity separation (baffle plates are present inside them) in which the components are separated depending on their density.

2.6.5 Pumps

Pumps are basically used for transporting incompressible fluids like crude oil by creating large pressure difference for its transportation along pipelines. Presently in ONGC centrifugal type pumps are used for general purposes.

2.7 STRUCTURE

Structure discipline designs the supporting structure of the platform and the topside considering the stress analysis criteria. They use many softwares like SACS, MicroStation etc. for the design purposes.

2.7.1 Supporting Structures

The supporting structure on which the platform rests is divided into:

1. Jackets
2. FPSO(Floating production storage and offloading)
3. Jack up rigs
4. Semi Submersible Platform
5. Gravity based structures
6. Spar

2.7.1.1 Jackets

Jackets are broadly classified into 3/4/6/8 legged, depending upon the surface area of the platform required. A jacket can be used only for smaller depth say 60-70 metres as the jacket structure rests on the seabed, a typical four legged jacket is shown below. The jacket supports a sub-frame with production equipment and accommodation deck on top of it. The jacket has to be transported on a barge to its installation site at sea. While installing jacket on the seabed steam hammering is done while piling them for stability. Sometimes skirt piles are also given for providing support to the bigger jacket structure. The other processes which are involved while installing the jacket are: cementing of legs of jacket, provision of the mud mat at the base, battering of the legs (single batter on one side and double batter on the other side, this is done in order to let the barge approach to the platform to install the drill rigs), provision for the riser is also included in the design.

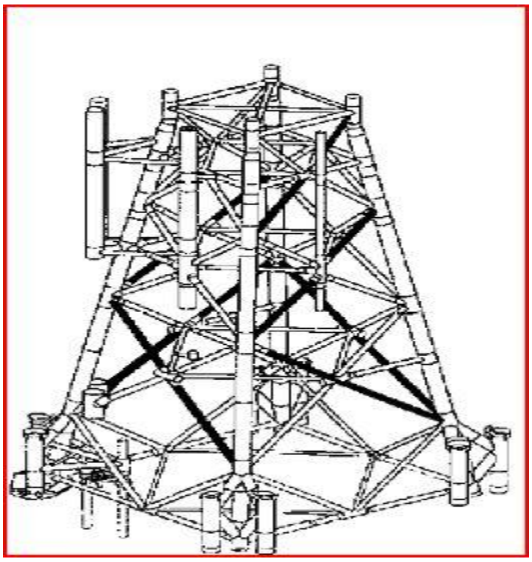


Fig.2.5 A Four Legged Jacket[9]

2.7.1.2 FPSO

A Floating Production, Storage and Off-loading vessel (FPSO) is generally based on the use of a tanker hull, which has been converted for the purpose. Such vessels have a large storage capacity and deck area to accommodate the production equipment and accommodation. When converting old tankers for this purpose, special attention has to be paid to the fatigue life of the vessel.

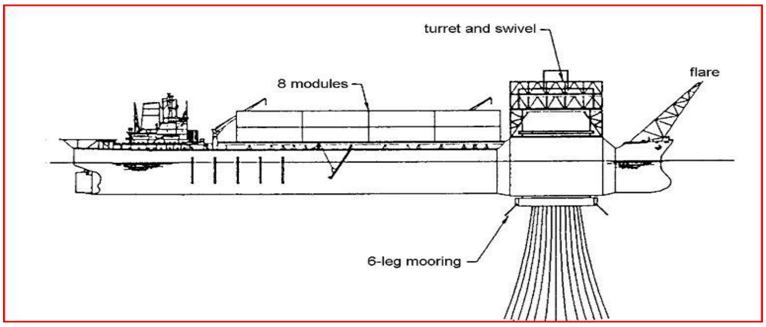


Fig.2.6 FPSO[9]

2.7.1.3 Jack-Up Rigs

A jack-up is a mobile drilling unit that consists of a self-floating, flat box-type deck structure supporting the drilling rig, drilling equipment and accommodation. It stands on 3 or 4 vertical legs along which the platform can be self-elevated out of the water to a sufficient height to remain clear of the highest waves. Drilling operations take place in the elevated condition with the platform standing on the sea bed. This type of platform is used for drilling operations in water depths up to about 100 m. Jack-ups spend part of their life as floating structures. This is when such platforms are towed to a new location by means of ocean-going tugs. In this mode, the legs are lifted up and extend upwards over the platform.

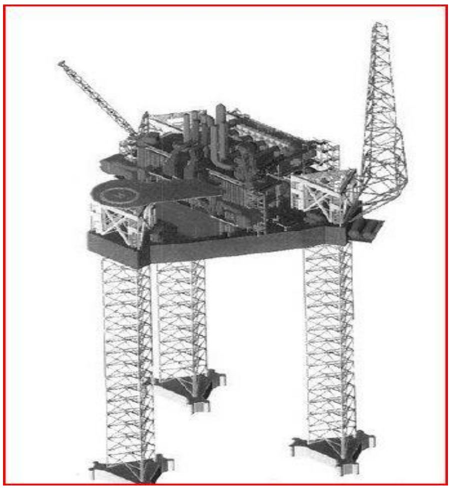


Fig.2.7 Jack-Up Rig

2.7.1.4 Semi-Submersible Platform

A Semi-Submersible Platform consists of a rectangular deck structure supported by 4to 8 surface-piercing vertical columns standing on submerged horizontal floaters. These vessels have good motion characteristics and do not require the heading changed as the predominant direction of the weather changes. The vessels are moored by means of 8 to 12 catenary mooring lines consisting of chains or combinations of chain and wire. Parts of the pipelines transporting the oil to the floater have to be flexible to allow for the wave induced motions of the floater. These flexible pipe lines have to be sufficiently strong and resilient to withstand high pressures and temperatures of the crude oil as well as the continual flexing due to the floater motions.

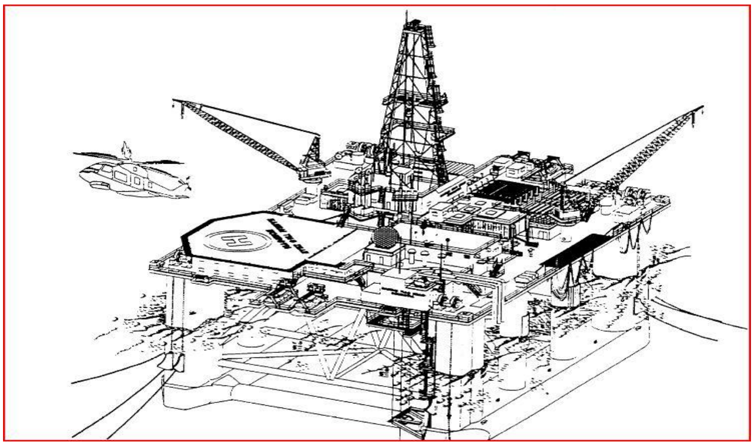


Fig. 2.8 A semi Submersible platform

2.7.1.5 Gravity Based Structures

Gravity Base Structures (GBS) are applied to remote fields in deep and harsh waters in the central and northern part of the North Sea. They consist of a combination of a number of large diameter towers, placed on top of a large area base which contains also storage capacity. Piling to the sea bed is not required because of the large size of the base and the mass of the structure, but the sea bed has to be levelled. The towers support a sub-frame with a production equipment and accommodation deck on top of it.

