OIL AND NATURAL GAS CORPORATION

" GROUP GATHERING STATION"

PROJECT REPORT

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In partial fulfillment for the award of the degree

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in

PETROLEUM ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES) DHANBAD – 826001

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BONAFIDE CERTIFICATE

This is to certify that the submitted Project Report in a **BONAFIDE** work of Mr. **SACHIN BANGRAWA (22JE0833), BACHELOR OF TECHNOLOGY in PETROLEUM ENGINEERING** 3rd year at **INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES) DHANBAD-(826001).** Who carried out the project work under my supervision. Certified further that to the best of my knowledge the work reported here does not form part of any other project work /thesis or dissertation based on which a degree or award was conferred on an earlier occasion on these or any other candidate.

Yours Faithfully,

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ABSTRACT

The oil and gas industry's quest for efficiency and optimization is embodied in the design and operation of Group Gathering Stations (GGS). This report commences with an exploration of the core aspects of GGS, illuminating their critical role in the collection, processing, and preparation of hydrocarbons for subsequent transportation or refinement. It enumerates the various components that form a GGS, such as separators, heaters, storage tanks, and notably, the effluent treatment plants, discussing their functions across a spectrum of operational scenarios. The report emphasizes the adaptability of GGS configurations to meet specific field requirements, showcasing the industry's dedication to customized solutions. Progressing from this groundwork, the report hones in on the Narimanam GGS within ONGC's Cauvery Asset. It offers an intricate examination of the station's distinctive features, operational challenges, and the bespoke strategies implemented to overcome them. Additionally, the report delves into the effluent treatment process, a vital aspect of environmental management in GGS operations. The case study of the Narimanam GGS demonstrates how it not only fulfills but surpasses the standards set by its general counterparts, establishing itself as a paragon of tailored efficiency and environmental stewardship in the field.

DECLARATION

SACHIN BANGRAWA pursuing Bachelor of Technology PETROLEUM ENGINEERING 3rd year in INDIAN INSTITUTE OF TECHNOLOGY DHANBAD. I hereby declare this project report at Oil and Natural Gas Corporation (ONGC) Cauvery Asset in partial fulfillment of requirements for the award of Bachelor of Technology in PETROLEUM from INDIAN INSTITUTE OF TECHNOLOGY DHANBAD as my original work.

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Introduction

- The Oil and Natural Gas Corporation Limited (ONGC) is an Indian central public sector undertaking under the ownership of Ministry of Petroleum and Natural Gas, Government of India. The company is headquartered in New Delhi. ONGC was founded on 14 August 1956 by the Government of India.

- ONGC is involved in exploring for and exploiting hydrocarbons in 26 sedimentary basins of India and owns and operates over 11,000 kilometers of pipelines in the country.

- ONGC's operations include conventional exploration and production, refining and progressive development of alternate energy sources like coal-bed methane and shale gas. The company's domestic operations are structured around 11 assets.

- ONGC has single-handedly scripted India's hydrocarbon saga and is the largest producer of crude oil and natural gas in India, contributing over 68% of Indian domestic production of oil and gas.

- ONGC has a unique distinction of having in-house capability in all aspects of exploration and production of oil and gas business i.e., Acquisition, Processing & Interpretation (API) of Seismic data, drilling, work-over and well stimulation operations, engineering & construction, production, processing, refining, transportation, marketing, applied R&D and training, etc.

Vision

To be global leader in integrated energy business through sustainable growth, knowledge excellence and exemplary governance practices.

Mission

- **World Class**: Dedicated to excellence by leveraging competitive advantages in R&D and technology with the people involved. Foster a culture of trust, openness and mutual concern. To make working a stimulating and challenging experience for our people. Strive for customer delight through quality products and services.

- **Integrated In Energy Business**: Focus on domestic and international oil and gas exploration and production business opportunities. Provide value linkages in other sectors of energy business. Create growth opportunities and maximize shareholder value.

- **Dominant Indian Leadership**: Retain dominant position in Indian petroleum sector and enhance India's energy availability.

- **Carbon Neutrality**: ONGC will continually strive to reduce CO2 emissions across its activity chain with the objective of achieving carbon neutrality

Cauvery Asset

ONGC started exploration in the southern peninsular basins of India during the 1950s and made its first discovery in the Cauvery basin with the Madanam gas field in 1970. Except for Hardy Oil & Gas (UK), which operates the offshore PY-3 oil field, ONGC is the sole producer in the Cauvery Basin and all its production is located onshore. ONGC's oil production from the Cauvery basin began in 1986 with the first gas production four years later. Cauvery basin occupies most of the coastal plains of Tamil Nadu, Pondicherry & includes Gulf of mannar, Palk Bay & coromandel waters on the east coast of India. The total surface area is estimated around 45000km^2 of which 22500km^2 area is on land extending from Pondicherry in the north to Ramnad in the south & Tanjore in the west to Karaikal in the east & the remaining offshore up to 200m water depths. The basin is roughly 100 to 150km wide in east west directions & 400km long in NE-500 direction. The exploration activities were initiated in 1958. Twenty years of active exploration during subsequent years has led to the drilling & finding of non commercial oil strike in 1977 Second phase of drilling was commenced in 1984 at Narimanam.

