SUMMER TRAINING REPORT

Submitted in partial fulfilment of the requirements for the award of the degree of

Bachelor of Technology in Petroleum Engineering

On

"Overview on Oil and Gas Production Services"

At

Oil and Natural Gas Corporation Limited

Under the guidance of

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CERTIFICATE

This is to certify that Ashmita Choudhury, Guttikonda Abhilash, Jerripothula Gunathmini, Kenchugundu Sai Venu, Manan Bhuteja, Padi Reethika, Parneet Nain, Vivek Singhal students of B. Tech in Petroleum Engineering at Indian Institute of Technology (ISM), Dhanbad, have successfully completed the project titled: “Overview on Oil and Gas Production Services”
The training was carried out from 12th May 2025 to 12th June 2025 at the Surface team, ONGC Cauvery Asset, Karaikal. During their training, they demonstrated a sincere attitude and took keen interest in the tasks assigned to them. Their performance was commendable and reflected a good understanding of the technical aspects of the project.

I wish them all the best in their future endeavours.

Shri. Murugan A, General Manager (Production)

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Sincerely,

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ABSTRACT

This report provides a comprehensive overview of oil and gas operations, drawing from the Standard Operating Procedures (SOPs) of the Oil and Natural Gas Corporation Limited (ONGC) and industry best practices. It covers the full spectrum of activities, from exploration and drilling to production, processing, and environmental management.

The oil and gas industry relies on complex technical operations, necessitating specialized equipment, skilled personnel, and stringent safety protocols. Key operational areas examined include drilling services, well logging, surface and subsurface production systems, geological evaluation, cementing operations, well stimulation, and workover services.

The report highlights that successful operations hinge on rigorous adherence to safety protocols, proper equipment maintenance, comprehensive training, environmental protection, and quality assurance across all phases. Critical infrastructure, such as Group Gathering Systems (GGS), Gas Collecting station (GCS), and Effluent Treatment Plants (ETP), ensures efficient and environmentally responsible operations.

Material Safety Data Sheets (MSDS) integrated into the SOPs provide vital guidance for the safe handling of chemicals and materials throughout the operational lifecycle. By synthesizing insights from ONGC training manuals and operational procedures, this report offers a detailed understanding of modern oil and gas operations, emphasizing the importance of safety, efficiency, and environmental stewardship in achieving operational excellence.

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1. Introduction To Oil and Gas Operations

Oil and gas operations represent one of the most complex and technologically advanced industrial activities. The Oil and Natural Gas Corporation Limited (ONGC), established as India's premier exploration and production company, has developed comprehensive Standard Operating Procedures to ensure safe, efficient, and environmentally responsible operations.

The upstream oil and gas sector encompasses three main phases: exploration, development, and production. Each phase requires specialized equipment, technical expertise, and adherence to strict safety and environmental protocols.

1.1. Overview of Upstream Operations

According to ONGC's operational procedures, upstream operations involve Geological and geophysical surveys to identify potential hydrocarbon-bearing formation, Drilling exploratory and development wells, Well completion and testing operations, Production and processing of hydrocarbons, Enhanced recovery techniques, Well workover and maintenance operations, Environmental protection and waste management.

The success of these operations depends on effective coordination between multiple disciplines including geology, drilling engineering, production engineering, reservoir engineering, and environmental management.

1.2. Regulatory Framework and Safety Standards

ONGC's Standard Operating Procedures emphasize compliance with national and international safety standards. The Oil Industry Safety Directorate (OISD) guidelines form the backbone of safety protocols, while API (American Petroleum Institute) standards provide technical benchmarks for equipment and operations.

Key regulatory aspects include:

1. Directorate General of Mines Safety (DGMS) regulation.
2. Central Pollution Control Board (CPCB) environmental norms.
3. Petroleum and Natural Gas Regulatory Board (PNGRB) guidelines.
4. International Organization for Standardization (ISO) standards.

2. Drilling Operations and Services

Drilling operations form the foundation of oil and gas exploration and development. According to ONGC's Standard Operating Procedures for Drilling Operations, drilling is defined as "the most cost-intensive operation of any exploration and production company" requiring high levels of efficiency and safety.

2.1. Drilling Rig Classification and Components

ONGC's SOP Manual classifies drilling rigs into two main categories:

1. Carrier-Mounted Rigs (Mobile Rigs)
    - Mounted on wheeled carriers
    - Self-contained units with telescopic masts
    - Suitable for shallow to medium-sized wells
    - Higher mobility and faster rig-up/rig-down times

2. High Floor Mast Rigs
    - Conventional drilling rigs with substantial substructures
    - Capable of drilling deeper wells
    - Higher load capacity and drilling capability
    - Suitable for complex drilling operations
3. The drilling rig system comprises five major components:
    - Power System (AC-DC or direct drive)
    - Hoisting System (drawworks, mast, and traveling block)
    - Rotating System (rotary table, kelly, or top drive)
    - Circulating System (mud pumps, tanks, and circulation equipment)
    - Blowout Prevention System (BOP stack and control systems)

Type of Rigs	**Shallow Type - I**	**Medium Type - II**	**Deeper Type - III**	**Super Deep Super Deep**
Capacity (ft.)	12000	16000	20000	20000-30000
Draw works (HP)	≤1000	1400/1500	2000	3000
Rig HP (Power Pack)	3000	4000	4000	6000
Mechanical Drive System	IR-750 IR-900 IPS-700 BHEL-450			
Electrical Drive System	E-760 F-3050 MBHEL-760	E-1400 F-4900 BI-1500	E-2000 F-6100 ARMCO-1320-UEBI-2000	E-3000