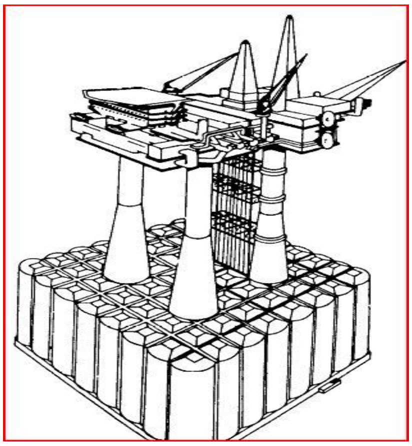


Fig 2.9. A GBS

2.7.1.6 Spar

Spar is basically a mono legged platform of smaller surface area and is mostly employed for larger depths of more than 1 km. All the basic facilities are provided on the platform for the various production purposes.

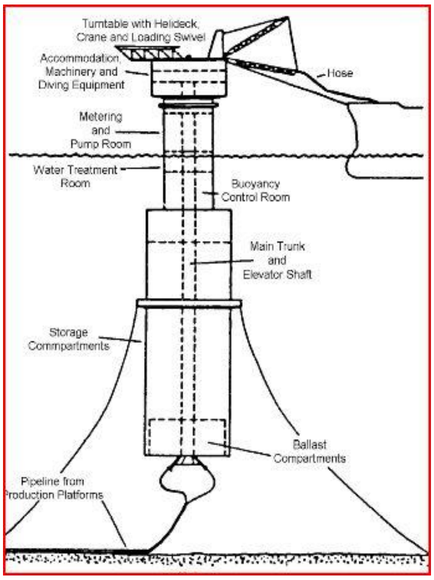


Fig 2.10 A Spar

2.7.1.7 Tension Leg Platform

A Tension Leg Platform (TLP) consists of a semi-submersible type hull with for instance four vertical surface-piercing columns standing on underwater floaters and supporting a large rectangular deck. At each of the four corners of the floater, pre tensioned tethers extend vertically downwards to foundation templates which are piled into the sea bed. Due to the vertical tendons, which are pre-tensioned to such a degree that they never become slack, any vertical motion of the TLP will be eliminated. This allows for steel pipe line connections between the wells and the floater, without the need for flexible sections of pipe lines.[9]

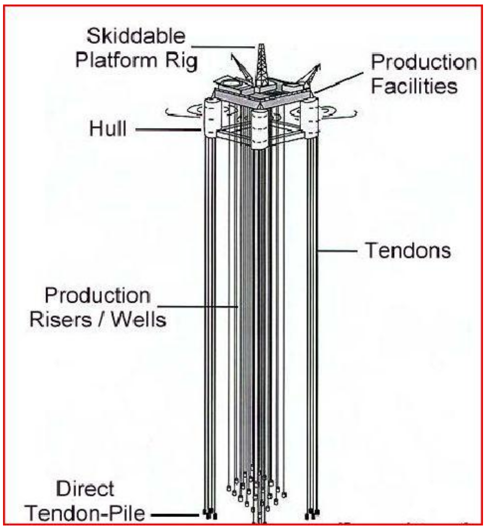


Fig 2.11 A TLP

2.7.2 Topside

The topside is a structure resting on a supporting structure having all the basic facilities for the process, unmanned platforms. They are divided into:

1. Cellar Deck
2. Sub-Cellar Deck
3. Heli Deck
4. Living quarters Deck

Fig 2.12 The Topside with all the decks.[10]

3. DRILLING PROCESSES

A major difference between onshore and offshore drilling is the nature of the drilling platform. In addition, in offshore drilling the drill pipe must pass through the water column before entering the lake or seafloor. Offshore wells have been drilled in waters as deep as 10,000 ft (305 m).

The following text provides an overview of drilling in offshore environments:

3.1 DRILLING TEMPLATES

Offshore drilling requires the construction of an artificial drilling platform, the form of which depends on the characteristics of the well to be drilled. Offshore drilling also involves the use of a drilling template that helps to connect the underwater drilling site to the drilling platform located at the water's surface. This template typically consists of an open steel box with multiple holes, depending on the number of wells to be drilled. The template is installed in the floor of the water body by first excavating a shallow hole and then cementing the template into the hole. The template provides a stable guide for accurate drilling while allowing for movement in the overhead platform due to wave and wind action.

3.2 DRILLING PLATFORMS

There are two types of basic offshore drilling platforms, the movable drilling rig and the permanent drilling rig. The former is typically used for exploration purposes, while the latter is used for the extraction and production of oil and/or gas. A variety of movable rigs are used for offshore drilling. Drilling barges are used in shallow (<20 ft [<6 m] water depth), quiet waters such as lakes, wetlands, and large rivers. As implied by the name, drilling barges consist of a floating barge that must be towed from location to location, with the working platform floating on the water surface. In very shallow waters, these may be sunk to rest on the bottom. They are not suitable for locations with strong currents or winds and strong wave action. Like barges, jack-up rigs are also towed, but once on location three or four legs are extended to the lake bottom while the working platform is raised above the water surface; thus, they are much less affected by wind and water current than drilling barges.

3.3 DRILLING TECHNIQUES

Several types of drilling techniques are currently employed in oil and gas drilling: straight hole drilling, directional drilling, horizontal drilling, air drilling, and foam drilling. Regardless of the drilling technique, a well is typically drilled in a series of progressively smaller-diameter intervals.

3.3.1 Straight Hole Drilling

In straight hole drilling, the well bore is vertical and deviates by no more than 3 degrees anywhere along the well bore, and the bottom of the well deviates by no more than 5 degrees from the starting point of the well bore at the drilling platform. With straight hole drilling, the drill bit may be deflected if it contacts fault zones or dipping beds of hard rock layers.

3.3.2 Directional and Horizontal Drilling

Directional drilling (also termed slant drilling) involves the drilling of a curved well to reach a target formation. Directional drilling is employed when it is not possible, practicable, or environmentally sounds to place the drilling rig directly over the target area. Directional drilling is especially useful for offshore locations. With directional drilling, it may take several thousand feet for the well to bend from drilling vertically to horizontally.