28 long term & 4 short term PMLs

Long term 940.58 km^2

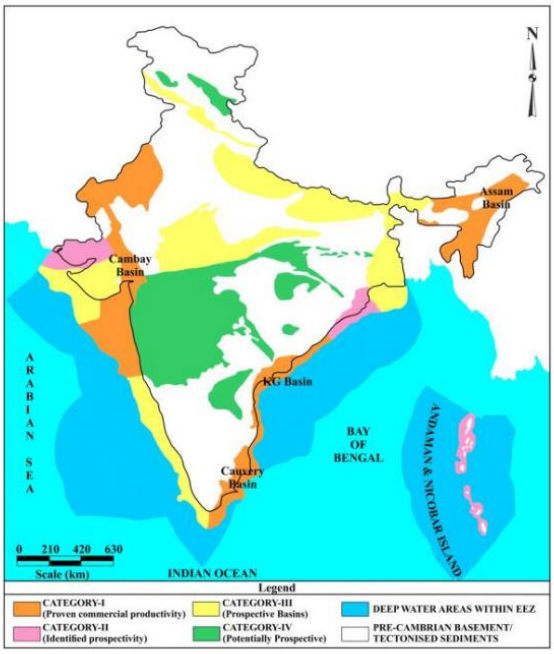
Short term 3774.43 km^2

ONGC

ONSHORE:38000 sq kms

Offshore:2,02,000 sq kms

Total cauvery Basin area: 2,40,000 Sq kms



❑ **<u>TIME LINE</u>** :

- 1958: Exploration Activities Started
- 1964: Drilling Activities Started
- 1977: First Success @KKL#10
- 1977-84: Drilling Holiday
- 1985: II Phase Drilling: Discovery of Narimanam &Kovilkalappal
- 1987: Bhuvanagiri
- 1988: Nannilam
- 1989: Athiyamangalam
- 1990: Kamalapuram & Tiruvarur
- 1993: Pallivaramangalam & Vijayapuram
- 1994: Perungulam
- 1995: Pundi
- 1996: Kuthalam
- 1997: Periyapattinam
- 1998: Kali
- 2001: Kanjirangudi
- 2010: Periyakudi
- 2012: Madanam
- 2018: Mattur West
- 2019: Vanjiyur

Group Gathering Station (GGS)

Group Gathering Station (GGS) is a surface facility in the oil and gas industry that collects and processes natural gas and associated fluids from a group of wells. GGS are generally located near the wells they service, and they are usually connected to a central tank farm (CTF).In ONGC (Oil and Natural Gas Corporation Limited), a Group Gathering Station (GGS) is a facility used to collect and process crude oil and natural gas from multiple wells before being transported to a main processing facility or for further processing. is done for These stations generally consist of well headers, separators, bath heaters, gas scrubbers, heater treaters, storage tanks, test tanks, Equipment such as pumps, compressors and dehydrators are included.

- GGS perform a variety of functions, including:
  - Collecting natural gas and associated fluids from wells
  - Compressing natural gas to increase its pressure
  - Removal of water and other impurities from natural gas
  - Metering of natural gas and related liquids
  - Storage of natural gas and related liquids
  - Loading natural gas and related liquids onto trucks or pipelines

The size of the GGS depends on the number of wells it uses and the type of production. A small GGS may serve only a few wells, while a large GGS may serve hundreds of wells.

- The design of GGS varies based on the specific needs of the production operation. However, most GGS include the following components:

  - A storage system for collecting natural gas and associated fluids from wells
  - A compressor station for compressing natural gas

- A dehydration unit to remove water and other impurities from natural gas
- A metering station for measuring the volume of natural gas and related liquids
- A storage tank for storing liquids
- A loading station for loading natural gas and related liquids onto trucks or pipelines

➢ Different Components of Group Gathering Station:

1. **Manifold**:

   The manifold at a GGS is primarily used for routing, regulating, and measuring the flow of oil and gas from the production wells. It's a complex assembly of pipes, valves, and fittings that directs the flow to various equipment or storage facilities.

Fig: Manifold.

2. **Group Header**:

   The group header is designed to collect and distribute the production fluids—oil, gas, and water—from multiple wells or gathering lines to the processing facilities within the GGS. It is in simple terms a big pipe in which many small pipes (flowlines) connect at manifold. It is used for production period only not for testing. These are of two types that are

Low pressure header (for collecting fluids from low pressure wells) and High-pressure header (for collecting fluid from high pressure wells).