2.2. Drilling Operations Procedures

Based on ONGC's Standard Operating Procedures, drilling operations follow a systematic approach:

1. Preparation for Spudding:
    - Ensure mast centering is carried out before spudding
    - check and test all surface equipment (engines, mud pumps, drawworks, compressors)

- Pressure test high-pressure mud lines to 3,000 psi
- Ensure availability of pre-hydrated bentonite suspension (minimum 7%)
- Install false conductor with proper grouting

2. Common Drilling Practices:
   - Hold toolbox meetings before each operation
   - Record bit details and drilling parameters
   - Maintain proper mud properties and circulation
   - Monitor drilling parameters continuously
   - Conduct regular safety inspections
3. The drilling process follows a telescopic approach with multiple hole sections:
   - 26" hole section with surface casing
   - 17½" hole section with intermediate casing
   - 12¼" hole section with production casing
   - 8½" hole section if required
   - 6" hole section for final completion

Each section requires specific mud formulations, drilling parameters, and safety considerations as outlined in the ONGC SOPs.

2.3. Drilling Fluid Management

Effective drilling fluid management is essential for safe and efficient drilling operations. ONGC's SOPs highlight the primary functions of drilling fluids, which include carrying cuttings to the surface, cooling and lubricating the drill bit, maintaining wellbore stability, controlling formation pressures, forming a filter cake to prevent fluid loss, and suspending cuttings when circulation ceases.

Drilling fluids are categorized into water-based muds (WBM), oil-based muds (OBM), synthetic-based muds (SBM), and air/gas drilling fluids, with selection depending on formation characteristics, environmental considerations, and operational needs. Proper mud formulation and maintenance are critical to prevent formation damage, ensure wellbore stability, facilitate effective cuttings removal, control formation pressures, and minimize environmental impact.

3. Well Logging Operations

Well logging is a vital component of formation evaluation, providing essential data for reservoir characterization and development decisions. This technique involves lowering specialized instruments into the wellbore to measure the physical and chemical properties of rock formations and their fluids, offering critical insights into subsurface conditions.

3.1. Fundamentals of Well Logging

Well logging, also known as borehole logging, serves multiple purposes in oil and gas operations. Its primary objectives include identifying hydrocarbon-bearing formations, determining reservoir properties such as porosity, permeability, and saturation, assessing formation lithology and structure, evaluating completion zones, monitoring production performance, and supporting reservoir management decisions.

The process entails lowering logging tools on a wireline to record continuous measurements against depth, providing indirect information about formation properties that cannot be directly observed. Key logging parameters include natural gamma radiation, electrical resistivity, bulk density, photoelectric factor, neutron porosity, acoustic properties via sonic logs, formation imaging, nuclear magnetic resonance, and pressure and sampling data. These measurements collectively enable a comprehensive understanding of subsurface conditions.

3.2. Types of Logging Operations

Well logging operations are classified into four main types based on industry practices and ONGC procedures. Openhole logging, conducted before casing installation, provides comprehensive formation evaluation through basic log suites and specialized measurements, critical for completion design decisions.

Cased hole logging, performed after casing installation, focuses on production monitoring, including production logging and cement evaluation, and supports workover planning. Logging While Drilling (LWD) offers real-time measurements during drilling, enabling geosteering in horizontal wells, immediate formation evaluation, and reduced non-productive time.

Measurement While Drilling (MWD) provides drilling parameters and directional data, facilitating real-time drilling optimization and safe operations through formation pressure measurements. Common log types include Spontaneous Potential (SP), Gamma Ray (GR), various resistivity logs, density-neutron combinations, Photoelectric Factor (PEF), sonic logs for compressional and shear waves, Formation Micro Imager (FMI), and Nuclear Magnetic Resonance (NMR).

3.3. Log Interpretation and Analysis

Log interpretation is a complex process requiring expertise in geology, petrophysics, and reservoir engineering. Basic interpretation involves quality control and environmental corrections, lithology identification using gamma ray and photoelectric factor data, porosity calculation from density-neutron logs, water saturation determination using resistivity data, permeability estimation from porosity and lithology, net-to-gross ratio calculation, and reserve estimation with completion recommendations.

Advanced techniques include multi-well correlation for structural interpretation, rock typing and flow unit identification, fracture detection and characterization, stress analysis for completion design, and time-lapse logging for production optimization. These results inform reservoir characterization, modeling, completion design, production forecasting, development planning, enhanced recovery implementation, and environmental impact assessments.

Modern interpretation leverages sophisticated software and integrated workflows, combining logging, seismic, and production data for a comprehensive reservoir understanding.

4. Surface Production Systems

Surface production systems are designed to process reservoir fluids from the wellhead to meet transportation and sale specifications. These systems separate, treat, and condition crude oil, natural gas, and produced water in compliance with regulatory requirements, ensuring safe and efficient operations.

4.1. Gas-Oil Separation Process

The primary objective of surface petroleum operations is to process reservoir fluids exiting the wellhead into marketable products. The Gas-Oil Separation Plant (GOSP) is the initial step in crude oil processing, utilizing differences in density and volatility to separate oil, gas, and water phases.

Flash separation involves pressure reduction to cause gas evolution from oil and temperature changes to affect vapor-liquid equilibrium, with multiple stages optimizing recovery. Gravity separation leverages density differences, allowing gas to rise, oil to settle in the middle, and water to collect at the bottom, with adequate retention time ensuring effective separation. Mechanical separation enhances efficiency through internals like mist extractors to remove entrained liquids from gas and coalescers to promote water droplet agglomeration.

