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YOKOGAWA

Field Instrumentation Selection and Total Cost of Ownership

WHITE PAPER

Table of Contents

KEY TAKEAWAYS

- ✓ Understand the importance of total cost of ownership when selecting field instrumentation.
- ✓ Understand the two main components that drive plant costs.
- ✓ Study the basic principles that inform and guide the selection of field instrumentation.

Part 1 Introduction

> *...ongoing maintenance... can be a significant and often unaccounted cost of operation.*

Within a plant, field instrumentation and actuators are the sensors of the process and the point at which the process automation system detects, measures, and responds to process conditions, including pressure, temperature, flow, and level. Process manufacturing plants of any size and complexity typically need thousands of field instruments, valves, actuators, and other devices. While critical to plant operations, field instrumentation is often purchased ad-hoc and based on the lowest initial cost. This paper describes the importance of considering the total cost of ownership across their lifecycle, from initial purchase through their useful life.

Two components of plant costs have been identified and will be discussed in-depth in this paper:

Capital Expenditures (CAPEX)

Any investments associated with the design, procurement, and construction of a major asset are referred to as CAPEX. These costs are taken into account in the very early phases of a project, and are often handled by an Engineering, Procurement, and Construction (EPC) contractor or by an in-house staff of engineers.

Operating Expenditures (OPEX)

Once a plant is operational, the ongoing costs associated with running the plant, including operating labor, maintenance, and engineering are referred to as OPEX.

All equipment utilized at a plant, including instruments, valves, and a Distributed Control System (DCS), require ongoing maintenance, which can be a significant and often unaccounted cost of operation. Having a clear record of the types of maintenance costs associated with each piece of equipment is essential.

Many buyers select instrumentation based on initial purchase price only, which often leads to higher total cost of ownership than instrumentation that cost more initially. Inferior products can lead to more maintenance work orders as a result of drifting or failing instruments, even to the point of negatively impacting process quality or availability. A tremendous amount of engineering effort is invested in selecting the right control system architecture; in contrast, the decision to purchase a single instrument or instrument package is frequently undertaken with far less rigor.

Figure 1 - Sources of cost across the lifecycle of a typical field instrument.

Total cost of ownership should be considered in any capital investment, and field instrumentation is no exception. While total lifecycle costs typically include the cost of the initial purchase and the maintenance over the estimated useful life of the instrument, instrument engineers should also take into account stability and accuracy. Instrumentation that offers greater stability and accuracy is likely to require less maintenance and improve process quality. ***Figure 1*** depicts the sources of cost over the lifecycle of a typical instrument, which can be used as a guide when selecting field instruments.

Plant maintenance is a massive business. Worldwide costs for process instrumentation and controls alone are estimated at $23 billion, while costs strictly for plant maintenance are three times that amount at $69 billion annually[1]. In light of these figures, the selection of both a supplier and product can have a considerable impact on a plant's CAPEX. Accurate comparisons between instrumentation and suppliers should take into account the full range of costs, from implementation to the point at which the instrument is decommissioned.

1. *"TDC - Real Examples of Downtime Cost," Business Industrial Network, February 8, 2019, Accessed on May 8, 2019, www.downtimecentral.com/examples.shtml*

Part 2 Quantifying Savings Potential

A simplified example of cost savings potential helps clarify concepts to be discussed in this paper. The table in Figure 2 lists the drivers affecting both CAPEX and OPEX. A straightforward business case example based on 500 pressure transmitters shows a scenario of CAPEX costs and OPEX costs when compared to traditional pressure transmitters that are less reliable and require higher maintenance over their useful life. While CAPEX costs are nearly equal, there is a substantial savings in OPEX costs.

Figure 2 – CAPEX and OPEX savings for a refinery project with 500 pressure transmitter devices at an average unit price of $1,000 for Yokogawa devices and $800 for Traditional devices. Initial CAPEX costs are slightly higher for Yokogawa due to higher initial price but Yokogawa capabilities provide increased value for nearly the same price as Traditional. Due to improved quality and performance of Yokogawa over Traditional devices, OPEX savings are $550,000 over a 15-year life.

