Report on HLS Asia Industrial Visit

Bachelor of Technology in Petroleum Engineering

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Declaration

We declare that this written submission represents our ideas in our own words, and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea / data / fact / source in our submission. We understand that any violation of the above will be cause for disciplinary action by PANDIT DEENDAYAL ENERGY UNIVERSITY.

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Approval Sheet

This report titled **"Report on HLS Asia Industrial Visit"** is recommended for the credits of Industrial Orientation.

Sign of Examiners:

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Sign of Supervisor:

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Date: ________________________

Place: ________________________

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Introduction

1.1 Company Profile: HLS Asia

HLS Asia Limited (HLSA), originally known as HLS India Limited, was established in 1987 as a public limited company in collaboration with Halliburton Energy Services Inc., USA. Created to provide world-class oilfield services in India, HLSA introduced advanced wireline logging and reservoir evaluation technologies to the country's growing petroleum sector. Over the years, it expanded its operational capabilities, adopted international standards, and built a strong technical workforce. The company has consistently supported both national and global E&P operators, earning a reputation for reliability, technological excellence, and professional service delivery across diverse terrains and challenging well environments.

Figure 1.1: HLS Asia Logo

Significance in Petroleum Industry:

- Provides high-quality subsurface data crucial for exploration and drilling decisions
- Enhances reservoir understanding and supports accurate field development planning
- Improves well performance and production optimization for E&P companies
- Maintains international standards in logging, safety, and service quality
- Operates reliably in challenging terrains and high-temperature/high-pressure wells
- Provides advanced Halliburton technologies to Indian operations
- Strengthens India's domestic oilfield capabilities through skilled and internationally trained engineers
- Ensures timely data delivery through advanced computing and satellite transmission

- Maintains strong HSE practices, ensuring safe and environmentally responsible operations

Main Services Offered by HLS Asia:

- Open-hole, cased-hole, and production wireline logging
- Completion and pipe-recovery logging operations
- Wireline and tubing-conveyed perforation
- High-tech logging: Magnetic Resonance Imaging (MRI), Resistivity Imaging, GEM elemental analysis
- Reservoir description and fluid analysis services
- Reservoir monitoring in complex and high-pressure/high-temperature wells
- Tool pusher logging and casing-patch solutions
- Training programs and equipment maintenance support
- Data processing, log interpretation, and real-time satellite data transmission

1.2 Aim and Scope of Visit

The industrial visit to HLS Asia Limited was organized to offer students practical exposure to the tools and principles studied in the curriculum. In Semester 4, we learned the basics and applications of Well Logging, and in Semester 5, we focused on Production Logging. While lectures and laboratory sessions built our theoretical understanding, this field visit allowed us to witness how these logging tools are actually deployed in oilfield environments with accuracy, safety, and coordinated teamwork.

The primary aim of the visit was to observe real field equipment used for formation evaluation and production diagnostics. During the session, we were introduced to several important tools and technologies, including: Cement Log Tools, Resistivity Tools, Sonic Tools, Calliper Tools, Gamma Ray (GR) Tools, Neutron Tools, Perforation Guns, Shaped Explosive Charges and Data Acquisition Van.

Being able to see these tools, understand their working mechanisms, observe the operational workflow, and learn the associated safety practices gave us a level of insight far beyond classroom learning. The visit highlighted the meticulous planning, accuracy, and risk management necessary for successful subsurface operations.

2

Industrial Orientataion

2.1 Introduction to Well Logging Services

Well logging is a critical formation evaluation technique employed to characterize subsurface geological formations and fluid content within a borehole. The process involves deploying sophisticated sensor suites into the well—typically via wireline conveyance or logging-while-drilling (LWD) assemblies—to acquire continuous, depth-correlated measurements of physical rock properties. These acquisitions generate data records, known as logs, which facilitate the detailed analysis of the reservoir without the prohibitive cost and time associated with extensive physical coring. This diagnostic process is versatile, applicable in both “open-hole” environments to assess potential pay zones immediately after drilling, and “cased-hole” environments to evaluate cement integrity and monitor saturation changes during the well’s production life.

To construct a comprehensive petrophysical model, a diverse array of logging tools is utilized to quantify specific parameters. Fundamental services include Gamma Ray logs for lithological identification and shale volume estimation, alongside Resistivity logs, which are essential for discriminating between non-conductive hydrocarbons and conductive formation water. To assess reservoir storage capacity, porosity logs—comprising density, neutron, and sonic measurements—are utilized to quantify void space volume.

Complementing these are auxiliary tools such as caliper logs, which map borehole geometry to assess stability, and formation testers that isolate specific zones to capture pressure gradients and in-situ fluid samples, validating the physical state of the reservoir.

The integration of this data is indispensable for accurate reservoir characterization, reserve estimation, and field development planning. By accurately delineating rock types, fluid contacts, and permeability, operators can mitigate drilling risks, determine the commercial viability of a zone, and optimize completion strategies, such as precise perforation placement. Furthermore, cased-hole logs provide essential assurance regarding hydraulic isolation and zonal integrity. Ultimately, well logging serves as the foundation for robust reservoir modeling, enabling data-driven decisions that maximize economic efficiency and hydrocarbon recovery throughout the asset’s entire lifecycle.