Key equipment includes three-phase and two-phase separators in horizontal or vertical configurations, pressure control systems, safety devices, level control instrumentation, and temperature control systems.

4.2. Crude Oil Treatment Systems

Crude oil from primary separators requires further treatment to meet pipeline and refinery specifications. Emulsion treatment and dehydration involve heating systems to reduce oil viscosity and promote water coalescence at temperatures of 120-180°F, chemical treatments with demulsifiers to break water-in-oil emulsions, neutralizers to control pH, and corrosion inhibitors to protect equipment, and electrostatic coalescence using high-voltage fields to reduce water content to less than 1% BS&W, improving crude oil quality.

Desalting operations use fresh water washing and electrostatic treaters to reduce salt content to 15-20 PTB, critical for downstream refining. Stabilization removes light hydrocarbons to control vapor pressure, preventing excessive vapor loss during transportation using distillation or stripping columns to meet Reid Vapor Pressure (RVP) specifications.

Sweetening operations remove hydrogen sulfide (H_2S) and mercaptans when H_2S exceeds 400 ppm, using chemical absorption or catalytic processes to ensure safe handling and transportation.

4.3. Gas Processing Systems

Natural gas processing prepares raw gas for pipeline transportation and sale through several steps. Acid gas removal eliminates H_2S and CO_2 using amine absorption systems to meet pipeline specifications.

Dehydration removes water vapor to prevent hydrate formation, employing glycol absorption or molecular sieve adsorption to achieve pipeline dewpoint requirements. Natural Gas Liquid (NGL) recovery separates propane, butane, and heavier components through cryogenic processing or absorption methods, producing valuable byproducts. Compression boosts pressure for pipeline transportation using reciprocating or centrifugal compressors with multiple-stage compression and intercooling.

Associated facilities include fuel gas systems for facility operations, flare systems for emergency gas disposal, storage systems for stabilized liquids, loading facilities for product transportation, and utility systems for power, water, air, and nitrogen, ensuring safe, efficient, and environmentally compliant processing while maximizing product recovery and value.

5. Subsurface Production Systems

Subsurface production systems encompass all downhole equipment and techniques used to establish and maintain hydrocarbon flow from the reservoir to surface facilities. These systems are vital for optimizing production rates, maintaining well integrity, and ensuring safe operations throughout the well's productive life.

5.1. Well Completion Systems

Well completion systems provide the interface between the reservoir and surface facilities, with several types utilized based on ONGC's completion procedures. Cased and perforated completions involve setting production casing through the reservoir, with cement providing zonal isolation and perforations creating flow paths to the wellbore, enabling selective completion and stimulation. Open hole completions set casing above the productive formation, leaving the lower interval open, suitable for stable formations with maximum flow area.

Liner completions install liners across productive intervals, which may be cemented or uncemented, with screen liners providing sand control, offering cost-effectiveness for long intervals. Multiple completions produce multiple zones through separate tubings, enabling independent zone management with specialized downhole equipment to maximize reservoir contact. Completion design considers reservoir characteristics, drive mechanisms, expected production rates, fluid properties, sand production potential, artificial lift requirements, workover accessibility, and economic optimization to balance initial productivity with long-term operability and cost-effectiveness.

5.2. Production Tubing and Downhole Equipment

Production tubing systems transport reservoir fluids from the completion interval to the wellhead. The tubing string, made of API-specified steel or corrosion-resistant alloys for sour service, features various wall thicknesses, grades, and threaded or welded connections. Packers isolate the annular space, enable pressure containment, and are available in permanent or retrievable types, essential for zone isolation.

Safety equipment includes subsurface safety valves (SSSV), surface-controlled for emergency shutdown, operated via wireline or hydraulics, critical for well control. Artificial lift equipment includes sucker rod pumps for low-pressure wells, electric submersible pumps (ESP) for high rates, gas lift systems for flowing wells, and progressive cavity pumps for heavy oil. Downhole monitoring involves pressure and temperature gauges, flow meters, phase detection, and real-time data transmission for production optimization. Tubing design accounts for internal and external pressures, tensile loads, buckling resistance, corrosion allowance, and thermal expansion to ensure safe and efficient production with accessibility for workovers and interventions.