Savings for Hypothetical Refinery Project with 500 Pressure Transmitters in Instrumentation Package: Yokogawa Pressure Transmitters vs. Traditional Pressure Transmitters[1]

CAPEX Drivers		OPEX Drivers	
• Inventory Costs • Application Complexity • Corrosive Environments		• Ongoing Maintenance & Calibration • Unplanned Downtime • Proof-Testing • Replacement Costs	
Yokogawa CAPEX Costs	$1,187,500	**Yokogawa OPEX Costs**	$250,000
Traditional CAPEX Costs	$1,183,750	**Traditional OPEX Costs**	$800,000
CAPEX Savings	**($3,750)**	**OPEX Savings**	**$550,000**
Assumptions: Assumes average unit price of $1000 per device for Yokogawa and $800 per device for Traditional. Assumes $1500 per device for installation. Accounts for Yokogawa pressure transmitter capabilities that significantly impact total installed cost in the areas noted above, based on a typical refinery's application requirements.		**Assumptions:** 15-year transmitter life. Assumes longer time between calibrations, fewer chances of unplanned downtime, extended proof test intervals and reduced replacement costs for Yokogawa pressure transmitter.	

[1] A traditional pressure transmitter is defined as a lower quality, less reliable and poorer performing device.

As evidenced by the table above, initial purchase price is not the only factor when determining long-term costs associated with instrumentation purchases. From CAPEX to OPEX, this paper will highlight and explore each of these cost drivers and other considerations in more detail to better discern a more accurate total cost of ownership for field instrumentation investments.

Part 3 Capital Expenditure (CAPEX) Considerations

3.1 INSTRUMENT SELECTION

Consider the overall business impact of poor or even mediocre quality instrumentation, which may appear to be cheaper at the outset, compared to instrumentation that offers greater stability and has superior performance under all process conditions.

The following three basic principles inform and guide the selection of field instrumentation:

Accuracy

High accuracy allows control loops to be run at the desired setpoint, regardless of process conditions. This produces greater quality and consistency of the product stream with less waste or scrap.

Reliability

High reliability means reduced cost of maintenance and fewer work orders, thereby reducing spare parts inventory.

Stability

High stability equates to increased time between calibrations, or allows calibration to be done during scheduled plant turnarounds.

If there is prior experience with the same class or type of instrumentation, lifecycle cost can be estimated and compared on a statistical basis using the following inputs to a financial model:

- Initial cost of the instrument
- Mean Time Between Failures (MTBF)
- Estimated useful life of the instrument
- Manufacturer's recommended maintenance cycle

3.2 APPLICATION EXPERTISE

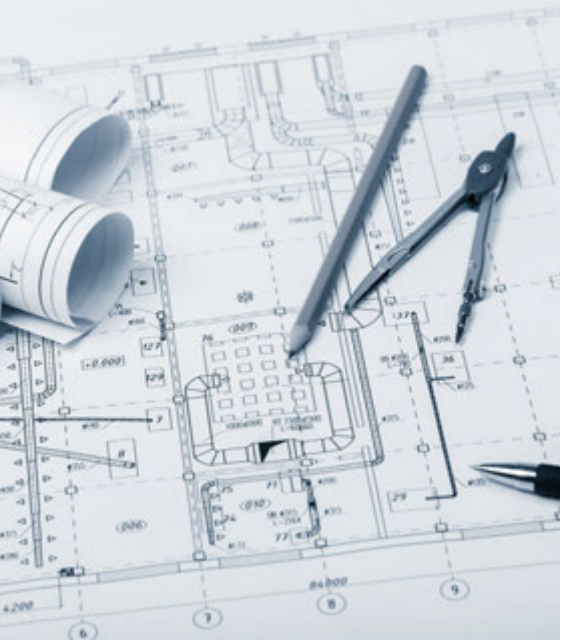
Demographic Changes

As baby boomers retire in the coming years, plants will struggle to find qualified, experienced workers to take their place. According to Pew Research, Generation X contributes nearly 53 million workers to the U.S. economy overall. This demographic shift will leave a deficit of approximately 10 million workers to replace the baby boomers who will retire. This same gap will be seen in process facilities, resulting in a need for new engineers and technicians who may lack experience and need support when performing such functions as selecting instrumentation for the plant or determining the best solutions for pressure, temperature, flow, or level applications. These changing demographics of the workplace underscore the importance and long-term impact of selecting the right field instrumentation at the outset.