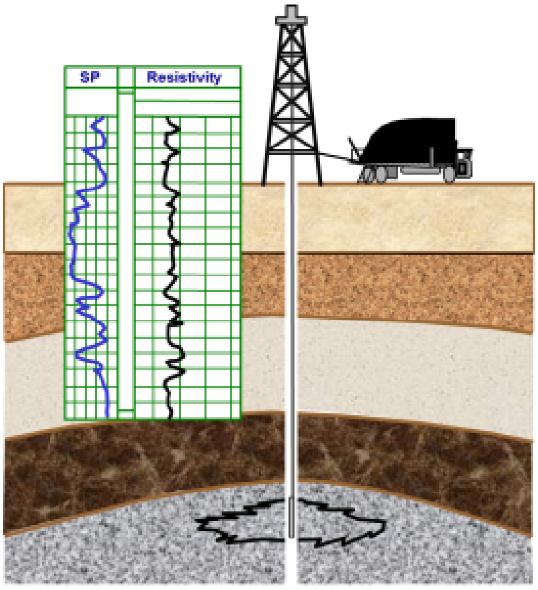

Figure 2.1: Well Logging Process

2.2 Overview of Well Logging Tools

2.2.1 Open Hole Tools

Open hole tools are the logging tools used just after the drilling has completed, before the casing is set. They typically measure and log the formation properties.

Spectral Gamma Tool

Introduction: The Spectral Gamma Ray Tool (SGR) is a wireline logging tool designed to measure the natural gamma radiation spectrum emitted by subsurface formations. Unlike the conventional total gamma ray log, the SGR can discriminate individual radioactive elements by separating the gamma ray signal into different energy windows.

Formations naturally emit gamma rays from three primary isotopes:

- Potassium-40 (^{40}K)
- Uranium Series ($^{238}U \rightarrow ^{214}Bi$)
- Thorium Series ($^{232}Th \rightarrow ^{208}Tl$)

Each isotope emits gamma rays with distinct photon energies. The SGR tool uses a scintillation detector (typically NaI(Tl) crystal) to measure and separate these energies.

Outputs:

- Total Gamma Ray (API units): Summation of all energy windows.
- Elemental Concentrations:

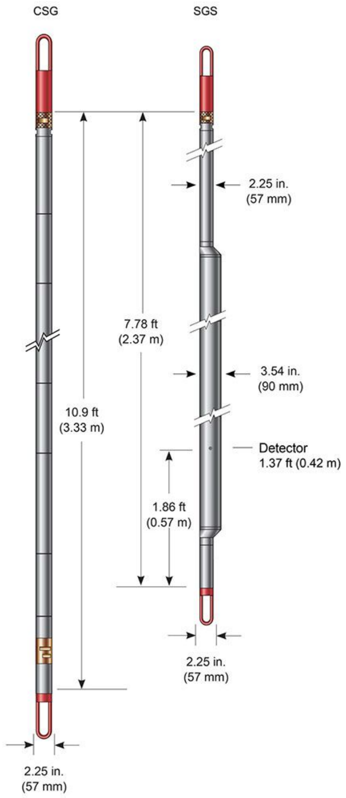

Figure 2.2: Spectral Gamma Ray Tool

Potassium (
Thorium (ppm)
Uranium (ppm)

- Derived Ratios (Used in shale typing & geological correlation):
  Th/K ratio – clay mineralogy indicator
  U/Th ratio – identifies organic-rich shale & reducing environments

Geological Interpretation:

- Shale Identification:
  High Th → kaolinite / illite shale
  High K → potassium-rich feldspar or illitic shale
  High U → organic-rich shale (TOC potential)
- Clay Mineralogy:

Mineral	**Indicator**
Illite	High K
Kaolinite	High Th
Smectite	Lower Th/K

Applications:

- Sequence stratigraphy (maximum flooding surfaces identified by uranium peaks)
- Shale volume calculation (Vsh)
- Distinguishing radioactive sands vs. clean sands
- Identifying non-clay radioactive minerals (zircon, monazite)
- Depositional environment interpretation

- Heavy mineral mapping

High-Resolution Induction Tool

Purpose: The High-Resolution Induction Tool is designed to measure the apparent conductivity of subsurface formations, which is later converted to resistivity through data processing. Its primary purpose is to deliver accurate formation resistivity (R_t) across a very wide resistivity range (0.2–2000 ohm-m), enabling improved evaluation of water saturation, identification of hydrocarbon-bearing zones, and assessment of invasion profiles such as R_{xo} and invasion diameter. The tool also provides digitally focused resistivity (DFL) in conductive muds, allowing shallow radial investigation and enhancing interpretation in thinly laminated reservoirs.

Technical Specifications: The HRI tool belongs to the induction logging family and operates using an electromagnetic induction principle. It contains four transmitters and one receiver, with the transmitters operating at 20 kHz. The receiver is built with a three-coil configuration, which provides enhanced vertical resolution. The tool records both real (R) and quadrature (X) components of conductivity; the X component is used for skin-effect corrections. The processing chain applies corrections for shoulder-bed effects, skin effects, and borehole influence, resulting in high-quality deep (HDRS) and medium (HMRS) resistivity logs. A digitally focused resistivity (DFL) measurement is also available, offering a 15-inch radial investigation and matching vertical resolution with the main induction curves. The tool achieves a 1-ft vertical resolution, improving thin-bed evaluation.