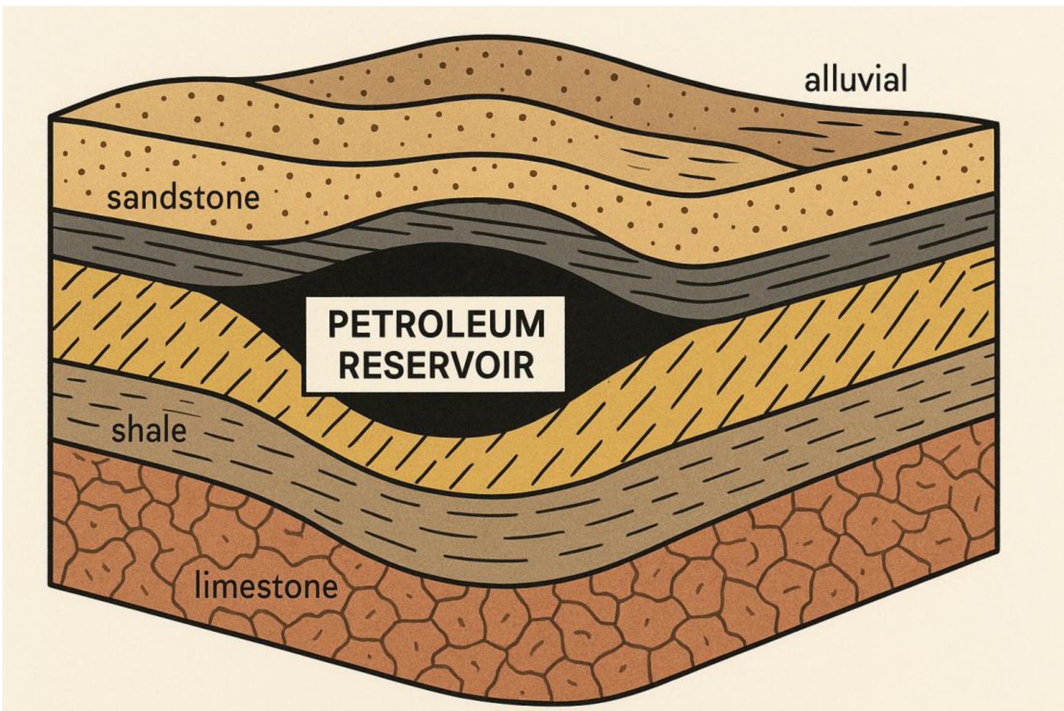
5.3. Reservoir Drive Mechanisms

Understanding reservoir drive mechanisms is crucial for optimizing subsurface production systems. Solution gas drive relies on dissolved gas expansion, with rapid pressure decline and recovery factors of 5-30%, requiring early pressure maintenance. Gas cap drive uses free gas cap energy, maintaining pressure longer with recovery factors of 20-40%. Water drive involves aquifer water displacing hydrocarbons, offering natural pressure maintenance and the highest recovery factors of 35-75%, though it may require water management.

Gravity drainage, driven by fluid segregation, is significant in fractured reservoirs, enhanced by horizontal wells, and is slow but efficient. Combination drive involves multiple active mechanisms, common in complex reservoirs, requiring integrated management with variable recovery factors. Production optimization strategies include reservoir pressure maintenance through injection, artificial lift implementation, enhanced oil recovery techniques, intelligent completion systems, and real-time optimization to align with the reservoir drive mechanism and production profile, maximizing recovery while maintaining economic viability.

5.4. Petroleum Geology and Formation Evaluation

Petroleum geology underpins the understanding of hydrocarbon occurrence, migration, and accumulation, while formation evaluation integrates geological knowledge with engineering data to assess reservoir potential and guide development decisions.



5.5. Hydrocarbon Generation and Migration

Hydrocarbon formation requires specific geological conditions. Source rocks need adequate organic matter content, typically from marine algae and plankton (Type I and II kerogen) or terrestrial plant material (Type III kerogen), with a minimum of 1-2% Total Organic Carbon (TOC) and quality determined by hydrogen index.

Thermal maturity occurs in the oil window (0.5-1.3% vitrinite reflectance) or gas window (>1.3% vitrinite reflectance) at temperatures of 50-150°C, controlled by burial depth and geothermal gradient. Preservation conditions involve anoxic depositional environments, rapid burial to prevent oxidation, low permeability for retention, and adequate organic matter preservation. Primary migration involves expulsion from source rock through pressure-driven compaction, thermal expansion, and molecular diffusion, while secondary migration entails movement through carrier beds via buoyancy-driven vertical migration, hydrodynamic flow, and structural control.

Accumulation requires reservoir rock with adequate porosity and permeability, a structural or stratigraphic trap, a seal rock to prevent leakage, and appropriate timing between generation, migration, and trapping.

5.6. Reservoir Rock Properties

Reservoir characterization assesses critical rock properties. Primary porosity, including intergranular porosity in sandstones and intercrystalline porosity in carbonates, depends on depositional environments and typically ranges from 10-30% in good reservoirs. Secondary porosity, such as fracture porosity in tight rocks or solution porosity in carbonates, is created by diagenetic processes and can significantly enhance productivity.

Porosity measurement techniques include core analysis for direct measurement, density logs for bulk density porosity, neutron logs for hydrogen index porosity, nuclear magnetic resonance for effective porosity, and integration of multiple data sources.

Absolute permeability, measured in millidarcies (mD), controls maximum flow potential, varying from <0.1 mD in tight formations to >1000 mD in high-permeability reservoirs.

Relative permeability depends on fluid saturation history and is critical for multiphase flow prediction, measured through core flooding tests. Permeability anisotropy, involving directional variation, affects well placement and drainage patterns.

The formation evaluation workflow includes geological modeling, structural interpretation, petrophysical analysis, rock typing, fluid contact determination, reserve estimation, uncertainty analysis, and development planning to optimize field development and production strategies.

6. Cementing Operations

Cementing operations are vital for well construction, providing structural support to casing strings and ensuring zonal isolation throughout the well's life. ONGC's Cementing Manual emphasizes that the quality of the primary cementation job is critical for well integrity and viable production.

6.1. Objectives and Functions of Cementing

Cementing serves multiple critical functions as per ONGC's SOPs. It bonds and supports casing, providing structural integrity, distributing loads to the formation, preventing casing movement and wear, and enhancing well strength. Zonal isolation prevents fluid communication between formations, protects freshwater aquifers, isolates high-pressure zones, and enables selective production and injection.

Cementing also protects formations by sealing unstable zones, preventing wellbore collapse, controlling lost circulation, and shielding against corrosive fluids. It enhances well control by providing an additional barrier to formation fluids, supporting blowout prevention, and facilitating well-killing operations, critical for safety. Historically, cement use in oil wells began in 1903 when Frank F. Hill used Portland cement to stop water influx in a California well, evolving into modern practices with specialized equipment and additives.