2. **Test Header**:
   As several wells are connected to a GGS, the wells need to be tested regularly for generating test data for proper monitoring and evaluation of field performance. It is achieved by producing the well through test header in the manifold through test separators to storage tank. Oil, Water and Gas flow rates of the well are determined.

3. **Bath Header**:
   A Bath Heater is a type of indirect-fired heater commonly used in Group Gathering Stations (G.G.S.) to heat the fluid components, such as oil or gas, before further processing or transportation. The fluid component, such as oil or gas, enters the Bath Heater from the Header. The fluid may need to be heated to a specific temperature for various reasons, including reducing viscosity, preventing the formation of hydrates, or meeting transportation specifications.
   Well fluids are heated in bath heater by a heat transfer medium, such as thermal oil or glycol, is circulated within the Bath Heater. The heat transfer medium is heated externally using burners or other heat sources, and it transfers heat to the fluid component through a heat exchanger. The Bath Heater is equipped with temperature control systems to maintain the desired temperature of the fluid component. This can be achieved by controlling the flow rate of the heat transfer medium or adjusting the burner output. The Bath Heater includes a combustion system, typically fueled by natural gas or other hydrocarbon fuels, which provides the heat for the heat transfer medium.

Fig: Bath Heater

4. **<u>Separator</u>:**

   Separators by propose are of two types:

   a. Test Separators: Test separators are used to separate the well flow from one or more wells for analysis and detailed flow measurement. In this way, the behavior of each well under different pressure flow conditions can be defined. This normally takes place when the well is taken into production and later at regular intervals, typically 1-2 months, and will measure the total and component flow rates under different production conditions. Undesirable consequences such as slugging, or sand can also be determined. The separated components are analyzed in the laboratory to determine hydrocarbon composition of the gas oil and condensate.

   b. Group Separators: The main separators in ONGC are gravity type 2-phase separators. Separation is done in stages. The high-pressure wells are sent to high pressure separators (1^{st} stage separators) and then the remaining liquid is sent to the next stage or low-pressure separators. The low-pressure wells join the low-pressure separators through low pressure header.

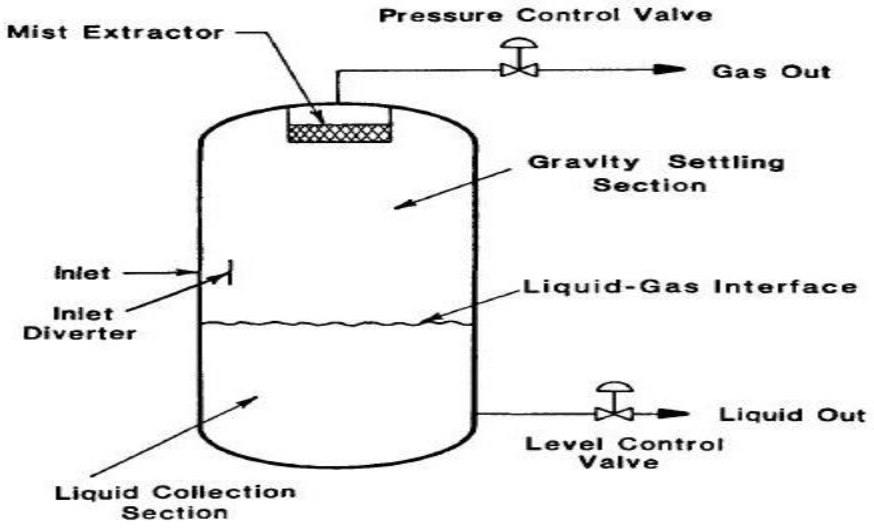


Fig: Schematic of Vertical 2-phase separator.

5. **Heater Treater:**

A heater treater is an oil and gas industry device designed to separate well fluids into gas, oil, and water. Liquid from the 2-phase separator is sent to the heater treater. The main use of it is to remove water from oil and water mixture.

- **Function:**
  - Separates oil, water, and gas from the production fluid.
  - Removes contaminants like water and sediment from crude oil.
  - Stabilizes the crude oil by removing lighter hydrocarbons.
- **Principle:**
  - Heating: Increases the temperature of the incoming fluid, reducing its viscosity and making it easier for the different phases to separate.
  - Gravity Separation: Takes advantage of the different densities of oil, water, and gas to allow them to naturally separate. The gas rises to the top, oil stays in the middle, and water settles at the bottom.

- Coalescence: Uses electrical or mechanical methods to encourage small droplets of water to combine into larger ones, which then settle out of the oil more easily.