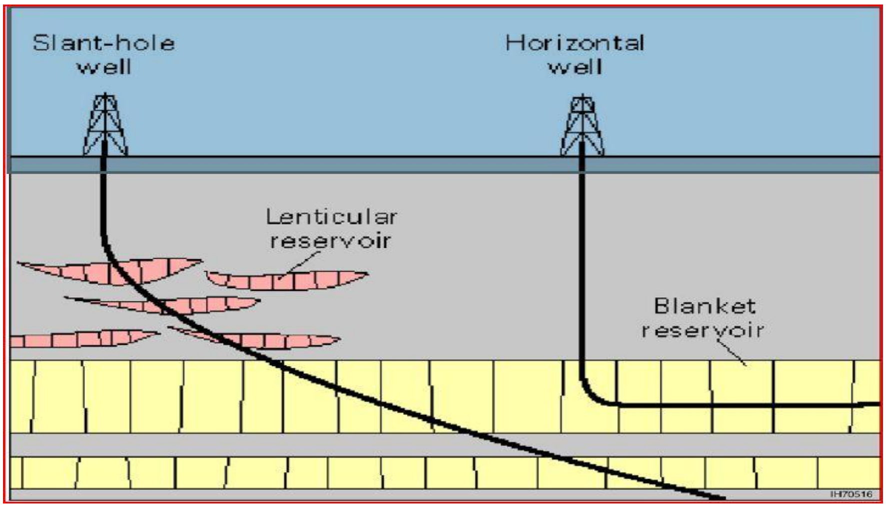


Fig 3.1 Directional and Horizontal drilling

3.4 WELL COMPLETION

Once a well has been drilled and verified to be commercially viable, it must be completed to allow for the flow of oil or gas. The completion process involves the strengthening of the well walls with casing and installing the appropriate equipment to control the flow of oil or gas from the well. Casing consists of a stacked series of metal pipes installed into the new well in order to strengthen the walls of the well hole, to prevent fluids and gases from seeping out of the well as it is brought to the surface, and to prevent other fluids or gases from entering the rock formations through which the well was drilled.[11]

4. URAN VISIT

4.1 INTRODUCTION :

Crude oil and associated gas produced at Bombay High fields and satellite fields are transported to URAN onshore facilities through sub-sea pipelines for further processing. Oil & Gas is brought from Bombay High fields through 204 km long 40" dia. & 26" dia. trunk lines respectively and from satellite fields through 81 km long 2" dia. & 26" dia. trunk lines respectively.

4.2 OIL & GAS PROCESSING FACILITIES:

The crude oil received from offshore is stabilised in crude stabilisation unit (CSU) through three stage separation with a view to optimise the liquid recovery. The liberated gas from CSU is compressed and mixed with offshore gas and fed to gas processing unit. The stabilised oil is stored in floating roof tanks and as per demand of refineries is sent to Trombay Terminal for onward transportation to refineries situated at Trombay and to various coastal refineries through Jawahar Deep tanker loading terminal.

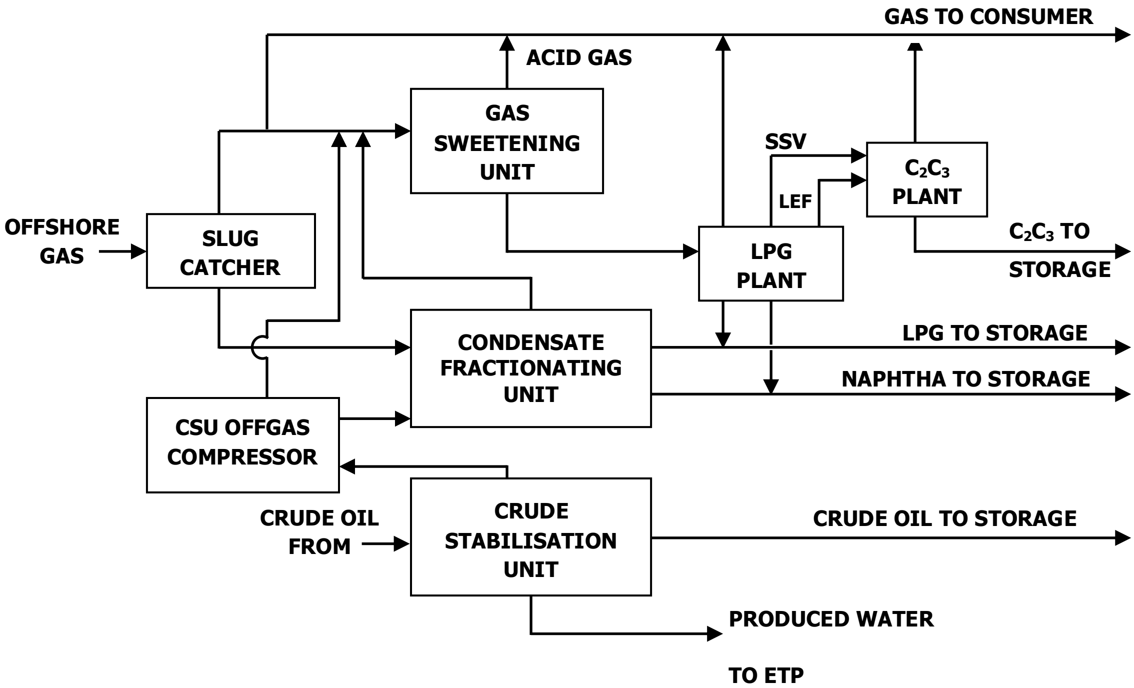


Fig4.1: Overall Schematic of Uran Complex

Associated gas is received at slug catcher, where condensate formed during travel time gets separated. Gas from slug catcher along with CSU offgas and Condensate Fractionating Unit (CFU) offgas is routed to Gas Sweetening Unit (GSU) which consists of two trains viz. GSU-I & GSU-II with handling capacity of 5.75 MMSM[4] per day of each train. The remaining gas is directly sent to consumers along with lean gas coming from the processing plants. After removal of CO_2 & H_2S at GSU, treated gas is routed to LPG recovery plant, which consists of two Units viz. LPG-I & LPG-II for extraction of LPG & NGL/Naphtha. Remaining Second stage vapours (SSV) & Light End Fractionating column (LEF) overhead vapour is taken to Ethane Propane Recovery Unit (EPRU) for recovery of Ethane-Propane. The lean gas after recovery of Ethane-Propane is supplied to M/s. GAIL for onward supply to various gas consumers like USAR LPG Plant, RCF, MSEB, TEC,BPCL/HPCL, DFPCL etc. Ethane-Propane (liquefied) is sent to MGCC, Nagothane for using as feed stock to Gas Cracker Unit. LPG & NGL/Naphtha are supplied to BPCL & HPCL refineries. Naphtha is also supplied to various on land consumers or exported.

Condensate separated at slug catcher and at CSU off-gas compressors is sent to CFU-II for removal of light end hydrocarbon gases and for recovery of LPG & NGL/Naphtha. The treated condensate can also be routed to LPG plant for recovery of LPG & NGL/Naphtha.

There are various interconnection and safety features in the plants for ensuring greater flexibility and safe operation of each plant.

<u>4.2.1 Crude Stabilisation Plant</u> :

There are five identical trains [four in line & fifth hot stand by] each consisting of high pressure separator (HP), Dehydrator and low pressure separator (LP). Each train is having the processing capacity of 5 MMTPA. The process description is given below.