Cementing operations include primary cementing during casing installation, secondary cementing for remedial operations, squeeze cementing for zone isolation, and plug cementing for well abandonment.

6.2. Cement Systems and Additives

Oil well cements must withstand extreme downhole conditions. API Class G/H cement is most common, suitable for temperatures up to 200°F, offering high sulfate resistance and compatibility with additives. Special-purpose cements include high-temperature cements for deep wells, lightweight cements for weak formations, rapid-setting cements for emergency repairs, and salt-resistant cements for salt formations.

Essential additives include accelerators like calcium chloride (2-4% BWOC) to reduce thickening time, retarders like lignosulfonates to extend pumpable time, fluid loss control agents like bentonite or polymers to maintain slurry properties, density control additives such as microspheres or hematite to match formation pressure requirements, and mechanical property enhancers like silica flour or latex for strength and flexibility.

The slurry design process involves defining well conditions, selecting base cement and additives, laboratory testing, field mixing, quality control, and continuous monitoring during placement to ensure long-term integrity and performance.

6.3. Cementing Equipment and Procedures

Successful cementing operations require specialized equipment and precise execution. Surface equipment includes cementing units with high-pressure pumps (up to 15,000 psi), mixing systems for consistent slurry, density measurement, and additive injection capabilities; bulk handling systems with pneumatic cement transport, silo storage, and dust control; and mixing equipment like jet mixers for rapid hydration and recirculating mixers for homogeneity.

Downhole equipment includes casing centralizers to maintain casing position, cementing plugs for displacement and cement-mud separation, stage tools for multi-stage cementing, and float equipment to prevent backflow. ONGC’s cementing procedure involves pre-job planning with well surveys and laboratory testing, wellbore preparation with circulation and mud optimization, cement mixing and pumping with continuous monitoring, displacement operations with precise volume calculations, waiting on cement for 8-12 hours to achieve compressive strength >500 psi, and evaluation through cement bond logs, pressure testing, and formation integrity testing to ensure successful zonal isolation and well integrity.

7. Well Stimulation Services

Well stimulation enhances hydrocarbon production by improving fluid flow from the reservoir to the wellbore, critical for maintaining economic production rates and maximizing recovery.

7.1. Types of Stimulation Treatments

Stimulation treatments, based on ONGC SOPs and industry practices, are divided into matrix treatments and fracturing treatments. Matrix treatments, performed below fracture pressure (70-80% of fracture pressure), restore natural permeability by removing near-wellbore damage, such as drilling mud damage, mineral precipitates, or clogged perforations.

Fracturing treatments, conducted above fracture pressure, create new flow paths and extend the drainage radius, significantly increasing productivity. The choice between treatments depends on formation permeability, damage extent, economic considerations, well completion design, reservoir characteristics, and environmental constraints.

Candidate selection involves production decline analysis, formation damage assessment, reservoir pressure evaluation, completion design review, and economic analysis to ensure optimal treatment selection.

7.2. Hydraulic Fracturing Operations

Hydraulic fracturing is the most widely used stimulation technique for low-permeability formations. It involves applying pressure (typically 15,000-20,000 psi) to exceed formation breakdown pressure, creating tensile failure and extending fractures into the formation.

Proppants, such as sand or ceramic particles, hold fractures open, providing conductive flow paths sized based on fracture width and closure stress. Fluid systems include water-based slickwater, gel-based systems for proppant transport, foam fluids for low-pressure formations, and hybrid designs for optimization. The fracturing process includes pre-fracture analysis with stress testing and fluid selection, well preparation with perforation optimization and equipment installation, fracture execution with real-time monitoring and proppant ramping, and post-fracture flowback, cleanup, and performance evaluation.

Multi-stage fracturing in horizontal wells uses plugs or packers for isolation, with up to 200+ stages in long wells. Environmental considerations include water source management, flowback fluid handling, air quality monitoring, and noise mitigation.

7.3. Chemical Stimulation (Acidizing)

Acidizing involves injecting acid solutions to dissolve formation minerals and remove damage. Hydrochloric acid (HCl, 15-28%) is commonly used for carbonates, dissolving limestone and dolomite to create wormholes. Hydrofluoric acid (HF), mixed with HCl as mud acid, is used for sandstones to dissolve clays and feldspar, requiring special handling. Organic acids like formic and acetic acids are used in high-temperature wells, being less corrosive.

Acidizing techniques include matrix acidizing below fracture pressure to restore productivity, fracture acidizing above fracture pressure to create acid-etched fractures in carbonates, and acid washing for wellbore cleaning. Safety considerations involve comprehensive risk assessment, specialized equipment, trained personnel, emergency response procedures, and environmental protection measures.

Acid system design includes formation mineralogy analysis, acid type and concentration selection, additive optimization, injection rate and volume design, and post-treatment evaluation to ensure optimal results and safety.

8. Well Workover Services

Well workover operations encompass remedial activities to restore, maintain, or enhance production, as outlined in ONGC's Workover Operations Manual, essential for maintaining field productivity throughout the reservoir's life cycle.

8.1. Types and Objectives of Workover Operations

Workover operations serve various objectives, categorized into production enhancement, remedial operations, and re-completion activities. Production enhancement includes well stimulation, sand control installations, artificial lift optimization, and completion modifications. Remedial operations involve casing repair or replacement, tubing changeouts, packer repair, and wellbore cleanout.