> *...changing demographics of the workplace underscore the importance and long-term impact of selecting the right field instrumentation at the outset.*

Recommendations

This issue can largely be remedied through the use of instrument consultants who work for suppliers, as well as their salespersons or technical specialists. Also, software tools provided by the supplier can help identify optimal solutions for specific applications. At Yokogawa, for example, specialists can be involved in all phases of the process, including during Front End Engineering & Design (FEED), offering detailed site surveys, risk assessments, and performance consultations. This wealth of experiential and procedural knowledge can be an asset when determining correct field instrumentation for specific applications.



Project Documentation

Project costs rise significantly when engineering drawings, such as a piping and instrumentation diagrams (P&IDs), need to be created to facilitate the layout of a plant for greenfield projects, and to ensure proper space requirements are met for instrumentation.

Recommendations

When considering engineering documentation, identifying an instrument supplier that can support 3D drawing requirements through the use of software can help keep this and related costs down. Automatic rendering tools can provide additional information about a supplier's products, including 2D and 3D drawings/CAD models. Partnering with a supplier that has these critical capabilities can mitigate any application knowledge deficit that may exist at the outset of a project.

3.3 INVENTORY COSTS

Process Control vs. Safety Applications

Traditionally, different transmitters are used for process control versus safety applications, which may require plants to carry separate instruments. Additionally, having too many different ranges of devices to cover all applications of a plant is costly and may lead to more error.

> *Traditionally, different transmitters are used for process control versus safety applications, which may require plants to carry separate instruments.*

Recommendations

With some manufacturers, the same transmitter can be used for both process control and safety applications. This allows the plant to significantly reduce the number of transmitters carried in spares inventory for facilities with safety applications. Transmitters that come with safety capabilities as standard means no additional cost for these measures and improved reliability. Moreover, instrumentation that has a more condensed number of ranges should be sought. If one transmitter range can cover multiple applications without sacrificing performance, this will significantly reduce both the number of additional devices that need to be kept in inventory, as well as maintenance costs. All Yokogawa pressure transmitters are certified for single transmitter use in SIL 2 safety applications and dual transmitter use in SIL 3 safety applications.

Multiple Suppliers

Many plants suffer from having too many suppliers for their instrumentation or several generations of product from a particular supplier. This can lead to higher costs due to a multitude of factors, including a greater number of spares needed to be kept in stock and more training required to ensure proper procedures are followed for each device type.

Recommendations

When possible, utilizing a single supplier for instrumentation allows for standardization of device design, procurement, installation, and commissioning. This streamlined approach avoids much of the logistical complexity and costs associated with both inventory and training when implementing and maintaining instrumentation from multiple suppliers.

3.4 APPLICATION COMPLEXITY

Excess Instruments

DP Level applications typically require two instruments in closed tank applications: one to measure tank level, and one to measure blanket pressure. This essentially doubles the cost for the device's mechanical/electrical hardware, I/O point, engineering, procurement, and installation.

Recommendations

There are instruments available that can perform multiple measurements in a single device while withstanding a wide range of rigorous process conditions. Such instrumentation should be considered when selecting new or replacement instrumentation since its robustness can reduce the total cost of ownership. Additionally, instruments that make multiple measurements eliminate process penetrations, and result in a reduction in potential leak points.

The multi-sensing feature of the DPharp sensor measures both static and differential pressure in one device. This eliminates the need for two transmitters to measure these process variables, saving the cost of a gauge pressure transmitter and the manifold, piping, wiring, I/O, construction, and associated engineering hours. The DPharp sensor also decreases the number of devices that have to be managed, maintained, and calibrated, which ultimately reduces overall lifecycle costs.

3.5 CORROSIVE ENVIRONMENTS

Material Quality

Most pressure transmitters on the market today use standard 316-grade stainless steel by default. While often sufficient, there may be many applications within a facility that require materials above this standard. This inevitably requires the special order of materials at an additional cost, driving up the initial purchase price. When situations necessitate installation in salt water environments, as exist in offshore facilities, high wash-down areas, or in the dairy, food, and beverage industries, 316 SST housings will often be required. These housings can add significant cost to the instrumentation package.