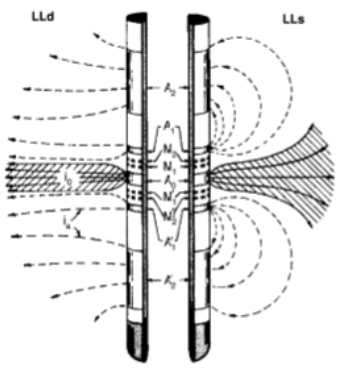

Figure 2.3: Induction Tool

Applications: The HRI tool is used to obtain reliable formation resistivity in wells drilled with water, air, or oil. Because it covers a broad resistivity range, it helps differentiate conductive water-bearing formations from hydrocarbon-bearing zones. Its high-resolution deep and medium induction curves, as well as the DFL measurement, are particularly effective in analyzing finely laminated reservoirs, estimating moveable hydrocarbon volumes, and quantifying radial fluid distributions around the borehole. The tool supports evaluation of invasion characteristics, including determining Rxo and invasion diameter. Overall, it provides crucial input for calculating water saturation (Sw) and improving estimates of hydrocarbon reserves, especially in complex, thinly bedded formations.

Caliper Tool

Description: The Caliper Log tool, also known as a caliper sonde, is a mechanical device used to measure the diameter and shape of the borehole along its depth. It consists of a body with two, three, four, or more extendable arms. Modern tools, often called multi-arm or dual-caliper (e.g., four-arm), can measure the diameter in two perpendicular directions (X and Y) to detect ovality. The arms are typically spring-loaded or hydraulically powered to push against the borehole wall. The movement of these arms is linked to a sensor, often a potentiometer, which translates the mechanical displacement into a varying electrical signal proportional to the hole diameter. The tool is run on a wireline and can have an open-arm measurement range that varies, but a 4-arm tool might open up to 30 inches or more.

Figure 2.4: Caliper Tool

Working Principle: The principle is purely mechanical: as the logging tool is pulled out of the borehole, the spring-loaded arms extend until they press against the borehole wall. Changes in the borehole diameter cause the arms to move in or out. This physical movement is continuously converted by the potentiometer into a changing electrical resistance, which is then digitized and recorded as a continuous measurement of the borehole diameter versus depth. For oval holes, two opposite pairs of arms (in a 4-arm tool) measure the maximum and minimum diameters.

Application and Interpretation: The primary purpose of the caliper log is to measure the borehole diameter and roughness of the wall. It is essential for:

- **Volumetric Calculations:** Determining the openhole volume for accurate cementing operations, ensuring casing can be properly secured.

- **Environmental Corrections:** Providing the hole size needed to apply necessary corrections to other logs (like Density and Neutron logs), as their readings are often affected by the distance to the formation and the volume of borehole fluid (mud).

- **Hole Condition Assessment:** Identifying zones of washout (enlargements caused by unstable formation or drilling fluid erosion), caving (breakdown of the rock), and key seats (wear on the wall in deviated wells).

- **Lithology Inference:** Hard, competent formations (like limestones or sandstones) usually show a diameter close to the drill bit size, resulting in a smooth log. Soft, unstable formations (like shales) often exhibit significant enlargements or rugosity. The presence of a mud cake (a layer of solids deposited on the wall of permeable zones) suggests a permeable formation, causing the measured diameter to be smaller than the bit size.

Neutron Porosity Tool

Description: The Neutron Log tool is a nuclear logging device used to measure the formation's hydrogen concentration, which is directly related to its porosity. The tool contains a source of high-energy (fast) neutrons, typically a chemical source like Americium-Beryllium (Am-Be). It also includes one or two detectors positioned above the source. Common tool types are the Compensated Neutron Log (CNL), which uses two detectors (a near detector and a far detector) to correct for borehole effects, and older tools like the Sidewall Neutron Porosity (SNP) log. The detector measures the flux of slowed-down neutrons (epithermal or thermal) or the resulting capture gamma rays in units like counts per second (CPS), which is then scaled and presented in porosity units (e.g., Limestone Porosity Units).

Working Principle: The tool's working principle is based on the interaction of neutrons with the atomic nuclei in the formation. The Am-Be source continuously emits fast neutrons into the surrounding rock. These fast neutrons collide with the nuclei of the formation atoms, a process called elastic scattering, losing energy with each collision. The most effective element for slowing down neutrons is Hydrogen (^{1}H), because its atomic mass is nearly equal to that of a neutron, leading to the maximum energy loss per collision. Neutrons slow down in stages:

- Fast Neutrons (high energy)
- Epithermal Neutrons (intermediate energy, detected by some tools)
- Thermal Neutrons (low energy, eventually captured, detected by most modern CNL tools via the resulting capture gamma rays).

The number of neutrons that successfully slow down and reach the detector is inversely proportional to the amount of hydrogen in the formation. Since most hydrogen in a rock is concentrated in the pore fluids (water and hydrocarbons), the measurement is primarily an indicator of the Hydrogen Index, which in clean, liquid-filled formations is directly proportional to the total porosity (ϕ).

Application and Interpretation: The primary purpose of the Neutron Log is to determine the formation porosity and fluid type. Key applications and interpretations include:

- **Porosity Determination:** It is a primary porosity tool, often used in conjunction with the Density log (ρ_b) to get a more accurate porosity value and to help determine lithology.