Re-completion activities include zone re-entry, testing, multiple zone completions, sidetrack drilling, and abandonment. Specific objectives address water coning control by reducing water production, plugging back, or installing shut-off systems; gas coning management to control excessive gas production and preserve pressure; sand control through gravel packs, sand screens, or chemical consolidation; and equipment replacement like pumps, tubing, safety valves, and surface equipment.

Candidate selection involves production decline analysis, economic screening, technical feasibility assessment, risk evaluation, and resource allocation optimization.

8.2. Workover Equipment and Procedures

Workover operations require specialized equipment, including mobile workover units for light to medium workovers, conventional workover rigs for complex operations, and hydraulic workover units (HWU) for live well interventions. Essential components include hoisting systems with drawworks and load monitoring, well control equipment like BOP stacks and choke manifolds, and circulation systems with mud pumps and solids control.

ONGC's workover procedures involve pre-workover planning with well history review and equipment selection, well preparation with production shutdown and pressure control, rig-up operations with BOP installation, downhole operations for tubing retrieval and completion repair, completion and testing for production evaluation, and safety protocols with risk assessment and emergency response planning. Quality assurance includes equipment inspection, procedure compliance, documentation, and performance evaluation to ensure successful operations.

8.3. Live Well Intervention

Live well intervention techniques, such as wireline, coiled tubing, and snubbing operations, enable operations without killing the well, maintaining reservoir pressure and minimizing damage. Wireline operations include electric and slickline services for logging, perforating, plug setting, and gauge installation.

Coiled tubing operations provide continuous circulation for chemical treatments, cleanouts, and completion modifications. Snubbing operations allow pipe insertion under pressure for complex downhole assemblies.

Well control involves pressure control equipment, primary and secondary barriers, and risk assessment to ensure safety. Benefits include reduced downtime, maintained reservoir pressure, minimized damage, cost-effective operations, and improved efficiency, with method selection depending on well conditions, objectives, equipment availability, and safety considerations.

8.4. Enhanced Oil Recovery (EOR) Techniques

EOR methods increase hydrocarbon recovery beyond primary and secondary phases. Primary recovery uses natural reservoir energy, recovering 10-15% of original oil in place. Secondary recovery involves pressure maintenance through waterflooding or gas injection, increasing recovery to 20-40%.

Tertiary recovery (EOR) includes thermal recovery (steam injection, in-situ combustion, hot water flooding) accounting for 40% of U.S. EOR production, chemical EOR (polymer, surfactant, alkaline flooding) at ~1%, and gas injection EOR (CO_2, nitrogen, hydrocarbon gas) at nearly 60%. Screening criteria consider reservoir temperature, pressure, oil gravity, viscosity, permeability, thickness, and remaining oil saturation.

Advanced EOR technologies include smart water flooding, low salinity water injection, nanofluids, microbial EOR, and hybrid methods to enhance recovery efficiency.

9. Group Gathering Station (GGS)

Group Gathering Stations (GGS) collect, process, and transport natural gas from multiple wellheads to central processing facilities or transmission pipelines, serving as a critical link in the gas infrastructure.

9.1. GGS Components and Design

GGS typically serve 20-40 wells and include wellhead connections with flow control and emergency shutdown systems, gathering pipelines with corrosion-resistant materials, separation equipment like three-phase separators and slug catchers, processing equipment for dehydration and compression, and storage facilities for oil, water, and condensate.

Design considerations include flow rate requirements, fluid properties, environmental factors, and economic optimization. Configurations include star, trunk line, loop, and hub-and-spoke designs, tailored to operational needs and future expansion.

9.2. GGS Operations and Maintenance

GGS operations involve daily monitoring of pressure, flow, and equipment status, process control with automated systems, and production optimization through well performance monitoring and system debottlenecking.

Maintenance includes preventive schedules for equipment inspection, predictive maintenance with vibration and oil analysis, and emergency response for leak detection and environmental incident management. Key performance indicators include system availability, gas recovery efficiency, operating costs, safety incident rates, and environmental compliance.

Technology integration with remote monitoring, predictive analytics, and digital twin modeling enhances operational reliability and efficiency.

10. Gas Collecting Station (GCS)

Gas Collecting station (GCS) maintain adequate pressure in gas gathering and transmission networks, overcoming pipeline friction losses and meeting downstream delivery requirements.

10.1. Compression Technology and Applications

Compressor types include reciprocating compressors for high pressure ratios and variable flows, centrifugal compressors for high flow rates, rotary screw compressors for continuous duty, and diaphragm compressors for high-purity applications.

Driver options include electric motors for efficiency, gas engines for remote locations, and gas turbines for high power. Design considers suction and discharge conditions, flow rates, and safety systems. Applications include wellhead compression, gathering system pressure boosting, gas injection, pipeline transmission, and gas processing plant compression.

10.2. Compression System Operations

Operations involve startup and shutdown procedures, performance monitoring of pressure, flow, temperature, and vibration, and control system operations with anti-surge protection. Maintenance includes routine oil changes, valve inspections, and scheduled overhauls, with condition monitoring through vibration and oil analysis.

Challenges include variable gas composition, capacity management, and environmental compliance with emission and noise regulations. Performance optimization focuses on energy efficiency, predictive maintenance, and advanced control strategies to ensure reliable operations.

11. Effluent Treatment Plants (ETP)

Effluent Treatment Plants (ETP) treat wastewater from oil and gas operations to ensure environmental compliance and enable water reuse, supporting sustainable operations.