> *At the beginning of a project, consider suppliers with more robust materials of construction that cover a broader range of applications as standard.*

Recommendations

At the beginning of a project, consider suppliers with more robust materials of construction that cover a broader range of applications as standard. This can help mitigate any potentially unforeseen CAPEX elements. Also, alternatives to the 316 grade SS standard, including corrosion-resistant aluminum housings or other materials, will perform well under certain extreme conditions, and can potentially lower costs.

3.6 PRE-ASSEMBLED SOLUTIONS

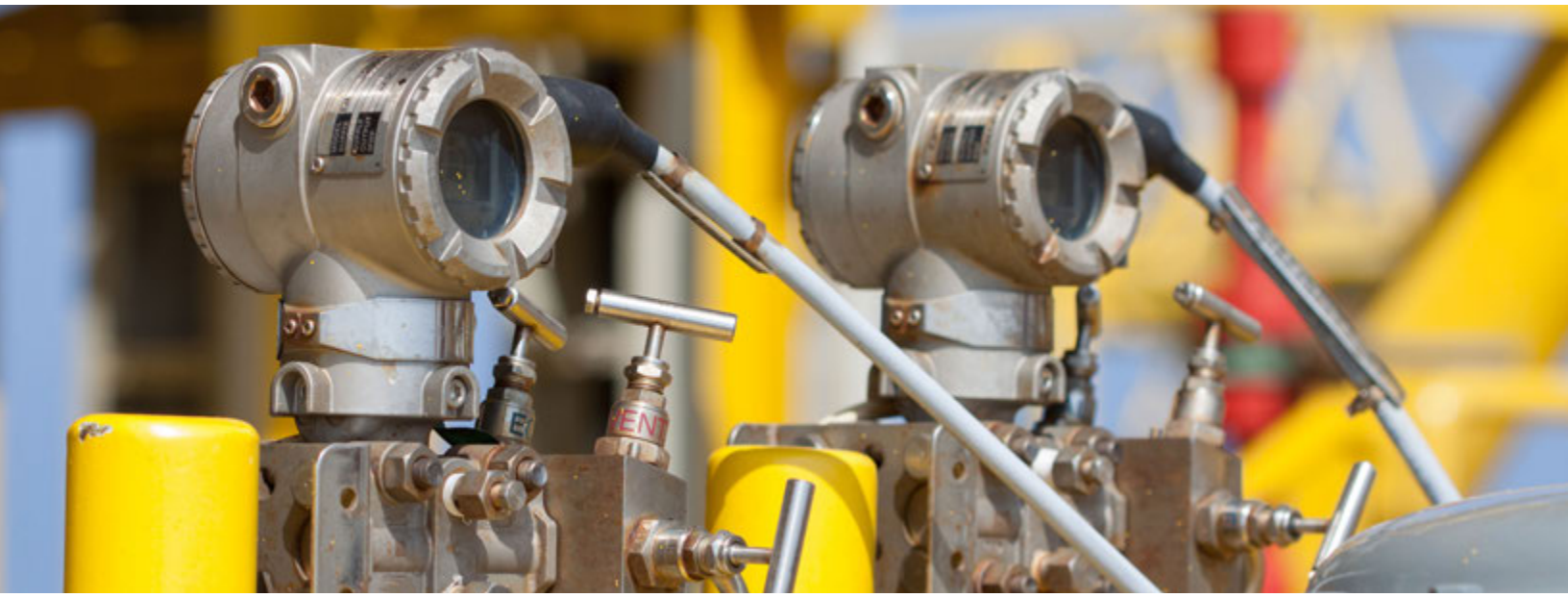
Site Integration

When assembling instruments on-site, individual parts often ship from different suppliers, leading to delays and difficulties in the process. Examples of such instruments include manifolds for pressure transmitters or differential pressure transmitters for primary elements. There is often other hardware needed such as pipe runs, heat tracing, impulse piping, pipe stands, mounting brackets, and other auxiliary equipment. These components require specific professionals to assist in the installation process, such as electricians, welders, pipe fitters, and other technical experts, and this can quickly drive up initial costs.