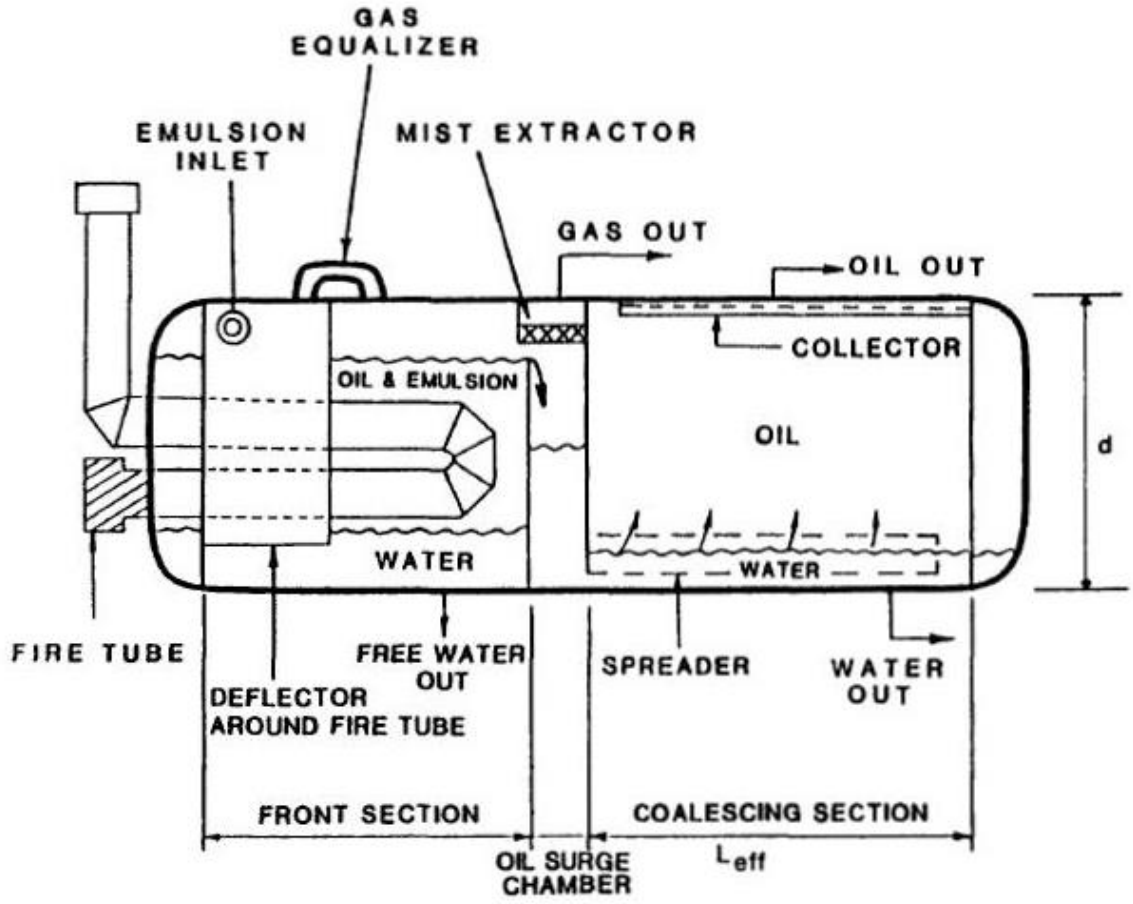


Fig: Horizontal Heater Treater.

6. Storage Tanks:

   Crude oil after heater treater goes to storage tanks or tank batteries. The crude is stored there temporary before sending to refineries for the following main reasons:

   - Storage tanks provide temporary storage for crude to send the crude to consumer at constant rate without fluctuations.
   - To settle down the sediments present in oil.
   - To remove water which settles down to meet consumer needs.

- There are sampling devices that sample crude are taken out of the tank and are tested for BS&W. If the quality is not matched, then it has to be re-treated.

Dyke wall is present around the storage tank in order to prevent spreading oil all over in case of tank leakage.

Level of water and oil is measured on regular basis, in case if the water level rises then water is sent to the disposal plant.

Fig: Storage Tanks.

7. <u>LACT unit (Lease Automatic Custody Transfer):</u>

   LACT units are automated systems in the oil industry for measuring and transferring crude oil from storage tanks to pipelines or Tankers. They ensure accurate transactions by:

   - Measuring: Using sensors and meters to quantify oil volume and quality.

- Transferring: Pumping oil that meets quality standards to the next phase of distribution.
- Automating: Minimizing manual intervention, enhancing efficiency and accuracy.
- Key Components:
  Pump: Moves oil into the system.
  BS&W Monitor: Checks for sediment and water.
  Air Eliminator: Clears air from the oil.
  Static Mixer: Mixes the oil evenly.
  3-Way Diverter Valve: Routes good oil to pipelines.
  Coriolis Meter: Measures oil mass flow rate.
- Outcome: Good oil, meeting quality criteria, is sent to pipelines or tankers, while off-spec oil is redirected for treatment.

Fig: LACT unit.