- **Gas Identification (Gas Effect):** Gas contains significantly less hydrogen per unit volume than oil or water. In gas-bearing zones, the Neutron log records a low

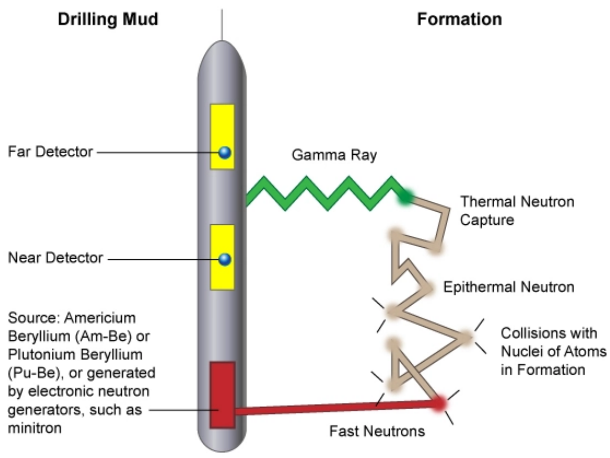

Figure 2.5: Schematic of Netron Porosity Tool

apparent porosity (low hydrogen content). When plotted with the Density log, the curves show a characteristic ”cross-over” pattern, which is a strong indicator of gas.

- **Shale Identification (Shale Effect):** Clays in shales contain chemically bound water, which is a source of hydrogen. This causes the Neutron log to read an overestimated, high apparent porosity in shales.
- **Lithology Identification:** A cross-plot of Neutron porosity versus Density is a standard method for determining the formation's lithology (e.g., distinguishing sandstone, limestone, and dolomite).

Spectral Density Tool

Purpose: The Spectral Density Log (SDL) tool is designed to deliver precise and high-quality measurements of bulk density (ρ_b) and borehole-compensated photoelectric factor (Pe), both of which are essential for accurate determination of formation porosity and lithology. The tool is built to operate reliably even in hostile downhole environments, providing stable, high-resolution density data that improves reservoir characterization.

The tool also reduces borehole sensitivity and enhances the accuracy of Pe, making it especially useful for evaluating thinly bedded formations when processed with the advanced Omega dynamic processing system.

Technical Specifications: The SDL tool uses a Cesium-137 gamma-ray source, tungsten shielding, and two high-efficiency scintillation detectors, all housed in a rugged pad design. This combination generates high gamma-ray count rates with minimal statistical variation. The tool incorporates advanced gain stabilization to maintain measurement integrity as temperature changes, and its pad geometry and articulation ensure consistent contact with the borehole wall.

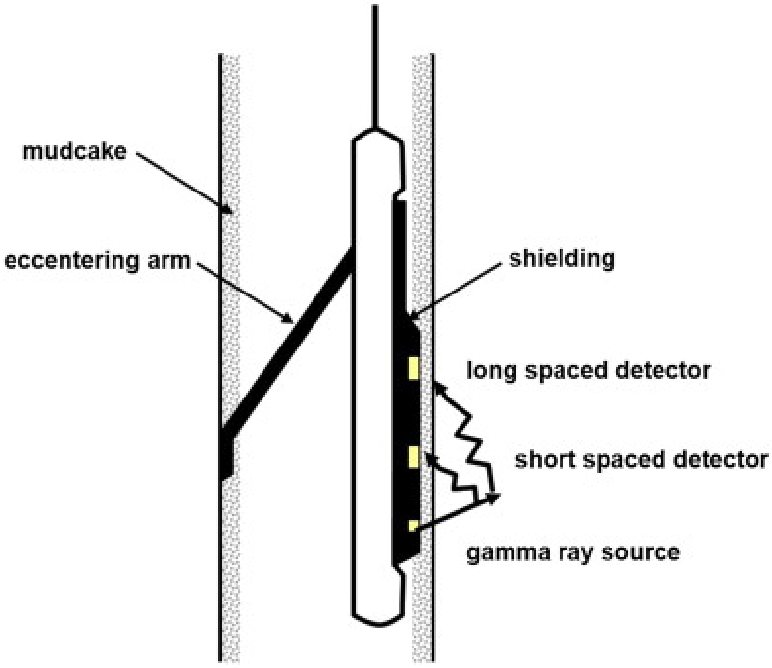

Figure 2.6: Schematic of Density Tool

Applications: The Spectral Density Tool is applied wherever high-accuracy formation density and Pe measurements are required. It is especially useful in:

- Porosity determination
- Lithology identification, including detection of thin beds
- Operations involving weighted borehole fluids, where stable density readings are necessary
- High-temperature, high-pressure wells where rugged design ensures reliability
- Combined density-neutron logging for improved reservoir evaluation and gas detection

Circumferential Acoustic Scanning Tool (CAST)

Introduction: The Circumferential Acoustic Scanning Tool (CAST) is a high-resolution ultrasonic borehole imaging tool that provides a 360° acoustic scan of the borehole wall. It is used for borehole geometry, fracture detection, casing inspection, and cement evaluation.

Principle: The CAST tool operates using a pulsed ultrasonic transducer that emits high-frequency acoustic waves (200–500 kHz). These waves travel through the borehole fluid and reflect back from the borehole wall. Each reflection provides:

- Amplitude – indicates the reflectivity of the formation or casing
- Travel time (Δt) – used to calculate borehole radius

Tool Construction:

Figure 2.7: Circumferential Acoustic Scannig Tools (CAST)

- **Transducer Assembly:** Contains one or more piezoelectric transducers. Operates in pulse-echo mode. Either mechanically rotates (older tools) or electronically scans (modern tools)
- **Caliper Mechanism:** Travel time difference provides micro-caliper measurements accurate to ± 0.1 mm.
- **Telemetry System:** High-speed digital transmission to surface for real-time imaging.