> *...it is more cost effective to find a supplier that can provide pre-configured or pre-assembled solutions that arrive on site ready to install with little or no additional hardware.*

Recommendations

With these added expenses in mind, it is more cost effective to find a supplier that can provide pre-configured or pre-assembled solutions that arrive on site ready to install with little or no additional hardware. Yokogawa's VERIS Accelabar, which can be furnished as a ready-to-install flow meter system, arrives complete with the primary element, configured transmitter, and RTD, along with other secondary instrumentation. The Accelabar is capable of measuring gases, liquids, and steam at previously unattainable flow rate turndowns and tested up to 65:1 with no straight pipe run requirements.



Part 4 Operating Expenditure (OPEX) Considerations

4.1 ONGOING MAINTENANCE AND CALIBRATION

Overpressure

Inferior instrumentation or instrumentation that is not well-suited for its specific applications will need ongoing maintenance and may have an adverse effect on the overall process. For instance, overpressure for pressure transmitters can occur during improper manifold sequencing, startup or shutdown conditions, or process upsets. Many sensor technologies cannot handle overpressure conditions and, as a result, users often see a shift in the output of the device, forcing the instrument to be re-zeroed or recalibrated.

> *Ultimately, inferior transmitters can mean a higher number of work orders to re-zero or recalibrate devices.*

An objective for safe and efficient boiler operation is to maintain a constant level in the boiler drum, as seen in ***Figure 3***. This can be accomplished by maintaining a balance between the amount of steam leaving and water entering the boiler drum. Boiler drum level is one of the most challenging power plant pressure transmitter applications due to high static pressures and low-level differential pressure. A change in static pressure can cause significant output shifts in level transmitters. Static pressure changes occur when a boiler is starting up or shutting down, at which time accurate level measurement is most critical. There is also a chance of over-pressuring the level device during boiler blow down. In this type of application and many others, devices can drift to the point where they no longer make accurate measurements for the process loop in which they were installed, resulting in a potential safety risk, off-grade product quality or lower yields.

Ultimately, inferior transmitters can mean a higher number of work orders to re-zero or recalibrate devices. Considering the number of pressure transmitters throughout any given plant, costs can grow exponentially.

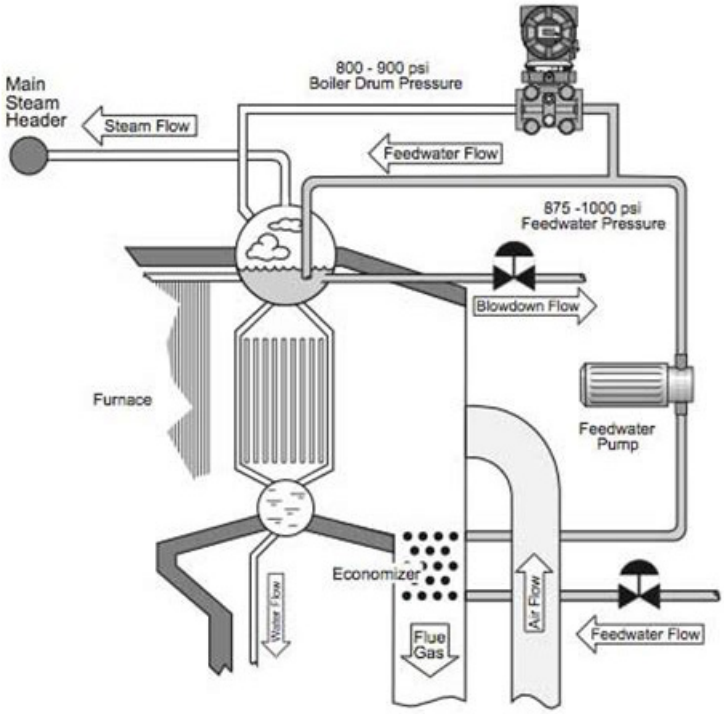


Figure 3 – Example feedwater flow control using a Yokogawa DPharp pressure transmitter that measures differential pressures up to 2,000 PSID with an accuracy of ± 0.075% of span. Boiler drum level measurement is an excellent application for the DPharp transmitter since it has superior static pressure performance and the ability to maintain transmitter calibration after overpressure effects that can occur during boiler blow down.

