Digitalizing the Oil and Gas Refinery **Laboratory with LIMS**

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The refinery laboratories, encompassing many instruments and processes, enable continuous evaluation and quality assurance of crude oil, semifinished, and finished products. Further, apart from product quality monitoring, businesses expect research-level evaluations from refinery labs start on new line. These labs face multiple challenges, including:

- During the quality evaluation, labs generate a large amount of data. Data storage, analysis, and report generation can be effort-intensive, error-prone, and expensive.
- Just-in-time (JIT) results are necessary for the effective operation of the refinery and the efficacy of lab instruments.
- Seamless sample management, sample collection scheduling, genealogy tracking, handling of containers and raw materials, and inventory management can be challenging.
- Lab operations must follow regulatory guidelines issued by various environmental protection agencies with electronic lab data transfer mandated by some of them.
- Labs must strictly adhere to standards, such as ASTM and ISO.
- Labs face difficulties in performance and efficiency comparison and availability tracking of lab instruments.
- Robust statistical analysis of results is another area where legacy refinery labs lag.

A digital-first Laboratory Information Management System (LIMS) can alleviate those challenges faced by oil and gas refinery laboratories.

Introduction to LIMS

A Laboratory Information Management System or LIMS is a software-based solution with features that support a modern laboratory's operations. Key features include but are not limited to workflow and data tracking support, integration with lab instruments, flexible architecture, and data exchange interfaces that fully support its use in regulated environments. Additionally, you can produce reliable results more quickly, and track data from sequencing runs over time and across experiments to improve efficiency.

The features and uses of the LIMS have evolved over the years from simple sample tracking to an enterprise resource planning tool that manages multiple aspects of laboratory informatics. It is an integral part of many manufacturing industries. Designed to measure different qualities of a product at various stages of the manufacturing process, the LIMS is the gatekeeper of product quality, boosting customer satisfaction, regulatory compliance, productivity, and cost-efficiency.

Moreover, various types of labs leverage the LIMS to track the digital equivalence of lab processes.

If you don't manufacture a superior quality product, you would end up making expensive mistakes.

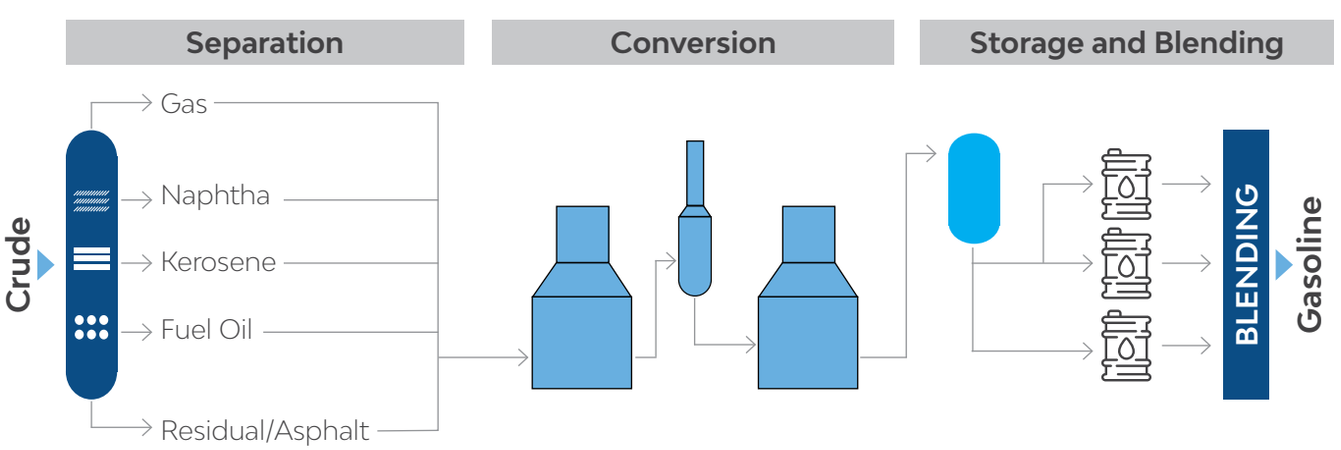
Introduction to the Oil and Gas Refinery

The O&G (oil and gas) refinery is a manufacturing facility where crude oil is processed and converted into finished and semifinished products. Finished products consist of but are not limited to gasoline (or petrol), diesel, kerosene, jet fuel, propane, lubricants, naphtha, natural gas, and more.