Log Outputs: The CAST provides the following high-resolution logs:

- Acoustic Amplitude Image:
  Low amplitude $\rightarrow$ fractures, washouts, vugs, mudcake, soft formations
  High amplitude $\rightarrow$ competent, hard formations
- Travel-Time (Radius) Image: Used to derive true borehole shape. Detects ellipticity, breakouts, and washouts
- 3D Borehole Reconstruction: Advanced processing gives unwrapped 360° borehole map, dip and azimuth of fractures, and structural orientation analysis.

Applications:

- Structural geology mapping
- Fracture swarm identification
- Stress field and breakout analysis
- Casing inspection logs
- Cement evaluation in cased wells
- Borehole rugosity and caliper analysis
- Reservoir geomechanics

- Core-to-log correlation

2.2.2 Cased Hole Tools

After the casing is set and cemented, operations shift to well completion. Cased-hole tools are then used to verify cement integrity and create controlled pathways for hydrocarbons to enter the wellbore.

Variable Density Log

The primary purpose of cementing the casing is to isolate zones, support the casing and prevent surface blowouts. Cement logging tools are used to verify the quality and placement of this cement behind the casing.

Objective: To provide a qualitative, visual representation of the cement bond by displaying the full acoustic waveform. Its main goal is to verify zonal isolation by showing the acoustic response of the formation behind the casing.

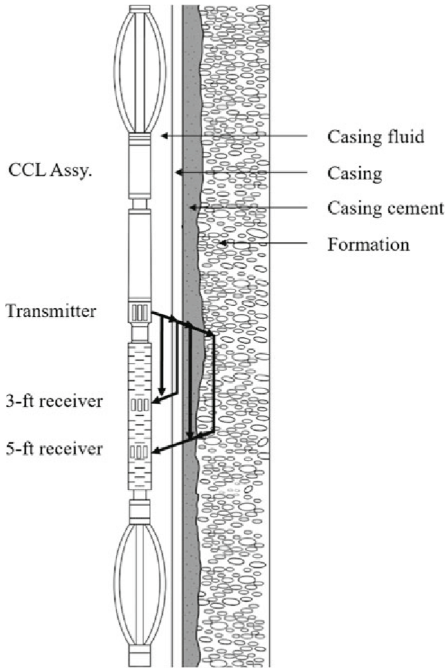

Figure 2.8: VDL and CBL tool

Working Principle: The VDL is an acoustic imaging tool that captures the full acoustic waveform rather than just amplitude. Using the same transmitter-receiver setup as the CBL, it converts the complete wave train into a visual log with varying shades indicating signal intensity. This allows clear identification of different acoustic arrivals, such as casing and formation waves.

Interpretation:

- Strong vertical lines indicate poor bond (casing arrival dominant).
- Strong wavy lines indicate good bond (formation arrival dominant).

Perforating Gun

Objective: The primary objective of a perforating gun is to create a hydraulic communication path between the wellbore and the hydrocarbon-bearing reservoir. It does this by punching holes through the steel casing, the cement sheath surrounding it, and several inches into the formation rock.

Working Principle: They operate using shaped explosive charges arranged inside a carrier. When detonated, each charge creates a high-velocity jet that penetrates the casing and forms perforation tunnels in the formation. The energy of the jet removes material along its path, creating clean, deep channels that connect the reservoir to the wellbore for efficient production.

Components:

- **Housing:** The steel body that holds the charges. It can be a hollow steel carrier or a strip/retrievable type.
- **Shaped Charges:** The individual explosive units that create the penetration jets.
- **Detonator:** The device that initiates the explosive sequence.
- **Detonation Cord:** A cord that runs through the gun, transferring the detonation from one charge to the next.

Figure 2.9: Perforating Gun

Types of Perforation Guns:

- **Wireline-Conveyed:** Lowered on a cable for accurate depth control. Mostly used in vertical wells.

- **Tubing-Conveyed:** Run as part of the production string, used for long or horizontal wells/high pressure wells.

2.3 Process of Well Logging

2.3.1 Data Acquisition Van (Logging Unit)

The Logging Unit, also referred to as the Data Acquisition Van, is the central control hub for conducting well logging operations. It is a mobile, fully equipped workstation designed to monitor, record, and process all incoming data from downhole tools in real time. The van is fitted with advanced data acquisition systems, high-performance computers, depth-tracking instruments, communication panels, and specialized software used for interpreting logging measurements. The interior environment is climate-controlled to protect sensitive electronics and ensure stable working conditions for logging engineers. During field operations, the engineers seated inside the unit continuously monitor parameters such as gamma ray counts, resistivity curves, neutron-density responses, caliper readings, and tool status indicators. The van also houses power control modules, safety interlocks, and backup systems to prevent data loss in case of power instability. All surface equipment is integrated through cables running to the wellsite winch unit, enabling precise synchronization between downhole tool movement and data acquisition. In essence, the Data Acquisition Van acts as the "brain" of the logging operation, ensuring accurate, real-time interpretation and high-quality dataset generation for reservoir evaluation.

Figure 2.10: Data Acquisition Van

2.3.2 Data Acquisition and On-site Processing

The data acquisition and on-site logging process involves a systematic workflow that begins with rig-up and ends with quality control and data delivery. Once the tools are assembled and tested, they are lowered into the wellbore using the winch system, and the depth encoder ensures accurate measurement of tool position throughout the operation. As the tools descend and later ascend through the formation, sensors measure physical properties such as natural gamma radiation, formation resistivity, porosity, bulk density, borehole geometry, and acoustic travel time. These measurements are transmitted through the logging cable to the Data Acquisition Van, where the logging engineer continuously monitors the logs for abnormalities, depth mismatches, or tool malfunctions. During the process, calibration checks are performed to ensure the accuracy of tool readings, and real-time data is cross-verified with pre-job models and formation expectations.