8. Gas Compressors:

   Gas from the separator enters the first-stage suction scrubber. Any liquids that may have come through the line are separated at this point and the gas flows to the first stage. Compression heats the gas, so there is a cooler after each compression stage. At the higher pressure more

liquids may separate, so the gas enters another scrubber before being compressed and cooled again. Gas from the intermediate-pressure separator can be routed to either the second-stage or third-stage suction pressure, as conditions in the field change.

A scrubber is a device to remove dirt, water, foreign matter, or undesired liquids that are part of the gas flow stream. Air can be used to absorb water; also, an oil bath might be useful to remove dust, dirt or other liquids. A scrubber is used to protect downstream rotating equipment or to recover valuable liquids from gas.

Fig: A gas compressor.

9. <u>Sweetening Unit:</u>

   The sweetening unit in gas processing removes sour gases like H_2S. It uses an amine solution in an absorber tower where the gas reacts with the amines, turning sour gas into sweetened gas. The “rich” amine, now carrying the sour gases, is regenerated in a stripper, releasing the sour gases and recycling the “lean” amine back to the absorber. This process ensures the natural gas is safe and meets quality standards for further use or transport.

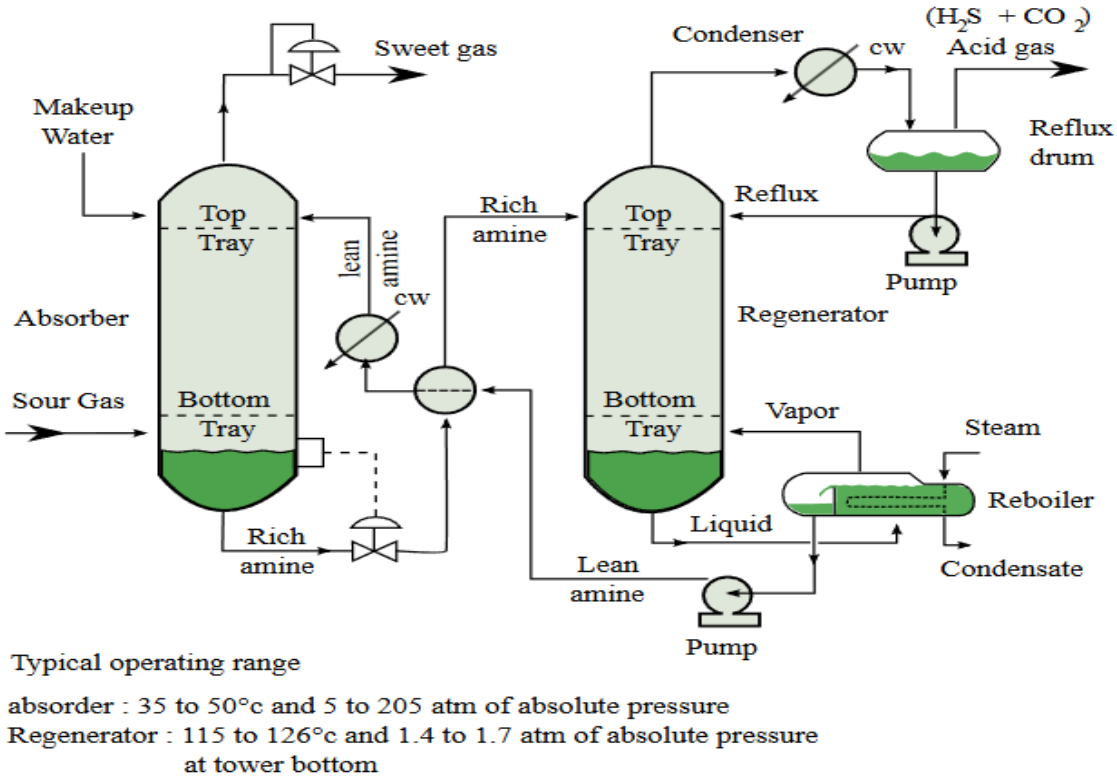


Fig: Process flow diagram of a typical amine treating process used in petroleum refineries, natural gas processing plants and other industrial facilities.

10. Gas Dehydration Unit:

A gas dehydration unit, also known as a glycol dehydration unit, is a critical component in natural gas processing that removes water vapor from the gas stream. Here's a simplified explanation:

- Contactor Tower: Natural gas enters a contactor tower where it comes into contact with a dehydrating agent, typically Tri ethylene glycol (TEG), which absorbs the water vapor1.
- Glycol Regeneration: The 'rich' glycol, now laden with water, is heated in a reboiler, causing the water to vaporize and separate from the glycol.
- Dry Gas Output: The 'lean' glycol, free of water, is cooled and recirculated back to the contactor tower, while the dry gas exits

the dehydration unit and is ready for transport or further processing.

This process prevents issues like pipeline corrosion, hydrate formation, and reduces the heating value of the gas due to excess moisture.