The O&G refinery has a complex structure. Grouped into multiple areas, which can be named areas A, B, C, or North area/East area, each of the refinery's areas consists of one or multiple units. The units can be the Crude Distillation Unit (CDU), Reformer, Coker, Hydrocracker, FCC, and VAC. Each unit encompasses different subunits, such as the furnace, fractionator, tank inventory, reactors, steam generator, and many more. Mechanical units, such as pumps, heaters, compressors, and heat exchangers, are also a part of sub-units.

Broadly, refineries perform a combination of continuous and batch processes. As one of the processes, refining consists of distillation, hydrocracking, hydrosulfurization, alkylation, polymerization, reforming, cracking, and blending.

The basic refinery process is as follows



Separation crude 0il into various fractions based on boiling point

- Crude Desalter.
- Atmosphere Crude Unit.
- Vacuum Crude Unit.

Converts lower value products into high-demand, premium products

- Residual Conversion.
- Middle Distillate Upgrading.
- Light Ends Processing.

Combines the various components from the conversion processes into end-use products

LIMS in the O&G Refinery

For the O&G refinery, with its complex structure, the labs remain at the center of all processes. Testing is crucial to ensure high-quality output in each phase of oil and gas production, from testing the incoming crude oil samples, finished products, and throughout the distribution process, and LIMS measures the quality of the product at each of those stages. Accurate testing is essential to determine the composition, purity, and presence of contaminants during all phases of oil and gas production, including distillation, filtration, and other processes.

The GO-NO-GO decision-making across many processes relies on tests performed in the LIMS. If the LIMS cannot generate a Certificate of Analysis (CoA) for the final products, customers do not accept them. The refining process needs to stop or defer if the LIMS indicates 'out of specification' values, reducing risk, and accelerating critical decision-making. Further, SPC and SQC analysis generated by LIMS can help to drive process optimization and improvisation.