Recommendations

Yokogawa's DPharp digital sensor measures the differential pressure (DP), static pressure (SP), and sensor temperature in a single device. Given these three pieces of process data, the differential pressure transmitter can compensate the DP measurement for temperature effect and static pressure effect in real time. In addition, a protective system within the transmitter provides overpressure protection by equalizing the excessive pressure before it reaches the sensor. Once stable process conditions return, these features enable the transmitter to return to normal operation within published specifications.

In the case of DPharp technology, calibrations can be extended by many years depending on the accuracy required for the application, resulting in significant calibration cost savings in the long term. In the example below, the Yokogawa EJX_A and EJA_E Differential Pressure Transmitters are compared to multiple suppliers on the market today. The graph shown in ***Figure 4*** represents a transmitter calibrated 0-100 in H2O in an application that has ambient temperature changes of up to 50 deg F, and static line pressure changes of up to 500 psi. The time between calibrations assumes the user wants to maintain a ± 0.5% of span accuracy for the application. In this example, the user would need to calibrate Supplier E's device every two years, compared to the Yokogawa EJX_A which would only need to be calibrated once every 14 years.

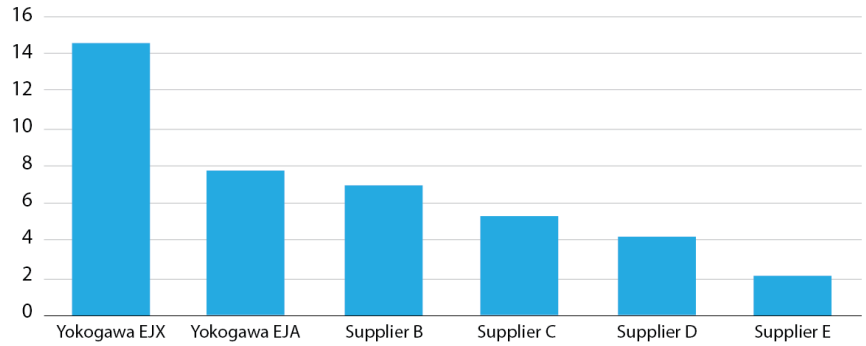


Figure 4 – Calibration interval in years for Yokogawa DPharp pressure transmitters to maintain .5% accuracy compared with other vendors.

Coriolis flow meters have design features that ensure more repeatable measurements will result in reliable performance, lower errors and extended calibration intervals, thus reducing maintenance costs. One such flow meter is the ROTAMASS Total Insight (TI) Coriolis Flow Meter with its box-in-box design, which isolates the measuring tubes from the pipe and process influences to maintain a stable and accurate reading with no zero drift.

Another feature of Yokogawa's ROTAMASS TI Coriolis is its Total Insight patented health check that can be performed while the device is in operation, without disturbing running measurements. Influences on the meter are diagnosed at an early stage so any necessary re-calibrations can be planned more efficiently, reducing costs while eliminating the potential for downtime. When it's time to perform a verification, a tube health check can be run to verify the health of the tubes and a report is generated within 90 seconds using Yokogawa's FieldMate calibration software. These types of preconfigured methods for device verification/calibration can help streamline support and reduce maintenance costs.

Tank Overflows

One example of costly downtime involves level measurement on tanks. While DP Liquid Level is the most well-understood level technology, it does have certain disadvantages. With a closed tank located outdoors, the transmitter and capillary system is subject to temperature swings day-to-night, season-to-season, or even shaded-to-sunny. This change in temperature affects the fill fluid just like any liquid. The fluid contracts and expands within the capillary causing inaccuracy in the reading; likewise, the density of the fill fluid changes, resulting in a change in head pressure. The resulting change in the reading reflects a change in the capillary fill fluid instead of an actual change in level. There is also the potential for process temperature changes to impact the tank level reading. Incorrect level measurement due to changes in ambient or process temperature can cause the tank to overflow, leading to lost product, unplanned downtime, safety hazards, environmental problems, burned-out pumps, or errors in inventory control.