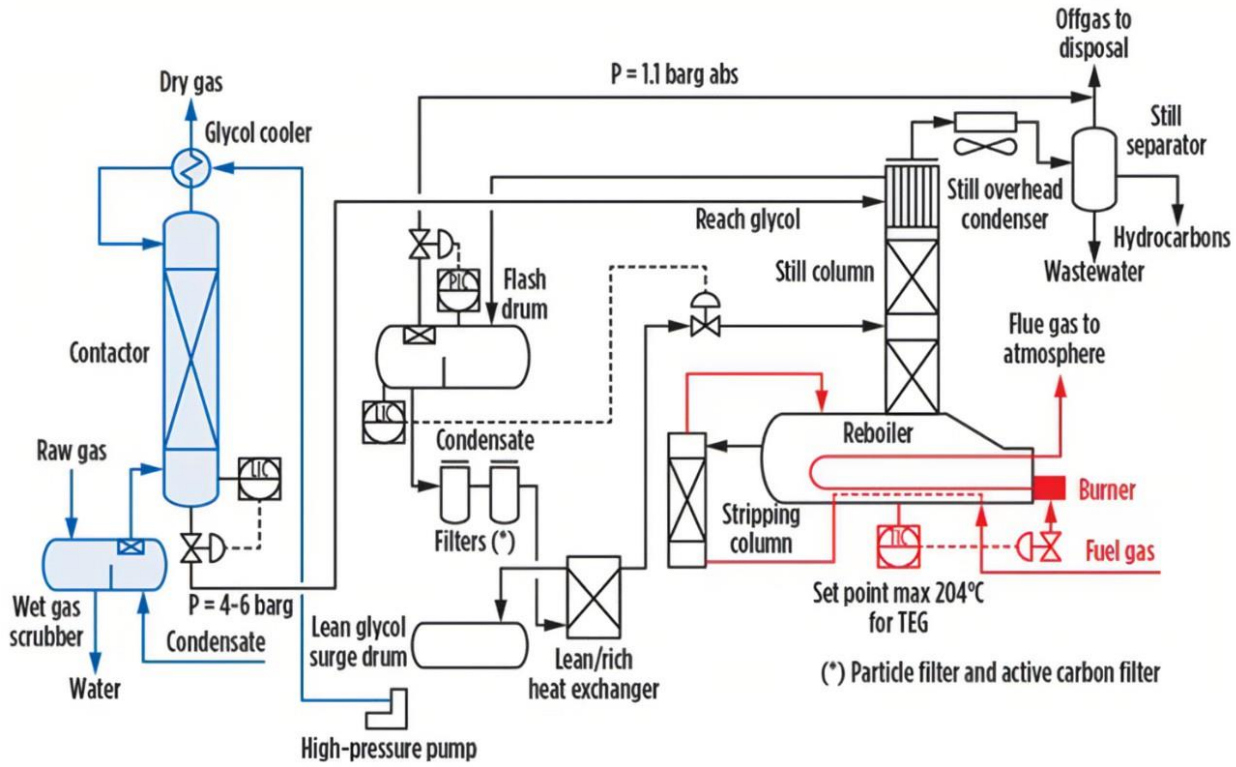


Fig: The TEG dehydration process.

11. Flaring Unit:

Why we flare gas:

- Low pressure gas which cannot be used or is not economically viable.
- High pressure created in separators
- During well activation
- In case of emergency shut down

In all these cases, the gas is sent to the flare stack.

There is a Knockout drum before to separate liquid from gas so that only gas is sent to flare stack. There is always a running flare in flare stack so

that in case of emergency we have not to ignite the flare. The blower unit is also there so that full combustion of flaring gas can happen. Flame Front Generator is also there for ignition of flare.

Fig: Flare Stack in GGS.

12. Fire Fighting Facilities:

Firefighting facilities are a necessity of a GGS. In ONGC, it is said that production is must, but safety is first. Production Engineers in ONGC say themselves a firefighter before a Production Engineer.

Firefighting facilities include Flame Detection System, Fire Detection System, Gas Detection System, use of deluge valves, water tank for firefighting, and many other facilities as per requirements and regulations.

13. SCADA Control Room:

SCADA (Supervisory Control and Data Acquisition) systems play a crucial role in group gathering stations (G.G.S.).

- Purpose: SCADA systems are used for controlling, monitoring, and analyzing industrial devices and processes. They ensure safe and effective operation of remote facilities, including G.G.S. sites.
- Components: A SCADA system consists of both software and hardware components. These components work together to collect data from industrial equipment, both remotely and on-site.
- Functionality: SCADA allows operators to monitor real- time data from various field devices, such as sensors, pumps, and motors. It provides an interface (Human Machine Interface or HMI) to interact with and control these devices.
- Applications in G.G.S.: SCADA systems are widely used in the oil and gas industry to monitor and manage equipment at G.G.S. sites. They help in collecting essential data, improving plant efficiency, and minimizing errors and downtime through timely alerts.

Fig: SCADA Control Room in GGS.