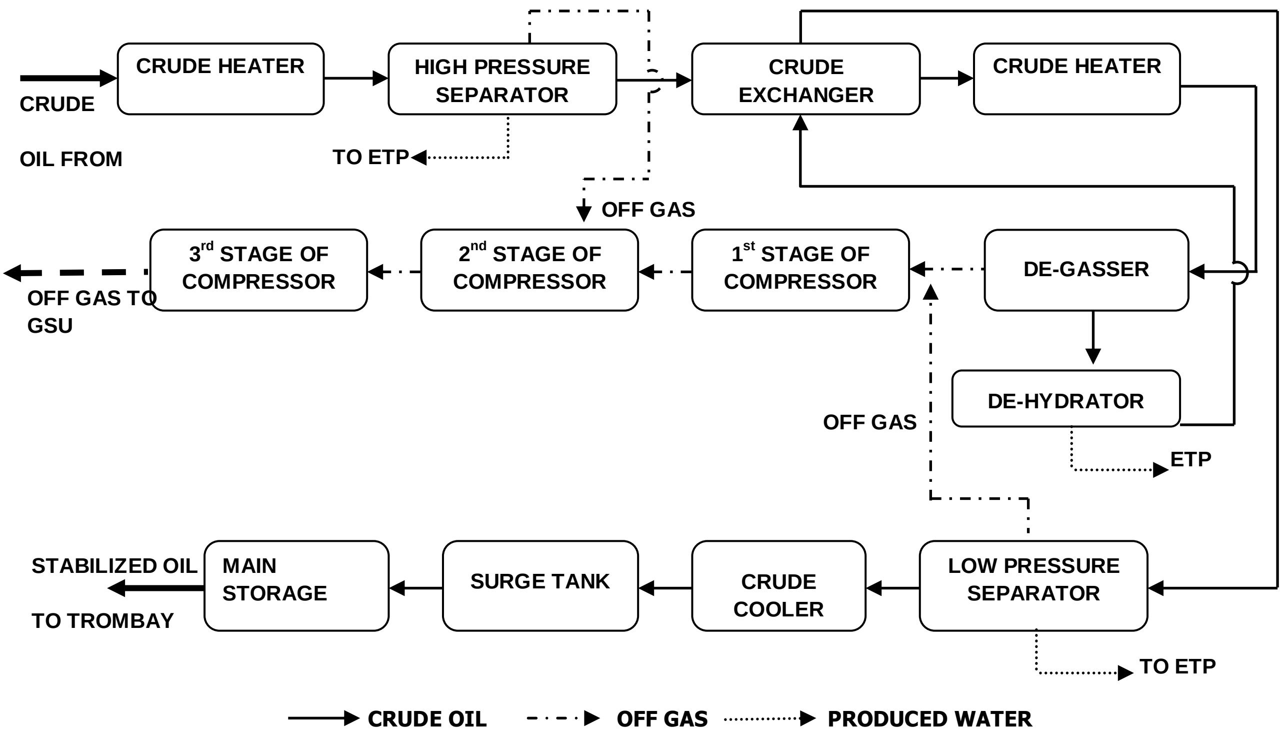


Fig4.2: Crude Oil Stabilization Unit (CSU)

At first Oil is preheated by steam to 50^0C before it enters H.P. (high pressure) separators operating at 4.5 Kg/cm^{2}g. Oil flows out under level control and can be sent directly to low pressure separators or can be pumped to the Dehydrator system. Gas liberated from H.P. separator under pressure control is sent to second stage of compressor system for compression. Oil containing water and salt, can be dehydrated in the Dehydrator systems. A high voltage electric field (normally 16,000 volt) is applied inside the dehydrator for effective separation of water from oil. Gas liberated from the dehydrator flows under pressure control to the first stage of the compressor. The produced water flows through interface level control valve and is sent to the Effluent Treatment Plant for further treatment. The dehydrators are also capable of desalting for which fresh water injection and mixing valve facility are provided upstream of Dehydrator. Oil from the low pressure separators after getting cooled to 4^0C in the water cooler, flows to the Surge Tanks. Gas liberated from L.P. separator is sent to first stage of compressor system along with gas coming out from dehydrators for compression. The stabilised oil is pumped to the main storage tanks (8 Nos. x 60000 M^4). Oil is pumped to Trombay Terminal for onward distribution to BPCL, HPCL storage and other coastal refineries via Jawahar Dweep jetty. Gases from HP separators, Degassers and LP separators are compressed in the associated gas compressors and mixed with offshore gas before feeding to GSU.

4.2.2 Condensate Fractionating Unit (CFU - I) :

The condensate fractionation unit will remove CO_2, H_2S and lighter hydrocarbons from the condensate. The condensate from Slug Catcher unit is sent to a Stripper Feed Coalescer. The free water collected in the bottom is removed through interphase level controller. Condensate from the Coalescer is taken to Stripper Column through a back pressure control valve. GSU Knock-out Drum condensate is also fed to Stripper Column. The compressor discharge is sent to Gas sweetening Unit. Stripper Bottom Product is sent to LPG plants. Alternatively, bottom product from stripper column can also be sent to LPG column of CFU-II.

4.2.4 Condensate Fractionating Unit (CFU - II) :

The condensate fractionating unit-II will remove CO_2, H_2S and lighter hydrocarbons from sour condensate and will produce LPG & NGL/Naphtha.

Condensate is received from slug catcher alongwith condensate of CSU off gas compressors in condensate surge drum. The free water is collected in the bottom and removed through interphase level controller. After this, the condensate is passed through Coalescer to remove water content of the condensate. The column top gas leaves at and compressed in one of the two off gas compressors. The top vapours are cooled and collected in a vessel as LPG. Part of the liquid is refluxed to maintain the purity and remaining liquid is pumped to LPG sphere. The bottom liquid is pumped to storage as NGL/Naphtha.

4.2. Gas Sweetening Unit (GSU) :

There are two trains in GSU for sweetening of sour gas with design capacity of each train 5.75 $MMSM^4$/Day of mixed sour gas feed. Process used is Shell's proprietary sulfinol - D process. Process description is as given below.

The feed gas from the battery limit is fed to the Feed Gas Knock-Out Drum, where liquid gets separated. Then the gas is fed to the Absorber. CO_2 and H_2S in the feed gas are removed in absorber by the counter-current contact with the lean sulfinol solution (lean solution) to meet the feed specification of gas to EPRU. The treated gas from Absorber is sent to the LPG Plants. The rich sulfinol solution from the absorber bottom is flashed into flash Scrubber and the collected liquid is sent for regeneration. Flashed vapour is routed to recontactor where it is scrubbed counter currently by small quantity of lean solution. This treated flashed gas is used as low pressure fuel gas after eliminating the entrainment through flashed fuel Knock-Out drum. The flashed rich solution is then feed to the regenerator after heating against the hot lean solution through the lean/rich exchanger. In the regenerator medium pressure steam is used as heat carrier. The stripped CO_2 and H_2S with steam are routed to overhead condenser of regenerator and sent to the reflux drum to separate acid gas and condensed water. The separated acid gas is vented to atmosphere and water is used as reflux to regenerator. The regenerator solution is cooled to ambient temperature through stages of cooling and sent to the solution tank.