Recommendations

For challenging DP Level applications regarding tank overflow, Yokogawa has developed both a Single Compensating Capillary system, as well as a Dual Compensating Capillary system. These unique solutions compensate for changes in ambient and process temperature to provide the most accurate DP level measurement available, preventing costly tank overflows.

4.2 UNPLANNED DOWNTIME

Reliability

Downtime at a plant for any reason is expensive. Routine maintenance and turnarounds can result in missed production, and unplanned shutdowns can potentially cost a plant millions of dollars and add unnecessary stress to staff and equipment. These unplanned shutdowns can be a result of low-quality instrumentation that is performing poorly or in a failure mode that is undetected by the instrument's onboard diagnostic system. The average hour of downtime at a plant costs roughly $12,500, but can be substantially higher at a continuous process plant[2].

Recommendations

During project evaluation, ensure a full understanding of the diagnostic capabilities of the transmitters or instruments to be used, as many devices lack the intelligence to self-diagnose. Certain technologies, such as the DPharp sensor technology mentioned earlier, are active technologies. This means that transmitters based on DPharp sensor technology can self-diagnose when the sensor has failed, providing information that could help prevent an unplanned shutdown and loss of productivity.

Advanced diagnostics are available that provide insight to predict or prevent failures before they happen. Impulse line blocking diagnostics can warn of impending blockage in high side, low side, or both impulse lines. Additionally, heat tracing diagnostics increase reliability by warning immediately of abnormal temperature variations at the transmitter. With this type of advanced diagnostics built in, costly unplanned shutdowns or downtime is reduced.

2. *Larry O'Brien, "Delayed Maintenance Turnarounds a Major Source of Unplanned Downtime," ARC Advisory Group, April 27, 2017, www.arcweb.com/blog/delayed-maintenance-turnarounds-major-source-unplanned-downtime.*

4.3 PROOF-TESTING

Safety Instrumented Systems (SIS) monitor values within any preset parameters produced by the instrumentation of a plant, ensuring they stay within operational and safety limits. If values being generated have fallen outside of this safe range, alarms are promptly triggered. This system allows workers to take steps necessary immediately to rectify an issue or place the plant in shutdown mode, if necessary.

Annual Testing

To ensure that a device is not in an undetected failure condition, testing must be conducted on transmitters installed in safety instrumented system loops. These tests typically need to be administered at least once per year to uncover any undetected dangerous conditions, as well as bring the overall safety number for the loop to within a required range.

> *...tests typically need to be administered at least once per year to uncover any undetected dangerous conditions.*

Recommendations

During an evaluation, it is helpful to have an understanding of the capabilities of the transmitters or instruments for safety applications. As mentioned in previous sections of this paper, many devices available today lack the technology to self-diagnose. Transmitters based on DPharp sensor technology can self-diagnose when the sensor has failed, ultimately eliminating one potential undetected failure. This capability also allows proof test intervals to be extended and scheduled during plant turnarounds, thereby lowering operational costs.

4.4 REPLACEMENT COSTS

Failure Rates

When inferior instrumentation is used, the likelihood of failure increases. Statistically, given the number of instruments in a process plant, this means that a certain amount of devices will fail, even early on, due to the ambient or process conditions to which they are exposed. There is also the possibility of failure due to misapplication. Incompatibility between materials and process or environmental conditions is one of the leading causes of instrument failure, followed closely by improper installation. These failures can lead to unscheduled downtime in a facility and ultimately be realized in unforeseen plant expenditures.

> *Incompatibility between materials and process or environmental conditions is one of the leading causes of instrument failure, followed closely by improper installation.*

Recommendations

With these risks in mind, it is advisable to avoid purchases based solely on an initial purchase price. There are many hidden costs associated with instrumentation that, when identified, become cost savings opportunities. For instance, compatibility between the material that is in contact with the process and chemicals that make up the process should be checked before specifying or procuring any instrumentation. If not, efficiency and productivity will suffer and potentially require greater maintenance or repair. Several helpful online reference guides are available, and most chemical manufacturers publish this data. The following are just a few:

- https://www.coleparmer.com/chemical-resistance
- http://www.davis.com/Chemical-Resistance

4.5 SUPPLIER LONGEVITY AND GLOBAL REACH

Supplier Stability

Suppliers can exit a market at any time or intentionally obsolete a product they will no longer support. In addition, a supplier may not have the global support infrastructure necessary to provide a consistent level of product quality no matter where a facility is located.