- **Where Does It Go After the GGS?**

  On many sites, the produced resources leave the oilfield tank battery going through different directions, where midstream companies take over ownership.

  1.A meter run (flowmeter like Ultrasonic Flowmeters, Coriolis Flowmeters, Orifice Flowmeters, Venturi Flowmeters, Turbine Flowmeters, Positive Displacement Flowmeters, Vortex Flowmeters, Thermal Mass Flowmeters, etc) records the gas sales that take place. Pipelines send the gas downstream for further processing. It may also be used for gas lift operations.

  2. Steel tanks in the location where oil sales take place. Trucks come on site to pick up periodically.

  3. Free water from Heater Treater and the separated water from oil tanks are diverted to evaporation pits where from it may be pumped to effluents plants for further treatment and disposal or may be evaporated as such.

Effluent Treatment Plant

ETPs play a vital role in minimizing the environmental impact of oil and gas operations. They are designed to remove contaminants such as oil, grease, heavy metals, and other toxic substances from wastewater. This treatment is essential for protecting water bodies and soil from pollution, thus contributing to environmental sustainability. Wastewater or produced water is treated before being injected into the wells.

- **Flow path in a typical ETP:**
  - Effluent from the GGS is stored in storage tanks for primary separation, here oil is skimmed off from the rest part and the heavy metals or slug is deposited at bottom.
  - After primary separation, rest non separated effluent moves for secondary separation section. It enters the pH adjustment tanks where it's pH is increased by adding lime then it is sent to Flash Mixer in which alum is mixed in it to aid clariflocculation. Effluent is then sent to clariflocculator in which small droplets of oil merge to increase in size and then are separated.
  - Effluent after secondary separation section, enters in tertiary separation section. Before that in Filter Feed Sump, hypo chloride is added to prevent algae growth then sent to Dual Media Filter for tertiary separation.
  - After all these, treated effluent is sent to treated tanks and from treated tanks, it is injected to injection wells by pumps.