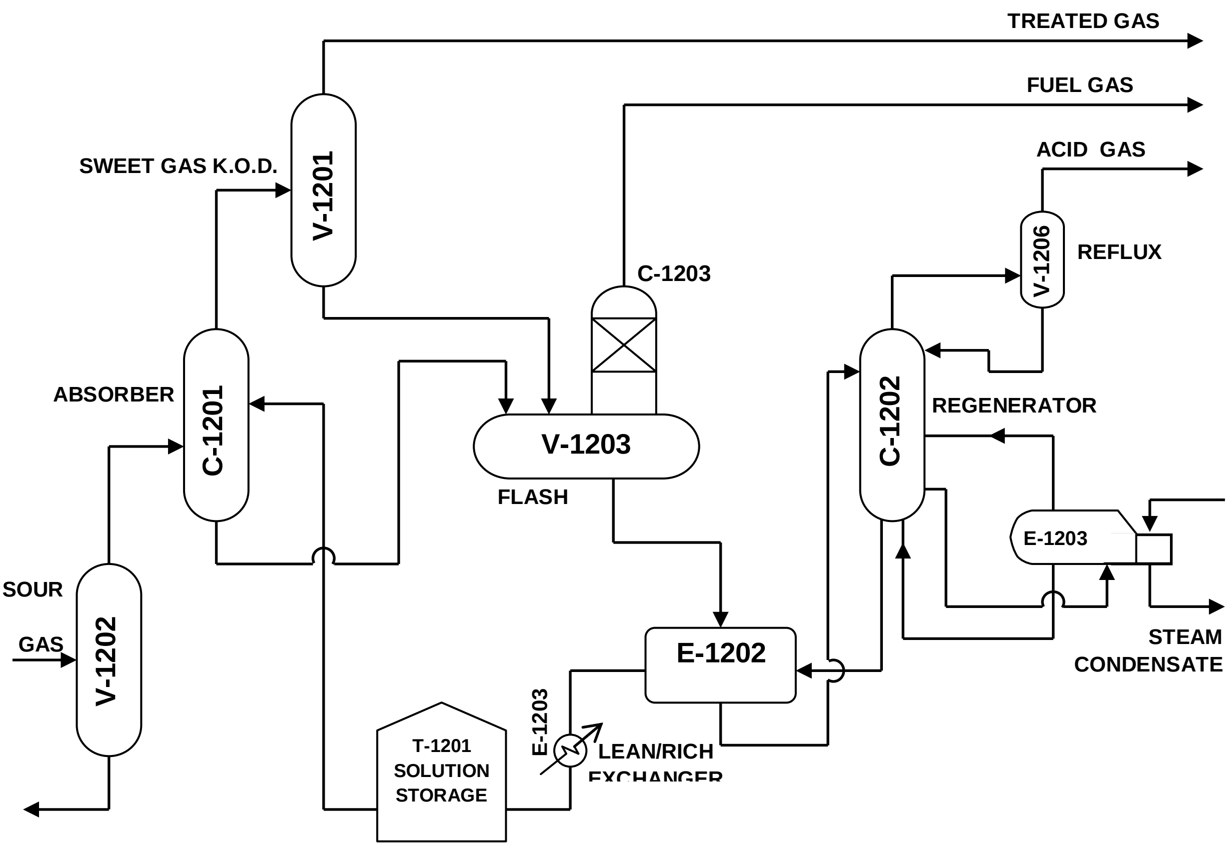


Fig 4.4: Gas Sweetening Unit (GSU-12)

<u>4.2.5 LPG Recovery Unit</u> :

The sweet gas from GSU is taken to LPG recovery plants as feed gas. When CFU-I is in operation, the sweet condensate from CFU-I can be fed to LPG recovery plants or LPG Column of CFU-II.

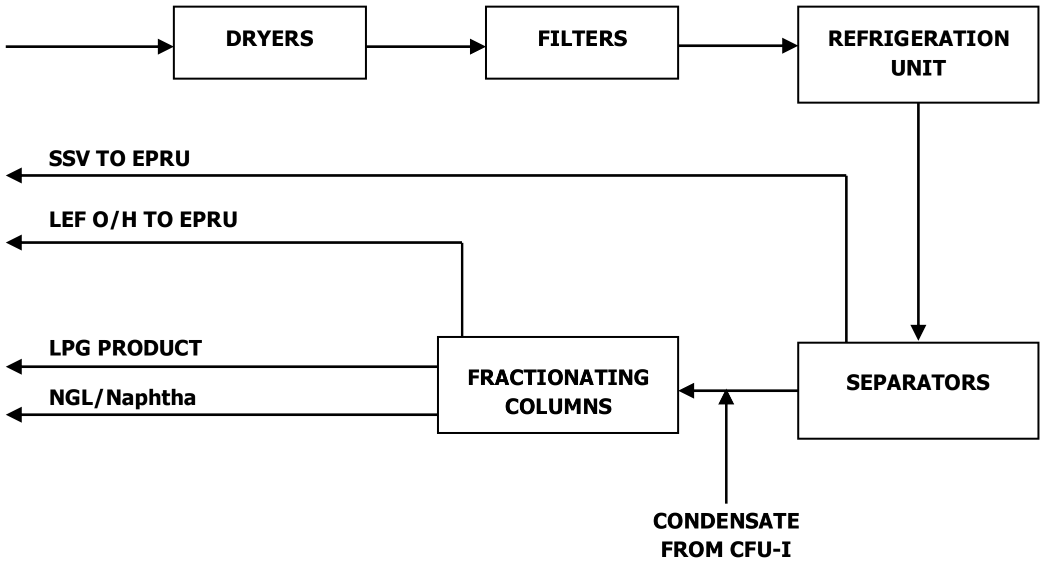


Fig4.: Schematic of LPG Plant

Basic process description is as given below:

4.2.5.1 Feed Gas drying:

Feed gas is dried in dryers to reduce moisture content to less than 5 PPM. Molecular sieve is used as desiccant. Drying follows filtration of dust particles generated from the Molecular sieves.

4.2.5.2 Chill down train :

Dry feed gas is progressively cooled in chill down train using process cold streams and external propane refrigeration. After cold recovery Second Stage Separator Vapour (SSV) is sent to EPRU for recovery of Ethane-Propane or sent to various consumers.

4.2.5.4 Light End Fractionator (LEF) & residue gas compressor :

It removes all methane, ethane & a part of propane. Bottom stream containing a part of propane (enough to make LPG), Butane and heavier hydrocarbons is feed to LPG column. LEF overhead vapour is taken to EPRU for further recovery of Ethane-Propane in EPRU Plant.

4.2.5. LPG Column :

Light end fractionator's bottom stream flows to LPG column on its own pressure. This column operates at 10 Kg/Cm^2 top-pressure and about 15 ^{o} C bottoms and 60ºC top temperatures. It separates out heavy ends from LPG. LPG is taken as top product and the bottom product is sent to storage as NGL/Naphtha.