Communication between the engineer, rig crew, and tool technicians remains constant to coordinate tool movement, manage wellsite risks, and respond quickly to operational changes. Once logging is complete, the data undergoes preliminary processing, environmental correction, and quality control. A field print or digital log is then generated and delivered to the operating company for further petrophysical interpretation. This structured workflow ensures that high-quality, reliable subsurface data is obtained during every logging operation.

2.4 Tool Storage, Maintenance and Dispatch

2.4.1 Asset Management and Storage Infrastructure

The Gandhinagar facility utilizes a segregated infrastructure model designed to preserve asset integrity and adhere to strict statutory inventory controls. The workshop is divided into distinct operational zones, separating non-hazardous wireline assets—specifically open-hole and cased-hole logging sondes—from hazardous materials. To mitigate the risks of galvanic corrosion and electronic degradation common in humid environments, all electronic cartridges, telemetry subs, and acoustic devices are housed in climate-controlled, humidity-regulated storage units. Hazardous materials are managed with heightened security protocols compliant with Indian national standards; radioactive sources used for density and neutron logging are secured in subterranean, lead-shielded bunkers approved by the Atomic Energy Regulatory Board (AERB), while explosive materials, including perforating charges, are stored in earth-mounded magazines licensed by the Petroleum and Explosives Safety Organization (PESO). All inventory movement is tracked via the HLS digital asset management system, ensuring real-time visibility of tool location, life-cycle history, and utilization statistics.

2.4.2 Maintenance Lifecycle and Calibration

To ensure “First Run Success” and minimize non-productive time (NPT), the facility executes a rigorous maintenance regimen immediately following every field deployment. The lifecycle begins with thorough decontamination and pressure washing to remove formation fluids and drilling mud, followed by a detailed mechanical inspection of pressure housings, threads, and connectors to identify erosion or physical trauma. Technicians systematically replace all elastomeric sealing elements (O-rings) and backup rings to guarantee pressure isolation up to the tool’s rated maximum. Concurrently, electronic diagnostics are performed using the HLS Test Bench to simulate downhole power loads and telemetry speeds, verifying the health of printed circuit boards and sensors. Critical formation evaluation sensors—specifically Gamma Ray, Neutron, and Density tools—undergo Master Calibration using traceable reference standards to correct for detector drift, while induction tools are verified against known resistivity markers. Prior to returning to the ready rack, pressure-critical assets undergo hydrostatic validation in a Pressure Test Vessel (PTV) to certify seal integrity.

2.4.3 Dispatch Operations and Pre-Deployment Verification

The dispatch phase consolidates technical preparation with logistics coordination to ensure operational readiness at the wellsite. This process begins with the assembly of the toolstring according to the specific client well program, followed by a System Integration Test (SIT). During the SIT, the assembled string is powered via a surface logging unit to verify inter-tool communication, telemetry synchronization, and software compatibility. Once validated, equipment is packed into shock-resistant transportation baskets designed to prevent vibration damage during transit. The logistics team coordinates the movement of these assets, paying strict attention to regulatory documentation. This includes the preparation of comprehensive manifest dossiers containing calibration certificates, inventory lists, and—for hazardous cargo—the requisite regulatory transport permits and TREMCARDS (Transport Emergency Cards) as mandated by the Motor Vehicles Act and AERB guidelines for the transport of Dangerous Goods (Class 7 and Class 1).

2.5 Health, Safety and Environmental (HSE) Management

2.5.1 General Site Safety

General site safety protocols at the HLS Asia Gandhinagar Workshop form the foundation of all operational activities, especially because the facility handles high-value logging tools, heavy mechanical equipment, radioactive materials, and explosives. Personnel are required to wear complete personal protective equipment (PPE), including helmets, flame-resistant coveralls, safety shoes, high-visibility vests, goggles, and gloves before entering work areas. The workshop is divided into controlled access zones—Green, Yellow, and Red—each restricting entry based on operational risk, with the Red Zone reserved for hazardous materials and accessible only to authorized staff. Before the start of daily operations, safety induction sessions and toolbox talks are conducted to brief workers about ongoing activities, potential hazards, emergency communication, and preventive measures.

All equipment handling is restricted to certified technicians who inspect hoisting and lifting tools before use. Fire safety measures are robust, with strategically placed fire extinguishers, functional alarms, and clearly marked evacuation routes. The workshop maintains high housekeeping standards by ensuring clean, hazard-free workstations, proper tool arrangement, and systematic waste segregation. Throughout all operations, documentation and compliance with HLS and OISD safety regulations are strictly maintained through logbooks, audits, and scheduled inspections. This strong HSE culture ensures safe operations and minimizes risks during all workshop activities.

2.5.2 Handling of Radioactive(RA) Sources

Radioactive sources used in well logging tools are handled under strict regulatory control following AERB guidelines. These sources are stored inside shielded lead containers placed within a dedicated RA bunker equipped with radiation signage, surveillance, and monitoring systems. Access to this area is highly restricted and permitted only to trained personnel holding valid AERB certifications. All handling of radioactive capsules, including loading and unloading into logging tools, is performed within controlled zones using specialized tools to minimize exposure. Radiation levels are continuously monitored using survey meters, area monitors, and personal dosimeters, and exposure records are updated monthly. Transportation of radioactive sources follows regulated procedures, using certified lead casks with tamper-proof seals, along with transport permits and chain-of-custody documentation.