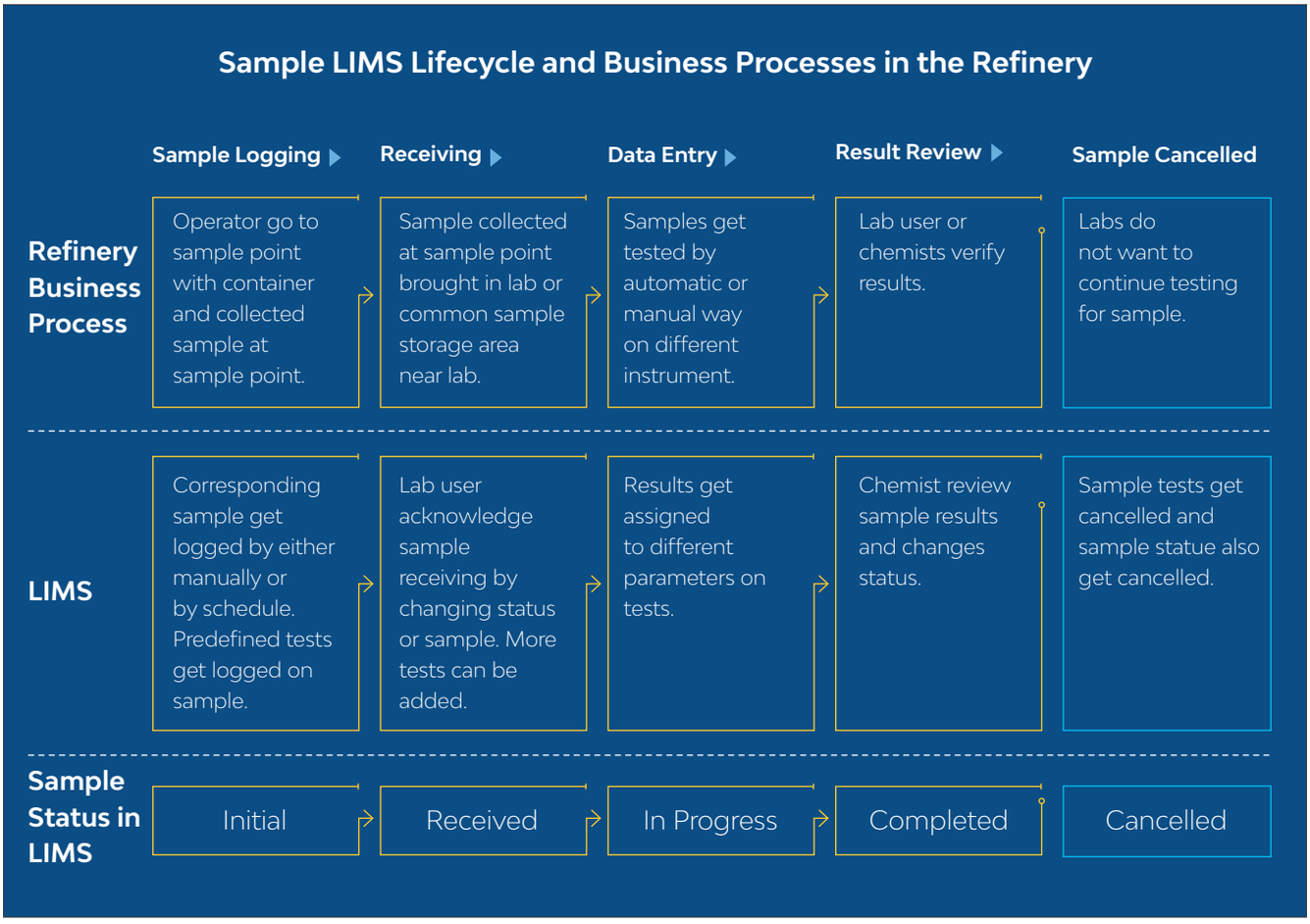
LIMS can also help in instrument maintenance and result collection from instruments, while advanced LIMS even come with leading-edge data science and machine learning capabilities.

The Function of LIMS in O&G Refinery

At a high level, LIMS facilitates the following functions at an O&G refinery:

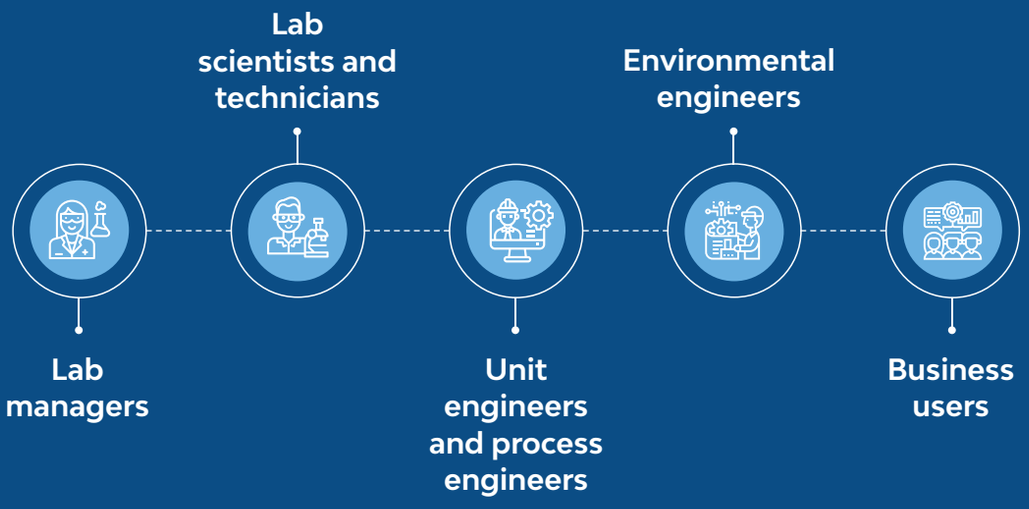
- **Digitization of the refinery:** LIMS allows users to virtually create area and process units sample points (where samples need to be collected), and helps to contextualize data.
- **Sample tracking:** Sampling is the core of the LIMS, involving collected specimens of products in the refinery at the sample point. The sample can be characterized in LIMS with multiple attributes like collection date, status, disposal date, type of sample, collected by, requested by, cost object, tests and specs associated with sample.
- **Batch management:** The collection of multiple samples forms a batch. The batch can be related to the final product to be shipped.
- **Parameters management:** These are the sample-specific variable for which results are stored.
- **Test and parameter list:** The grouping of parameters or variables.
- **Product management:** Products at different stages and undergoing various processes in the refinery are tracked in the LIMS.
- **Specifications management:** This involves the administration of operational limits for product-related parameters.
- **Routing:** It defines the sequence in which a sample is tested in different labs.
- **Reports:** LIMS can deliver persona-based reports for effective decision-making.
- **Certificate of Analysis (CoA):** CoA is the primary quality report without which a company cannot ship its products.
- **Instrument integration:** Sample data is downloaded to the lab instrument, and test results are uploaded to the LIMS.
- **Scheduling:** LIMS allows users to schedule the automated logging of samples.
- **Container management:** Samples are collected in different containers of varying sizes and materials, such as 100 mg glass containers or one-liter plastic bottles.
- **Label printing:** Involves printing labels to attach to containers.
- **Workflows:** The execution of sequential steps with well-defined workflows is a crucial feature of the LIMS.

- **SPC and SQC:** SPC and SQC statistical process and quality controls help detect a deviation in the process, further aiding in designing more robust procedures.
- **Policy management:** Enforces rules related to master data management while creating an instance.
- **Security:** Leading laboratory information management systems have industry-leading application and segment security features.
- **Actions and calculations:** The LIMS carries out complex calculations and triggers internal actions to be performed.
- **Templates:** These are used in instance creation for samples, batches, and more.



End-users of the LIMS at the Refinery:

- **Lab managers**: Manage specifications, test methods and procedures, sampling frequencies, operator training, and more through dashboards.
- **Lab scientists and technicians**: Execute laboratory testing quickly and easily, or with step-by-step guidance in the Laboratory Execution System (LES) for more complex methods. LIMS allows them to work in the lab, at their desks, or a sampling point with the mobile app.
- **Unit engineers and process engineers**: Make decisions about blending batches or not, based on quality data.
- **Environmental engineers**: Maintain refinery output within environmental and operational limits and report data to regulatory authorities.
- **Business users**: Track laboratory performance against critical metrics through enterprise dashboards and data visualization tools.



Conclusion

The persona-based LIMS software is positioned to significantly improve efficiency, compliance, and resource management for O&G organizations. It can be explicitly designed for the industry to support all aspects of the O&G production process. Optimizing performance with connected instrumentation and data, complying with regulations, and monitoring product quality, plant performance, and environmental conditions will lead O&G businesses towards better business outcomes.

About the Author

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Rohit Lagdive is an Associate Principal in Industrial-IOT vertical and performs the role of a techno-functional consultant for MES and LIMS. He has a vast experience across FMCG, Water, Electrical, Oils and Gas industries.

He has architect-ed and developed Quality, Production, and Reliability MES solutions with reference to ISA 88 and ISA 95 standards.