Significance and Critical Role of Calibration for Field Instruments!

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Abstract

Calibration has gone far beyond the simplistic requirement it started with, to ensure that devices, measuring instruments, and all operating equipment in manufacturing function accurately to pre-set values. It was important to ensure that the measuring instruments and sensors recorded and sensed correctly. Today with digitalisation, smart machines IIoT, AI etc calibration has become very crucial and its role includes not only precise measurements, to ensure quality of products and processes, safety, innovations and need to conform to manufacturing and greening, decarbonization, and sustainability.

Introduction

Calibration – a methodology to change and adjust instruments to bring systematic improvements in the way we measure and operate, is a significant procedure that generally stays beyond the purview of the users and even most of the value chain.

With increased digitalisation and smart machines, the necessity for calibration has reached an unforeseen level. Driven by the electronics market, research labs, material analysis, manufacturing, and particle analysis along with the particle analysis testing that includes particle counters, size analyzers, shape analyzers, surface energy analyzers, and zeta potential analyzers and many others. Hydrocarbons and downstream chemical industries are just one part of that vast number of fields that need calibration or accurate measurements.

Why Calibration?

While it is an accepted fact that calibration helps ensure accurate measurements, it is important to acknowledge that accurate measurements are foundational to the quality, safety and innovation of most products and services that we are using in a digitalised world. Even if we take a regular product like an air conditioner as an example, a smart and green AC today will need to react to the room temperature perfectly to auto-start when it crosses a designated temperature and go into sleep mode, when the coolness touches the threshold. The sensitivity of the sensor is seamlessly calibrated to the temperature regulator for the change to happen smoothly.

A better and regular example would be cars – every car owner understands that after a change of tyres or a long-drive, it is important to calibrate the wheels, so

While the awareness about the calibration services and necessity is still at a nascent stage, IMARC Group, the US-based research firm quotes the growth of the global calibration services market to reach $ 7.5 billion by 2028, exhibiting a growth rate (CAGR) of 5.1% during 2023-2028, up from US$ 5.6 billion in 2022 in their study "Calibration Services Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2023-2028". Incidentally, it is not only the global market that is showing the growth trend, India is also following similar patterns.

According to TechSci Research, Indian Test and Measurement Equipment Market was valued at US$390.77 million in 2022 and is anticipated to project robust growth in the forecast period between 2022-2028 with a CAGR of 4.33%.

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that the car remains fuel efficient and gives optimum mileage. Thus the purpose of calibration is not limited to precise measurements only but to support safety and innovation as well. If we broaden our outlook horizon, we can easily conclude that the right calibration or maintenance in a timely manner pushes the profitability of an organisation northward and also increases the durability of the machines. In hindsight, the use of testing and measurement equipment, helps to draw attention to any potential harm or error that can occur during the manufacturing process and improves the quality of the product leading to better brand value for the company.

For hydrocarbons or other chemical industries, field calibration allows the field instrument to be tested or calibrated at the true process and ambient conditions. Calibration done under field conditions is often very different from those done under shop conditions and they even produce different calibration results. Thus, it becomes important to adjust the instruments on the ground in true conditions, before using them in the process.

The calibration process is one of the most sustainable and cost-efficient ways for firms and industries to remain compliant with environmental and other regulations. It is the only way to imbibe a green manufacturing plan that aims to be carbon neutral or minimize emissions in its operations.

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Calibration in Hydrocarbons and Downstream Chemical Industry

While technology-led gadgets and modern electronics are fully balanced on the scale of calibration, old-age heavy industries like hydrocarbons or petroleum industry and downstream chemical industries like pharmaceuticals, oils, paints, gases, batteries, and many others are increasingly adapting the new digitized calibration methods and instruments for better results.

Especially with the digitisation of processes where it is the ultra-sensors that are detecting changes and analysis from that data leading to maintenance activities, the entire set-up is looking for more precision in parameters like temperature, humidity, pressure, and even ratio of mixing of chemicals for a given product.

If we take example of the pharmaceutical industry, there is no scope for mistake in manufacturing medicines and drugs; thus, the process demands perfect calibration. In the same manner for other chemical and refined products like petrol, paint, refined crude, and many others, temperature and changes at every node are crucial to the manufacturing of different products. In the lifecycle of petroleum, it is processed both for flying jets and airplanes and also for driving cars. The two fuels, while being sourced from petroleum has very different constituents and is prepared under different temperature and viscosity – thus demanding a very high level and specific calibration method.

Automation in the oil and gas industry presents strict requirements for the reliability of the programmable logic controllers (PLCs) and to their technical specifications. Digital input modules have a Sequence of Events capability built-in by default, to analyze events in the system step-by-step without the impact of the communication lines. Output modules can be configured for the strategies to properly shut down the underlying system(s) in case of complete loss of communication.

Extension with the integrated Supervisory control and data accuracy system (SCADA) brings in redundant servers for operational control, trends, alarms, events, historical data, in-house developed sequential database optimized for time series. Cascade regulation in the systems is available both at the controller level or through centralized control, thus leaving no space for mistakes. The instrumentation and automation applied together help the PLCs being built into SCADA, thus allowing the machines to communicate to each other.

With the focus in the oil & gas industry shifting from exploration to optimizing current operations, Lease Automatic Custody Transfer (LACT) units come forward in increasing efficiency of the oil transfer and providing more accurate accounting, collected at the SCADA level.