In case of any radiation abnormality or suspected source breach, emergency protocols require immediate evacuation, activation of alarms, restricted entry, and assessment by the Radiation Safety Officer (RSO). Spent or expired radioactive sources are not stored locally; instead, they are returned to manufacturers or other AERB-approved disposal facilities. These strict measures ensure safe, compliant, and efficient handling of all radioactive materials in well logging operations.

2.5.3 Handling of Explosives(EXPL)

EXPL refers to chemical compounds capable of rapidly transforming under specific stimuli to release large amounts of heat and gas. This reaction may result in a sharp blow, spark, or full detonation, producing significant explosive energy.

Classification of EXPL:

- **Low Explosives:** Substances that burn rapidly through deflagration but do not detonate.
- **High Explosives:** Compounds that detonate at high speeds and generate powerful shock waves.
- **Pyrotechnics:** Materials used for illumination, signaling, and special effects.

Sensitivity Factors: EXPL is highly sensitive to external conditions; improper handling can lead to unintended initiation. Key sensitivity factors include:

- **Electricity:** Static or stray electrical currents can unintentionally initiate electric detonators or assemblies.
- **Shock and Impact:** Dropping, striking, or mechanically stressing EXPL—especially primary explosives—may cause detonation.
- **Heat:** Elevated temperatures accelerate decomposition, increasing the likelihood of accidental ignition.

Controls and Safety Measures:

- Heat Control
  Store EXPL in cool, shaded areas away from direct sunlight.
  Outdoor storage of EXPL is strictly prohibited.
- Impact Control
  Handle all EXPL items, particularly detonators, with extreme caution.
  Prevent any dropping, vibration, or mechanical shock during handling or transport.
- Electric Current Control
  Avoid the use of electrically powered tools near EXPL assemblies.
  Utilize standardized control panels and meters.
  Ensure proper grounding at all times.
- Friction and Spark Control
  Only non-sparking, non-ferrous tools should be used.
  Storage and transport units must be lined with spark-free materials.
- Static Electricity Control
  Suspend EXPL operations during thunderstorms, sandstorms, or snowfall.
  Avoid helicopter movements near armed systems due to static generation.
  Use appropriate grounding and personal protective equipment to prevent static buildup.
- Physical Barricading
  Install suitable barricades around EXPL storage, handling, and operational zones to restrict unauthorized access.

Operational Guidelines: For field operations involving EXPL, the following procedural rules must be enforced:

- The term *explosive* must be replaced with EXPL in all communications and records.
- EXPL-related tasks should only be performed between sunrise and sunset to reduce risks associated with poor visibility.

2.6 Present Market Status and Future Scope

The global market for wireline services is experiencing consistent growth, with Fortune Business Insights projecting a compound annual growth rate of about 5.18% from 2025 to 2032. Additional estimates from WiseGuy suggest that the wireline logging segment alone may expand from USD 14.1 billion in 2025 to roughly USD 20.8 billion by 2035. Growth is particularly strong in the Asia-Pacific region, with countries such as India emerging as major contributors. Zion Market Research similarly forecasts that the global wireline logging services market could reach approximately USD 15.42 billion by 2034, further reinforcing the sector's upward trajectory.

In India, the oil and gas upstream sector is also set for substantial expansion. Mordor Intelligence reports that the country's exploration and production market may rise from around USD 16.08 billion in 2025 to about USD 20.53 billion by 2030, reflecting a CAGR of nearly 5%. The oilfield services segment is expected to grow even more rapidly. According to TechSci Research, this market could expand at a CAGR of about 12.4% through 2029.

OIL India's strategic vision for 2030 also highlights plans for upstream growth, indicating increasing demand for logging, reservoir evaluation, and related technical services.

Technological advancements are further shaping the industry's future. The growing adoption of digital and real-time logging tools, enhanced data analytics, and sophisticated reservoir evaluation techniques is boosting demand for advanced service providers such as HLSA. Additionally, the rising focus on carbon capture and storage (CCS) is creating new applications for wireline services, particularly in the monitoring and assessment of storage reservoirs, according to various market forecasts.

2.7 Competitors and Other Threats

The competitive environment for logging and wireline services is largely shaped by the speed of new technology, increasing digitalisation, and the dominance of international oilfield service companies. Academic research suggests that advanced logging tools which include spectral gamma ray, cement bond logs, and induction/neutron porosity tools are fundamental to subsurface evaluation workflows in the sector.

These tools require a high level of technical capability, on-ongoing technology investments, and specialised skills, making entry for regional service providers such as HLS Asia problematic. Well-logging is a significant reference for reservoir characterisation and formation evaluation (Rider & Kennedy, The Geological Interpretation of Well Logs, Elsevier).

Research on spectral gamma ray (SGR) logging also emphasizes that leading companies have developed multi-detector gamma ray systems which are capable of more advanced lithology analysis and shale discrimination than traditional single detector systems (Klaja & Dudek, 2016). These are simply now the standard operating procedure on multi detector gamma ray systems from companies such as Schlumberger, Halliburton, Baker Hughes and Weatherford.