4.2.6 Ethane-Propane Recovery Unit (EPRU) :

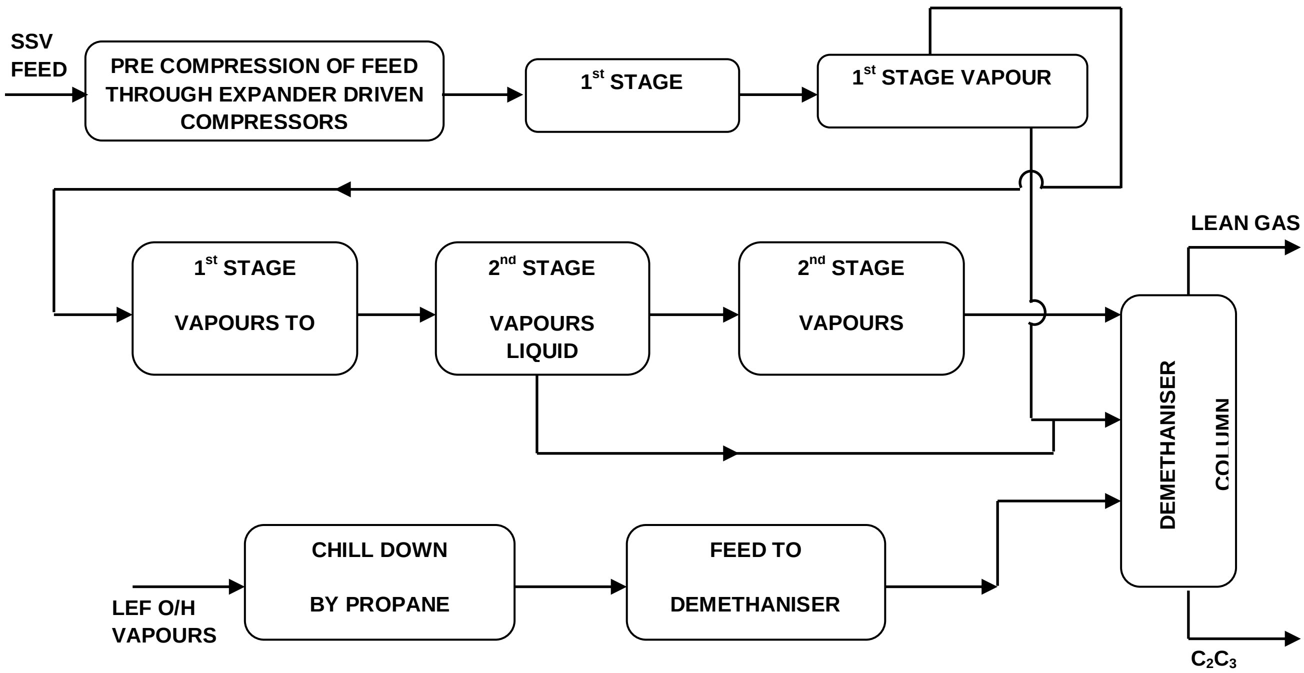


Fig 4.5 Schematic of EPRU

The Ethane-Propane Recovery Unit can be divided into the following subsections:-

- Feed Gas Compression
- Feed Gas Chilling & Separation
- Feed Gas Expansion
- Demethanizer
- Lean Gas Recompression
- Propane Refrigeration

4.2.6.1 Feed Gas Compression :

The second stage vapour from LPG-I & LPG-II is taken as feed gas to C_2C_4 plant. The LEF overload vapour from LPG-I & II is also diverted to EPRU as separate feed stock. The feed gas is taken to feed gas compressor suction knock-out drum. The gas from knock-out drum is taken to the compressor of Demethanizer overhead expander compressor. The compressed gas is directly taken to the suction of the compressor of the feed gas expander compressor. Then compressed gas at 52.5 kg/cm^{2}g is cooled to 0°C & taken to chill down section for further chilling.

4.2.6.2 *Feed Gas Chilling & Separation :*

Feed gas after compression is cooled through heat exchangers from 0ºC to about 20ºC. Further feed gas is taken to Demethanizer bottom reboiler where it cooled down to 2.5ºC. Then feed gas is taken to Chiller-I & Chiller-II for further chilling where it receives cold by propane refrigeration & chilled down from 2.5ºC to -17ºC to -27ºC to -55ºC. Then it is fed to separator-I to separate out condensate. The vapour from separator-I is taken to Chiller-III where it is chilled further to -67ºC by exchange of heat without going cold lean gas. The partially condensed feed gas at -67ºC is taken to separator-II to separate out the condensate. The condensate from Separator-I & Separator-II is directly fed to Demethanizer column at tray No.16. The vapour from Separator-II at -67ºC is taken to feed gas expander for expansion.

The LEF vapour received as feed to EPRU is available at 45ºC is taken to LEF vapour/lean gas exchanger where it is cooled down to 5ºC. Then it is further chilled down to -7ºC & -20ºC at Chiller-I & Chiller-II respectively by use of propane refrigeration. Then it is taken to Demethanizer side reboiler & chilled down to about -44ºC. Further it is taken to Chiller-III & chilled down to -47ºC & directly taken to Demethanizer column as feed at tray No.27.

3.2.6.3 *Feed Gas Expansion :*

Feed gas, after 2^{nd} stage separation at -67ºC from separator-II is taken to feed gas expander compressor for expansion. The majority of the refrigeration need is made available from this entropic expansion of gas from about 9.6 kg/cm^2(g) to about 19.5 kg/cm^2(g), the gas is further chilled down to about -100ºC and is partially condensed, mechanical energy generated due to expansion is utilised to drive the compressor used for compression of feed gas. The expander outlet partially condensed gas at -100ºC is taken directly to Demethanizer column at tray No.10 for fractionation.

3.2.6.4 *Demethanizer :*

The Demethanizer column is provided to recover C_2C_4 product from the condensed liquids at various stages in chill-down and expansion sections and remove all undeable methane from it. Feed to the column is taken as follows:-

- Feed gas expander outlet (vapour liquid) at tray No.10 at about -100ºC
- Mixture of separator-I & separator-II liquid at tray No.16 at about -67ºC.
- Partially condensate LEF vapour at tray No.25 or tray no.27 at about -47ºC.
- Of-spec C_2C_4 product, if any, from storage at tray No.0.

The vapour from Demethanizer reflux drum is taken to Demethanizer overhead expander compressor, where it is expanded to about 1.5 Kg/cm^{2}g. Due to this expansion, gas is further chilled down to about -111ºC. This cold methane rich vapour is utilised for refrigeration then it is taken to lean gas compressor.

4.2.6.5 Lean Gas Compression:

The lean gas, after recovery of Ethane-Propane is received in lean gas compressor knock-out drum at about 20ºC & 12.7 kg/cm^2(g). Then lean gas is compressed to about 0 kg/cm^2 (g) by lean gas compressor. The compressed gas after cooling to about 0ºC is supplied at battery limit for gas consumers.