The system is an improved-accuracy fiscal metering system for LACT units, able to measure, compute, and store data on oil:

- Volume
- Quality (density, viscosity, humidity)
- Flow
- Pressure and pressure drops
- Temperature

Today there are industrial control system (ICS) for the automation of production processes. The system combines SCADA and PLC in one package with one point of support. ICS is designed for creating control systems of large production facilities with distinct breakup by functional features as well as for building distributed control systems (DCS) with cascade regulation. ICS is a single control tool of production processes that allows for reducing the time of commissioning of control circuits, minimizing operation risks and saving project investments. The entire chain of controls needs high level of calibration and regular maintenance to offer optimum results and a continuous supply chain.

Not only the mainstream processes of hydrocarbons and the chemical industry are looking at calibration service as the critical cog in the wheel; even the smallest details in these industries like maintenance of the balance of the equipment and stock maintenance cannot escape regular calibration to be precise. A few constant calibrations required in hydrocarbons are:

- Computation of oil volume and mass for each measurement line for the entire system
- Automatic measurement of process parameters
- Automatic measurement of oil quality parameters
- Display, indicate, logging, and archiving of measurement results
- On-site use of calibration devices to control and check flow meter metrological parameters without interfering with the technological processes
- Providing personnel with a user-friendly interface for equipment access and operation

Calibration Services and Quality

As digitization intervened and intertwined with the calibration process with the machine tools communicating with each other, there are results and innovations around the processes that give the operator an upper hand in controlling the maintenance process through the main workstation functions. Building on smart technologies, today the mainframe can dictate and detect:

- Access control, authentication, and authorization of clients logging into the system
- Visualization of the technological process and the overall equipment status via flowcharts and light and sound event alarms
- Fast-tracking of emergency and pre-emergency events (audio and video data)
- Review of event logs
- Manual input of current oil parameter values based on sample-taking
- Creation of reporting documentation (operational, daily, hourly, and shift reports, measurement logs, oil acceptance acts, and oil quality passports)
- Report archiving
- Logging into the system with the ability to modify the maximum permissible values, as indicated in the system design
- Generation of control commands and indication of calibration process status
- Gathering of diagnostic data on the system hardware status and basic and application software status

However, this greater access brings heightened responsibility with choice of quality calibration instrumentations. The lucrative market of calibration and growing awareness is increasing the demand for these machine tools – IoT-enabled equipment, comprising sensors and actuators that can generate analytical insights into the equipment working conditions, which are shared with other machines and connected network and conclude to help in efficient operations -however, all products available in the market does not follow the standards, leaving a whole lot of possible threats to the system. As hydrocarbons and chemicals are flammable and overtly sensitive to heat, it is a bigger issue of quality calibration for these industries. Considering the impact of calibration, it is pertinent to accept that the Quality and Sensitivity of machine tools are important differentiators for the products in every segment.

Calibration is also a quality management activity that helps ensure all products and services are evaluated under the same value and precision. Quality assurance calibration reduces risk — the risk of poor customer service, the risk inconsistency, and the risk of wasted time. Calibration helps correct and steer processes through effective measurement seamlessly and tirelessly.

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Optimized results from investment in Quality Calibration will need a few steps in internal awareness creation, training, and following a strict schedule of maintenance activities:

1. **Identify and Categorize:** Businesses should list all their equipment and measurement devices. Further, they can be categorized as critical and non-critical based on their calibration range and tolerance limit. Also, the current calibration status should be identified for all the listed equipment.
2. **Train the Staff:** The dedicated calibration team must be prepared. They must be trained on how to use the tools and perform the calibration tasks accordingly.
3. **Fix Calibration Schedules to avoid missing on process check:** Calibrations are usually performed as follows:
   - During and after a large-scale measuring project
   - After the equipment stops functioning well
   - As necessary for the job at hand
   - As regularly as possible, monthly, quarterly, bi-annually, or annually

One must decide on the calibration schedules for different equipment, based on their criticality in the functions.

4. **Execute Calibration Activities:** The calibration staff is then responsible for performing the calibrations and ensuring all safety procedures are followed.
5. **Document the Calibration Records:** It is important to record and document the calibration process and process results regularly. Maintaining a calibration record is necessary to accurately track activities.
6. **Analyze the Calibration Records:** Equipment managers will then analyze the data collected from the documented calibration results to determine whether any corrective measures need to be taken.

Impact of Digitisation and Going Ahead

The innovations across process plants can be categorized under three main components:

- Artificial intelligence (AI) and its sub-sectors machine learning (ML) and deep learning
- Industrial Internet of Things (IIoT)
- 5G networks, cloud computing connectivity, and edge computing systems.

The technology disruptors are slated to impact the foundation of the process plants in a manner that was unseen or even unexpected. According to Gartner research global oil and gas markets are poised between two competing drivers – rising pressure to decarbonize energy provision and increasing demand for energy in developing economies, thus pressurizing businesses to find innovative ways to maintain competitiveness and growth. The unique stresses of 2020 have elevated three business imperatives for 2021 – optimizing business performance, creating new capabilities and strengthening technology foundations.

AI and its variations (ML, DL) today are applied to use cases like inventory management, demand forecasting, supply chain visibility, transportation cost reduction, process efficiency, product development, predictive maintenance, and more.

IIoT devices connect the entire plant, making it possible to streamline operations, increase safety, and reduce costs. Machine-to-machine (M2M) communications, which enable the smart factories of the future, is only possible through IIoT sensors.

5G, cloud, and edge computing systems speed up data sharing and reduce lag and latency while making connections more secure.

Industry 4.0 technologies that are enabling innovation in process plants today are hinged around precision for which calibration services are paramount. Thus, future challenges of green productivity and smart production processes will need better quality calibration management services. As firms imbibe immersive technologies like Digital Twins, Augmented Reality, Robotics and real-time predictive analysis; seamless process quality control through predictive calibration will become the underlying gamechanger.