11.1. ETP Design and Process Technology

ETP designs address wastewater from produced water, drilling fluids, process water, and refinery effluents. Treatment stages include preliminary treatment for solids removal and pH adjustment, primary treatment with oil-water separation and sludge removal, secondary treatment with biological processes, tertiary treatment with advanced filtration and disinfection, and sludge treatment for volume reduction and disposal.

Design considers variable flow rates, treatment efficiency, discharge standards, water reuse potential, and energy efficiency, with modular designs for expandability.

11.2. ETP Operations and Environmental Compliance

Operations involve process control, performance monitoring, and maintenance programs to ensure treatment efficiency. Environmental compliance adheres to Central Pollution Control Board norms, international standards, and industry guidelines, with continuous monitoring, laboratory analysis, and regulatory reporting.

Key performance indicators include treatment efficiency, compliance with discharge limits, water recovery rates, and chemical consumption. Challenges include variable influent quality, equipment reliability, and regulatory changes, with water reuse applications in cooling, irrigation, and process water systems. Advanced technologies like membrane bioreactors and zero liquid discharge systems enhance treatment efficiency.

12. Safety Protocols and Procedures

Safety protocols are the cornerstone of oil and gas operations, encompassing risk assessment, hazard identification, emergency response, and continuous improvement, as per ONGC's SOPs.

12.1. Well Control and Blowout Prevention

Well control is critical for drilling and workover safety. Blowout prevention equipment includes BOP stacks with annular and ram preventers, tested initially, weekly, and after repairs per ONGC SOPs. Control systems include hydraulic accumulators and remote panels.

Safety procedures involve IWCF-certified training, kick detection through flow and gas monitoring, and well-killing procedures like the driller's method. Material Safety Data Sheets (MSDS) provide chemical hazard information, and risk management includes hazard identification, risk assessment, and control measures to ensure safe operations.

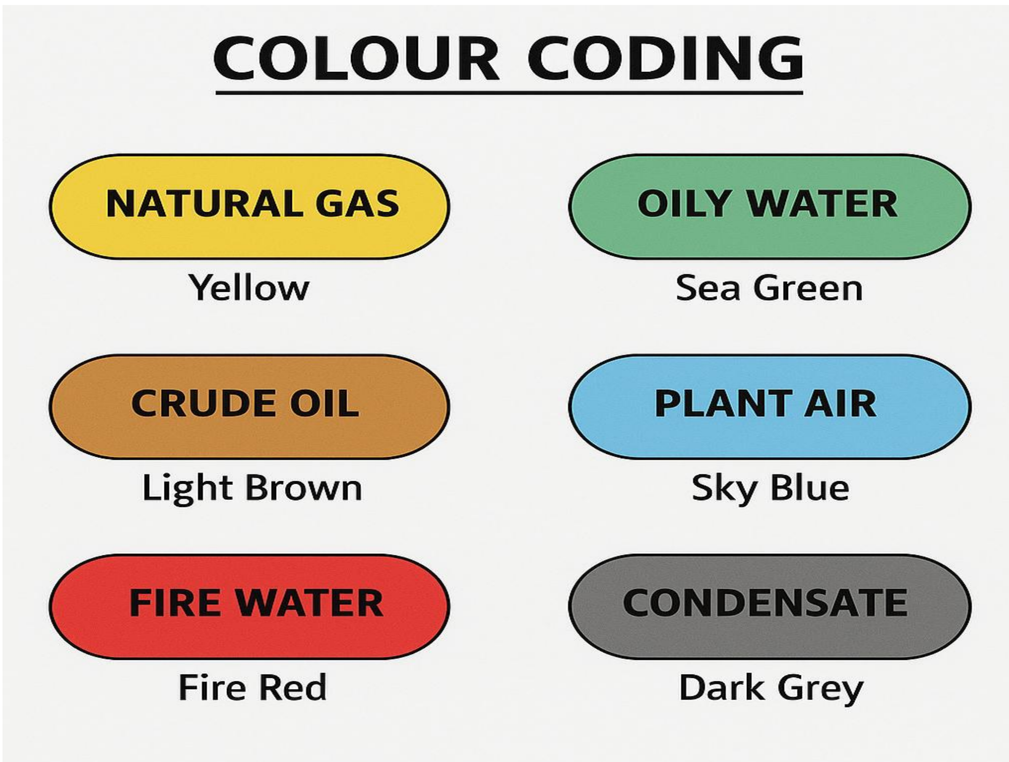
Chemical Name	Main Hazards & Health Effects	Fire/Explosion Risk
Ammonium Acetate	Eye/skin/respiratory irritant, ingestion risk	Combustible at high temp
Hydrogen Sulfide (H_2S)	Highly toxic by inhalation, CNS/lung effects	Highly flammable/explosive
Ammonium Chloride	Eye/skin/respiratory irritant, ingestion risk	Not flammable
Hydrochloric Acid	Corrosive, severe burns, fatal if inhaled	Not explosive, H_2 gas w/ metals
EDTA Tetrasodium Salt	Slight skin/eye/respiratory irritant	Combustible at high temp
Ammonium Bifluoride	Extremely hazardous, corrosive, lung damage	Non-flammable