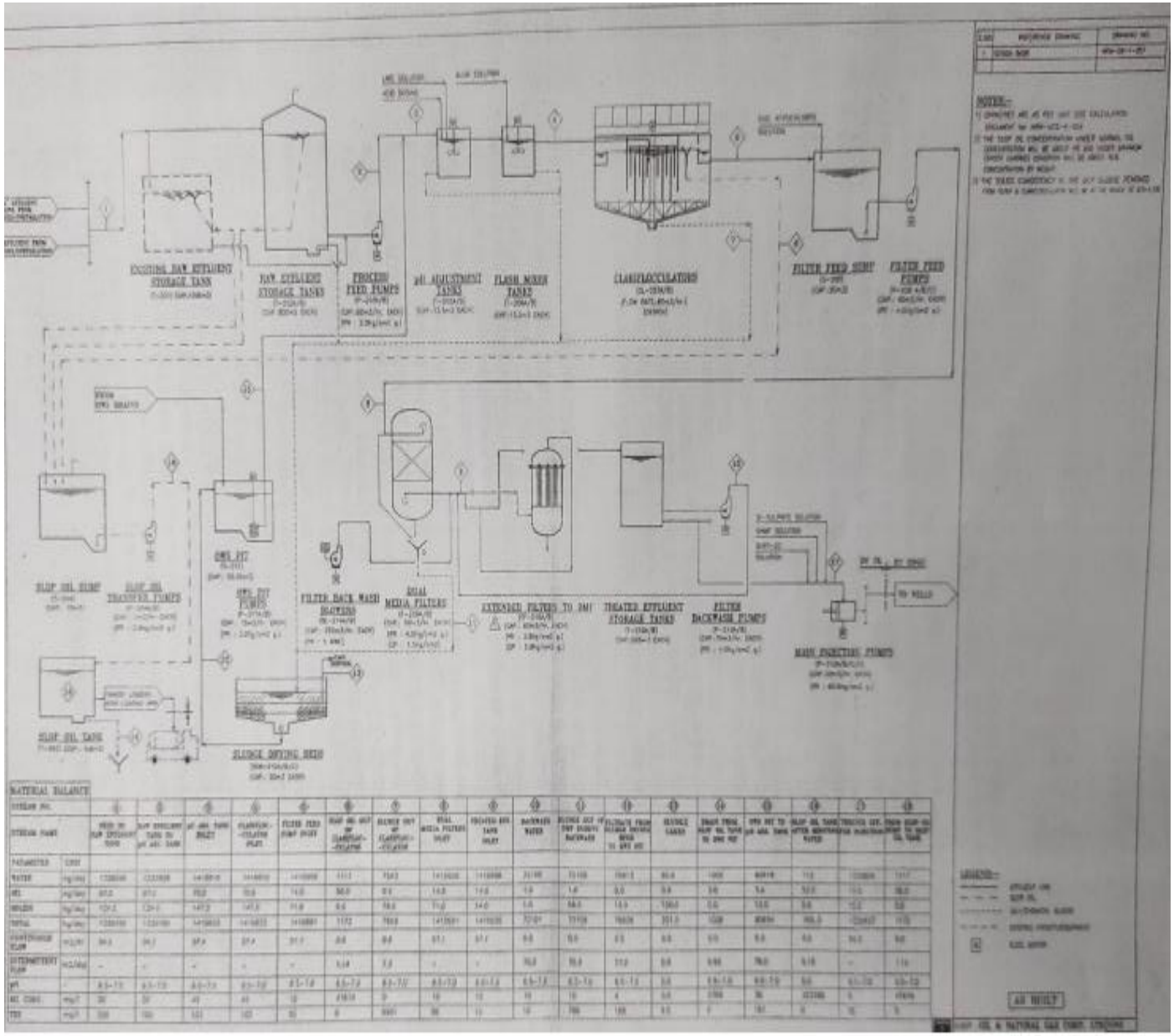


Fig: Process Flow Diagram of ETP.

GROUP GATHERING STATION NARIMANAM

Introduction:

ONGC has set up Narimanam (NRM) Group Gathering Station (GGS) at Kuthalam Village, Nagapattinam District. GGS sprawls over an area of about 5 hectares. Narimanam is one of the major Oil and Gas fields in Cauvery Basin.

Process Description:

GGS, NRM has facilities to process sweet and sour crude produced from Narimanam oil field.

- **Sweet Crude Processing:**

  Well fluid of each well from Narimanam oil field flows through separate flow lines, passes through a well manifold and finally gets separated at the three stage separators of the GGS. There are four headers in the well manifold to segregate the fluid in to four categories viz

  1. Pure oil header
  2. Emulsion header
  3. Low-pressure oil header
  4. Test well header.

  There are three batteries of separators, cach battery consisting of three separators Operated at different pressures. Emulsion collected in emulsion header of the well manifold IS passed through first battery. Pure crude from pure oil header is passed through second battery. Liquid collected in the low-pressure header is passed directly, through

the third stage of either emulsion or pure battery depending on the crude character. Whenever a well 1s required to be tested, it is diverted through third battery from test header.

Pure oil after gas separation is collected in any one of the storage tanks through a tank manifold.

Two storage tanks (T5 & T9) are used as wash tank to knock out free water from the bottom and pure oil from top. Water is collected in effluent pit of 300 m^3 capacity. Oil is taken in any of the storage tanks along with other pure oil stream.

In case of hard emulsion, emulsion oil is diverted from 2nd stage itself to heater treater. Heater treater is used to break hard emulsion using heating system in the vessel. Oil separated from heater treater is mixed with main pure oil stream and water drained is collected in effluent pit.

Gas separated from II and I stage separator are supplied to consumers through GAIL. Gas separated from III stage is flared as it produces low pressure and quantity is also insignificant.

- **Sour Crude Processing:**

  Well fluid containing H2S gas is called SOUR crude. SOUR wells are flowed separately to a manifold, which has four headers. First, Second, Third stage and Test headers. Total sour crude from 3rd stage is received in 6 stabilizing tanks of 45 M^3 each. Gas separated from all the sour separators is flared. Water knocked from separators is collected in effluent pit inside GGS. Residual H2S gas in sour crude is neutralized by adding 200 ppm caustic solution before the crude enters the stabilizing tanks. Treated and stabilized crude is pumped to main storage tanks. Crude received in storage a tank is then pumped to refinery after checking water content in the crude (it should not exceed 0.2%). Effluent received in effluent pond is pumped to ETP for further processing and disposal. Oil particles floating over the water are skimmed and pumped to tank.

- Ideally separated liquid after two phase separator should be sent to Heater treater then to storage tanks. But Narimanam is also classified as CTF, so it has three inlets:
    - Own Liquid after separator
    - Crude by other fields
    - Crude by Tankers

  Therefore, all these fluids are first collected in storage tanks for primary separation of free water then collectively fluids from all three inlets are sent to heater treater then again sent to storage tanks before transportation to CPCL Chennai.

Fig: Map view of Narimanam GGS.

CONCLUSION

In summation, the Group Gathering Station is a linchpin in the oil and gas industry's framework, essential in the hydrocarbon journey from extraction to market. The comprehensive analysis of GGS provided in this report paints a vivid image of their foundational significance, augmented by the detailed investigation of the Narimanam GGS. This station, with its specialized design, operation, and inclusion of an effluent treatment plant, encapsulates the spirit of innovation and customization in response to the intricate demands of oil and gas production and environmental conservation. The report not only accentuates the operational excellence achieved at the Narimanam GGS but also envisions the scope for future enhancements in GGS technology, methodology, and effluent treatment practices. It stands as a tribute to the dynamic and progressive nature of the industry, continually advancing towards greater efficiency and sustainability.

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