In a similar vein, cement bond logging work stresses the necessity of obtaining high quality CBL/VDL in order to ensure long-term well integrity (Saini et al., 2021). International contractors are continually upgrading their sonic based cement evaluation tools to enhance accuracy, reliability, and operational efficiency that clients will increasingly expect during tender evaluations.

One competitive threat is digital transformation. State of the art machine learning models can automatically execute functions such as synthetic log creation, lithofacies forecasting, and porosity prediction with high accuracy (Zhang et al., 2025). International service companies investing in modern day AI platforms have a clear competitive advantage compared to moderately sized companies without similar digital assets.

The research literature has also documented operational risks in wireline logging, such as tool failure, borehole washout, cement channeling, and depth mismatches. Bigger companies cope with these risks better because of experience, staff expertise, and redundancy in equipment. These situations, along with digitalisation and expectations from customers, are the most serious risks to HLS Asia in a competitive scenario.

3

Learnings from Industrial Visit

3.1 Key Learnings

The industrial visit to HLS Asia provided a clear understanding of how safety, technology, and operational discipline come together in real-world well logging environments. One of the most significant learnings was the uncompromising emphasis placed on safety, especially while working around high-risk equipment and hazardous materials. The detailed safety briefing highlighted strict procedures for handling radioactive sources and explosives, underscoring the need for certified personnel, secure containment, and continuous monitoring when working with tools that use gamma-ray, neutron, or other radiation-based measurements. This reinforced the idea that risk mitigation and operational planning are foundational to every field activity.

The visit also offered valuable exposure to the variety and complexity of well logging tools used in diagnostics and well-integrity assessments. Tools such as the VDL (Variable Density Log) tool, Spectral Gamma tool, and perforation guns illustrated the multi-physics nature of modern logging operations, where acoustic, radioactive, and mechanical measurements work together to provide comprehensive subsurface insights. Observing these tools up close demonstrated the level of precision, calibration, and miniaturization required for them to function reliably in high-pressure downhole conditions. Their integration within a toolstring further highlighted how advanced diagnostics depend on synchronized data from multiple sensors.

A key takeaway from the visit was the realization that even with sophisticated tools, successful data acquisition still relies heavily on human expertise. Engineers and operators continuously adjust acquisition parameters based on real-time data, ensuring high-quality measurements despite changing well conditions. The explanations provided by the crew highlighted the importance of judgment, environmental corrections, and collaborative interpretation with subsurface teams to derive meaningful conclusions from raw logs.

Finally, the tour of the Data Acquisition Van tied all these elements together. The van served as the operational hub where real-time data visualization, quality control, and digital processing took place. Seeing how numerous channels of data are monitored simultaneously emphasized the role of the digital workflow in modern well logging. Overall, the visit offered a comprehensive and practical understanding of the blend of safety, technology, and human decision-making that enables accurate and reliable well-diagnostics operations.

3.2 Connections to Classroom Learning

Our visit to HLS Asia helped us directly connect the theoretical concepts learned in classroom courses such as Petrophysics, Well Logging, Cementing, and Well Completion with how these ideas are applied in the industry. Topics that were earlier understood only through lectures and classroom notes became much clearer when we saw the actual tools and workflows in operation.

For example, during lectures we studied open hole logs—Gamma Ray, Resistivity, Sonic, Neutron, and Caliper—and their applications in lithology identification, porosity evaluation, and fluid typing. At HLS Asia, seeing these tools physically helped us understand how principles like Compton scattering in GR logs, current focusing in Laterolog resistivity tools, acoustic transit time in Sonic logs, and borehole geometry measurement in Caliper tools are implemented through real hardware. The demonstrations showed how mud invasion, borehole effects, and tool calibration are managed through tool design features such as centralizers, bucking currents, and advanced processing software.

Similarly, the CBL–VDL cement evaluation tools we studied in class came to life when we observed actual acoustic sondes and VDL waveform displays inside the Data Acquisition Van. Concepts such as E1 amplitude, free pipe vs bonded pipe, formation arrivals, and microannulus indication became more intuitive through real-time visual examples, reinforcing the interpretation techniques taught in lectures.

Our classroom discussions on perforation guns and explosive charges also connected strongly with the field demonstrations. Understanding the design of shaped charges, stand-off distance, and phasing angles became more meaningful when we saw actual perforation guns, carrier tubes, detonators, and charge assemblies. The way shaped charges penetrate casing, cement, and formation matched exactly with the well completion principles we learned academically.

One of the most valuable connections was understanding how radioactive sources (Cs-137, Am–Be) used in logging operations are handled. The strict safety protocols, radiation monitoring devices, shielded storage containers, and controlled loading procedures aligned perfectly with the nuclear safety principles we studied, highlighting their importance in real field conditions.

Finally, the Data Acquisition Van served as the perfect bridge between theory and practice. Concepts like real-time logging, telemetry, depth matching using CCL, waveform monitoring, and environmental corrections—often studied only through diagrams—were displayed live on multiple screens. This helped us understand how raw GR, resistivity, caliper, and CBL–VDL data are processed, filtered, corrected, and converted into the logs we later interpret.

Overall, the visit transformed classroom theory into practical understanding. It allowed us to see how logging principles, petrophysical evaluation, cement bond interpretation, perforation design, and radioactive handling procedures operate together as an integrated workflow in real industry operations. The experience improved our conceptual clarity and gave us a realistic view of how the tools and concepts taught in class are applied during actual well evaluation and completion activities.

4

References