Chemical Name	Main Hazards & Health Effects	Fire/Explosion Risk
Acetic Acid	Corrosive, flammable, organ toxicity	Flammable, explosive w/ oxidizers
Citric Acid	Eye/respiratory irritant, ingestion risk	Combustible at high temp
Ammonium Persulfate	Skin/eye/respiratory irritant, sensitizer	Oxidizer, fire risk
Benzoic Acid	Skin/eye/respiratory irritant, ingestion risk	Combustible at high temp
Boric Acid	Skin/eye/respiratory irritant, organ toxicity	Not flammable
Ethyl Acetate	Inhalation/ingestion hazard, organ toxicity	Highly flammable, explosive
Isopropyl Alcohol	Eye/skin/respiratory irritant, CNS effects	Highly flammable, explosive
EGMBE (Ethylene Glycol Monobutyl Ether)	Inhalation/skin/eye hazard, organ toxicity	Combustible, explosive vapors
Diesel Oil/HSD	Skin/eye/respiratory irritant, CNS/kidney/liver	Flammable, explosive vapors

12.2. Operational Safety Management

The safety management system includes policy and objectives, clear accountability, risk management, and competency requirements. Personal protective equipment includes hard hats, safety glasses, and respiratory protection.

Emergency response involves planning, response teams, and drills, with safety performance monitored through incident reporting, audits, and continuous improvement. Compliance with OSHA, OISD, and DGMS standards ensures regulatory adherence and operational safety.



12.3. Environmental Considerations

Environmental protection is integral to sustainable operations, with ONGC's environmental management systems addressing air quality, water resources, soil protection, waste management, and biodiversity conservation.

12.4. Environmental Management Systems

Air quality management involves controlling emissions from combustion, flaring, and fugitive sources using best available technology and leak detection programs. Water resource protection includes conservation, recycling, and groundwater protection through wellhead programs and remediation.

Soil and land management prevent contamination with spill response and site restoration. Waste management focuses on minimization, treatment, and disposal, with environmental monitoring of air, water, soil, noise, and biodiversity to ensure compliance and sustainability.

12.5. Climate Change and Sustainability

Climate change strategies address Scope 1, 2, and 3 emissions through energy efficiency, renewable energy, methane reduction, and carbon capture. Sustainable development goals focus on clean water, energy, climate action, and responsible consumption.

Environmental technologies include low-emission equipment and digital optimization tools, with stakeholder engagement through community consultation and transparency ensuring collaborative conservation and regulatory compliance with the Paris Agreement and national plans.

13. Problem Statements and Possible Solutions

13.1. Sucker Rod Pumping

Sucker rod pumping systems face challenges like abrasive wear, polymer backflow, undetected wear, frequent rod breaks, and reactive maintenance. Solutions include applying Al-Si/Graphite composite coatings to reduce friction and wear, optimizing stroke length and pumping speed to mitigate polymer backflow, using dynamometer card analysis to predict wear, implementing failure analysis protocols for corrosion and defects, and deploying AI-driven monitoring for fault detection and stroke efficiency. Implementation involves coating high-wear wells, integrating AI analysis, and training staff on mitigation protocols.

13.2. Sludge

Sludge management addresses recoverable hydrocarbons and environmental hazards. Ultrasonic-assisted solvent extraction with cyclohexane recovers 68.8% oil, pyrolysis at 500°C produces activated carbon, supercritical water treatment upgrades oil, CO2-responsive microemulsions achieve 97% recovery, and safety measures include foam pourers and proper storage. Implementation involves piloting ultrasonic extraction, deploying pyrolysis units, and integrating advanced treatment methods.

13.3. Salinity

High salinity in produced water exceeds discharge limits. Solutions include capacitive deionization (CDI/MCDI) for energy-efficient salt removal, constructed wetlands with halophytes for natural evaporation, hybrid systems combining CDI, MBR, and MVR, supercritical water treatment to degrade organics, and low-salinity waterflooding to improve recovery and reduce scaling. Implementation focuses on deploying these technologies in high-salinity environments.

CONCLUSIONS AND RECOMMENDATIONS

This report examines oil and gas operations based on ONGC's SOPs and industry best practices, highlighting the integration of technical disciplines, safety protocols, and environmental stewardship. Key findings emphasize operational excellence through standardized procedures, technology integration with intelligent systems, comprehensive safety management, environmental responsibility, and human capital development.

Strategic recommendations include accelerating digital transformation, standardizing best practices, investing in technology innovation, enhancing environmental leadership, and developing workforce capabilities. Implementation priorities span short-term digital and safety enhancements, medium-term production and recovery optimization, and long-term operational and environmental excellence. Success factors include leadership commitment, systematic operations, investment in people and technology, collaboration, and continuous improvement, ensuring safe, efficient, and environmentally responsible operations that meet stakeholder and regulatory expectations.

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2. API RP 10B-2 - Recommended Practice for Testing Well Cements
3. API RP 39 - Recommended Practice for Measuring the Viscous Properties of a Cross-Linked Water-Based Drilling Fluid
4. API RP 13B-1 - Recommended Practice for Field Testing Water-based Drilling Fluids
5. API RP 53 - Recommended Practices for Blowout Prevention Equipment Systems
6. ISO 14001 - Environmental Management Systems Requirements
7. ISO 45001 - Occupational Health and Safety Management Systems
8. ISO 9001 - Quality Management Systems Requirements

Regulatory References:

1. Petroleum and Natural Gas Regulatory Board (PNGRB) Regulations
2. Ministry of Environment, Forest and Climate Change Guidelines

3. Ministry of Petroleum and Natural Gas Policies
4. State Pollution Control Board Regulations
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6. Forest Conservation Act Requirements
7. Water (Prevention and Control of Pollution) Act
8. Air (Prevention and Control of Pollution) Act
9. Hazardous Waste Management Rules
10. Environment Impact Assessment Notifications