3.2.6.6 Propane Refrigeration System :

Propane refrigeration system has been provided to supplement refrigeration requirement in EPRU. The feed gas is chilled down upto -67ºC with the help of propane refrigeration system followed by further heat exchange.

4.2.7 Flare System:

In case of process upset gas is flared through two numbers of elevated flares for lighter hydrocarbon and one box flare for heavier hydrocarbon, which are kept alive with the help of purge gas for safety. If needed, low temperature liquids are diverted to blow down drums, where it is converted into gas with the help of low-pressure steam and then diverted to the flare header. Condensate formed, if any, is collected in flare knockout drum and pumped back to process unit.

4.2.8 Effluent Treatment Plant:

Effluent received from CSU is routed to EPTP, where oil & water are separated using gravity separation. Oil is sent back to CSU & water is further routed to surge pond where it gets mixed with the effluents of other plants like LPG, GSU, and EPRU. This effluent is sent to ETP (MINAS) Plant for further treatment before final discharge to sea through close conduit disposal system. The process description of ETP (MINAS) having the capacity of 450 M^3/Hr (dry weather) and 700 M^3/Hr (wet weather) is as given below.

- Pre-treatment by gravity separation using corrugated plate interceptors (CPI) to reduce gross separable oil contamination.
- Primary treatment by sand filtration with in line polyelectrolyte addition to remove suspended solids and flocculated oil.
- Secondary treatment using biological filtration with random packed plastic media as the substrate for the biomass. Di-ammonium phosphate addition in upstream of Biotowers. Secondary treatment is meant for removing soluble pollutants (BOD).
- Tertiary Treatment is provided in the form of conventional gravity clarifications to remove any humus sludge from the Biotower effluent.
- Polishing of treated effluent by means of sub surface aerators in the guard pond.
- Disposal by pumping through closed conduit disposal system to low tide level into the sea.

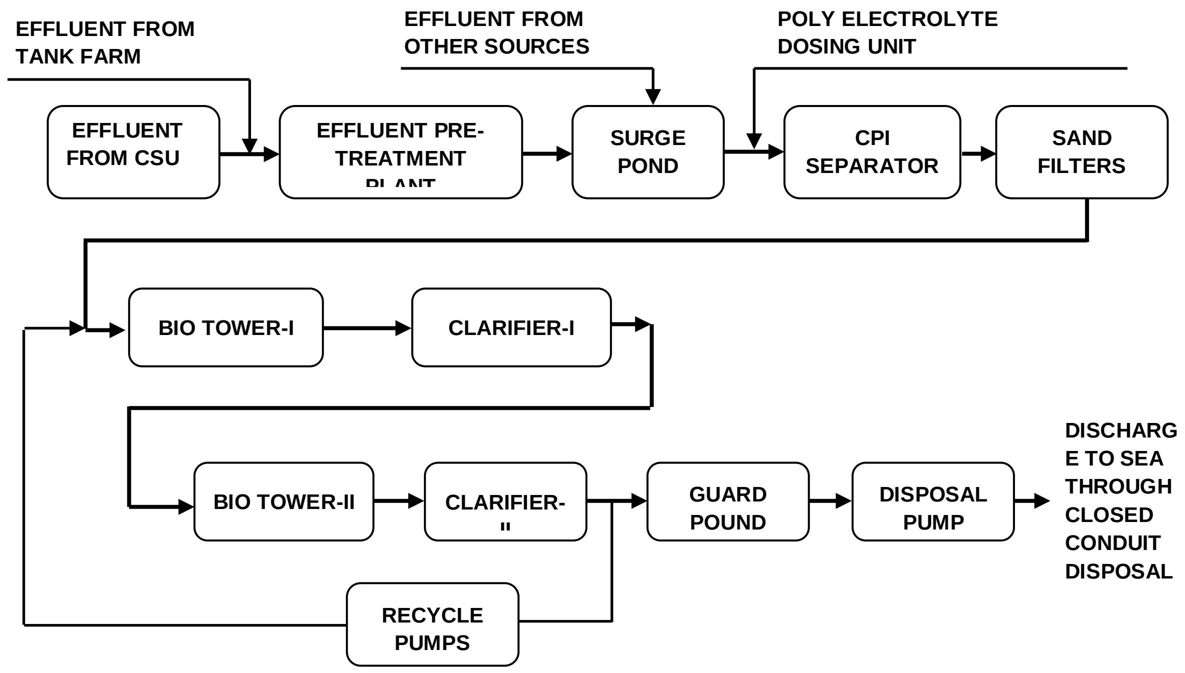


Fig 4.6 Schematic of Effluent Treatment Plant

4.2.9 Propane Recovery Unit:

Propane is produced from LPG in LPG-I plant. Propane column (10-C-104) takes LPG feed from the discharge of LPG reflux pump of LPG-I plant / LPG-II plant. The column operates at about 15 Kg/Cm2 top-pressures and about 85 º C bottoms and 0ºC top temperatures. Its top product is Propane and bottom which is butane goes to LPG spheres.

This is a small column and intended to meet the internal requirement of propane, which is used as refrigerant in LPG and C_2C_4 plants.

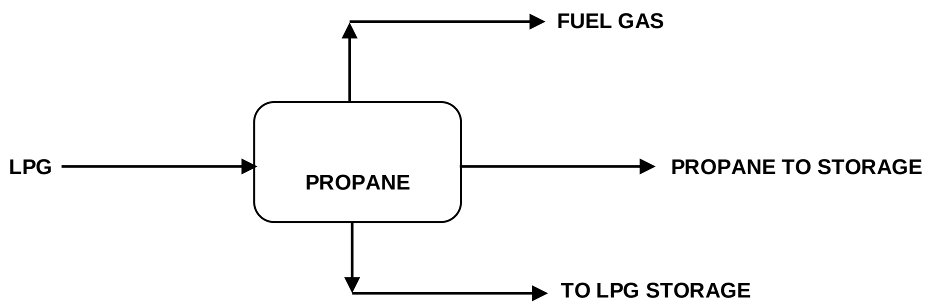


Fig4.7 Schematic of Propane Recovery Unit

5. SIMULATION OF PGC USING ASPEN HYSYS 7.1

5.1 INTRODUCTION:

ASPEN HYSYS 7.1 is a modern software meant for simulation and design of process techniques involved in various engineering fields.

Basically we have used the software for the modeling and simulation of a typical Process Gas Compressor Unit (PGC) in which three stage compression is done for higher efficiency purpose, i.e. Compressors consuming less power. Mainly the type of compressor used in the industry is the centrifugal type which is generally opted for handling higher mass-flow rates but lower compression ratio is achieved, While a reciprocating type can be used where necessarily higher compression ratio is deed.

5.2 DESCRIPTION:

Initially Sweet Gas is received from the Acid-Gas Recovery Unit (AGRU) and fed to a mixer, another inlet to the mixer is meant for the molecular adjustment supplying methane for controlling the molecular weight of the mixture whose composition is shown below:

Platform	B23-A
Components	**Vol(%)**
Methane	79.96
Ethane	5.10
Propane	2.02
i-Butane	0.34
n-Butane	0.54
i-Pentane	0.15
n-Pentane	0.20
Hexane	0.25
Heptane	0.15
CO_2	9.37
Nitrogen	1.92

In general increasing the molecular weight decreases the power input to the compressors but there is a limitation to the increase of molecular weight as it also increases the mass flow rate and a particular compressor is designed for handling a defined mass flow, also there is a third inlet to the mixer for the recycled gas and oil mix. In our case, the molecular weight is 20 gm/mol taken according to the standard specification sheets by SIEMEN’S. From the mixer, the Crude oil and gas mixture containing water is passed into a Knock Out Drum (KOD-1) which separates gas from oil and water mix. Basically it uses the gravity separation technique (having baffles) in which the gas being lighter passes from the top and the oil water mix passes from the bottom to the disposal unit. The gas from the top which is initially at 5 kg/cm2_g and 50 ^{0}C is passed into the compressor unit (comp.-1) which compresses the gas to a pressure of about 15 kg/cm2_g (comp. ratio 3) and 134.6 ^{o}C (calculations are based on Panng-Robinson’s equation) the first stage compression consumes a calculated power of 1866 KW, other data being provided in the schematic, the gas containing traces of oil and water mix. is passed through an air-cooler (AC-1) for bringing the temperature near to the initial temperature, the temperature at the outlet of the air-cooler AC-1 is 52.3 ^{o}C with a negligible pressure loss of 0.5 kg/cm2_g. Air cooling is done so that the piping material used can sustain the temperature as the properties of the material may change at high temperature from the compressor outlet, also considering the design costs and hence air-cooling is done. Now the gas is flowed into the KOD-2 from the top outlet of which, gas is separated from the traces reducing the percentage of the traces of oil and gas mix. The oil and gas mix. Is then obtained through the bottom outlet of KOD-2 which is recycled (RCY-1) and fed through the third inlet to the mixer. The gas obtained is now passed through another compressor (comp.-2) which compresses the gas from 14.5 kg/cm2_g to 34 kg/cm2_g(comp. ratio 2.345) consuming power of 1507 KW, here the temperature again raises due to compression to 123.4 ^{o} C , again the gas (with lower oil and gas mix. In ppm) is passed through AC-2 which brings the temperature down to 52 ^{o} C after cooling the gas to the required temperature, it is fed into the KOD-3 same process is followed here reducing the ppm of oil and water mix. even lower than the previous, RCY-2 recycles the oil and water mix. And fed to KOD-2 as shown, final compression i.e. the third stage compression is done (comp.-3) compressing the gas from 33.5 kg/cm2_g to 74kg/cm2_g (comp. ratio 2.209) increasing the temperature to final rise of 70.4 ^{o} C i.e. the temperature is now 122.4 ^{o} C consuming power of 1413KW, the total power consumption by the compressor module being 4786KW or 4.786MW, the temperature is again reduced to 52.3 ^{o} C using AC-3 and fed to KOD-4. RCY-3 recycles again the separated oil and water and feds it into the KOD-3. After passing through these stages the gas and oil are purified or separated enough from the undeable traces for transportation to other secondary units such as Gas Dehydration Unit (GDU).

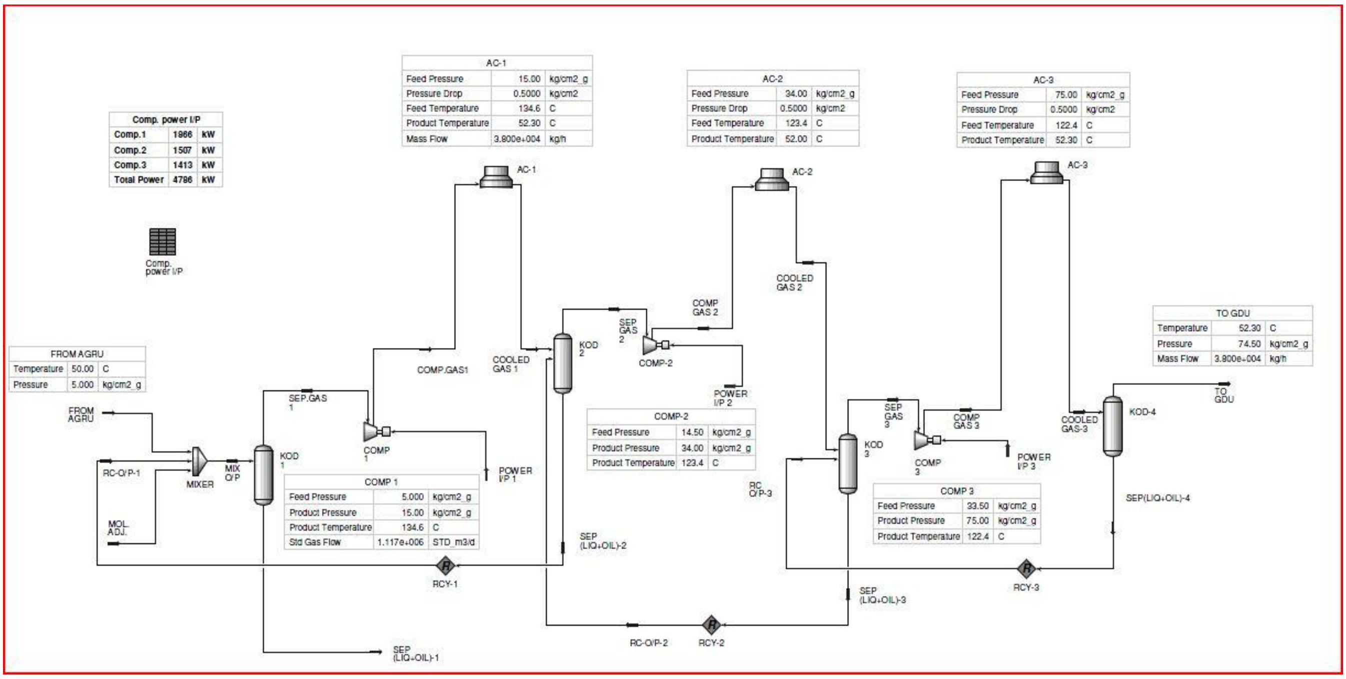


Fig 5.1 PFD for the PGC Unit

6. CONCLUSION

Engineering services plays a vital role in the off shore design. It imparts extensive support in the designing and processing of various off shore production taking place in the sea. It looks after a number of various departments and hence its importance can be compared to none when the question of implementing and executing the process comes.

Oil and gas industry thus has a huge role to play not only in the generation of power but as well as blossoming India's economy. They are the major contributors in Indian economy and hence continuous efforts are being made for their exploration in the near future.

Finally, summing it up we consider ourselves fortunate to be a part of India's tycoon company for Oil &Gas Production, though for a short tenure only. We had a great exposure to the oil and gas industry during our training as it continuously facilitated us developing our knowledge to the where-about of oil and gas industry.

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