Recommendations

Due to these uncertainties, it is vital to ensure the selected instrumentation supplier has a long-standing history in industrial automation, a robust development roadmap, and a comprehensive global presence. Equally important is to identify those suppliers that develop new products that are backward compatible with prior models. If not, costs can quickly rise in efforts to ensure compatibility with a pre-existing system, or a complete and costly revamp of a system may be necessary.

4.6 SUPPLIER SCORECARD

Supplier Performance After Installation

Throughout this paper, CAPEX and OPEX cost drivers have been explored and recommendations have been made on how total cost of ownership for instrumentation can be managed and optimized. As previously stated, initial purchase price is a strong driver when selecting an instrumentation supplier for any greenfield project, while business drivers like CAPEX and OPEX are not often considered. However, there is still a process that is followed to evaluate suppliers from a commercial standpoint before selection. This may include the financial stability of the organization, length of time in business, and reputation of the organization. In addition, a technical evaluation of the proposal will be conducted by the technical buyer to ensure that all application requirements have been met. From there, a supplier will be selected and while it typically comes down to overall purchase price, there can be other factors that weigh in as well.

After this stage is complete and instrumentation is installed, there are other key issues to consider. These can include managing the ongoing costs of the instrumentation chosen, supplier management, and the development of Key Performance Indicators (KPIs) to evaluate the performance of incumbent suppliers. Many companies do not effectively manage their ongoing instrumentation costs or their instrumentation suppliers.

Recommendations

Many plants today have deployed Computerized Maintenance Management Systems (CMMS) for dispatching maintenance staff to various jobs required to properly maintain all of the plant equipment, and manage work orders across their facility. This same system can be used to improve reliability across the facility by creating and automating a tracking system which can help identify inefficiencies within the facility to manage costs better.

> *Computerized Maintenance Management Systems (CMMS)... can help identify inefficiencies within the facility to manage costs better.*

In the case of instrumentation, one could create custom reporting to track observed Mean Time Between Failure (MTBF) by supplier and equipment type. This type of custom tracking can also include the number of times a work order is issued for each supplier and each supplier's equipment type, down to base model or specific model numbers. The work orders could be further broken down to categorize by type of service performed, such as configuration, re-zero, full calibration, or device replacement. This data can then be compiled by the plant to aid in the development of a supplier scorecard. Such information will be helpful when negotiating future contracts and provide real data for discussions on improving overall total lifecycle costs. It can also help to identify poorly performing instruments in a facility so that these can be addressed and eliminated.

> *There are ways to automate these methodologies through the use of Asset Performance Management (APM) solutions.*

There are ways to automate these methodologies through the use of Asset Performance Management (APM) solutions with lifecycle cost analysis functionality, which can incorporate maintenance cost data and calculate observed MTBF through the CMMS (if not part of APM).

Figure 5 is an example of a KPI-based supplier scorecard. This provides a starting point for identifying clear KPIs and the basis for supplier-to-supplier comparison. The concepts provided throughout this paper could also be added to a table similar to the one below to create a custom supplier scorecard for any specific category of instrumentation.

Key Performance Indicators (KPI's)	Instrument Vendor A - Top Tier	Instrument Vendor B - Top Tier	Instrument Vendor C - Low Cost
Observed MTBF	15+ years	11 years	7 years
10-year replacement cost	$0	$0	$3,500
10-year maintenance cost (labor[1])	$250	$750	$1,500
10-year maintenance cost (parts[2])	$0	$0	$400
Plant downtime costs attributed to instrument	$0	$1,000	$5,000

1. *Calibration, replacement of failed instrument, etc.*
2. *Separate from cost of replacing entire unit.*

Figure 5 – Example of KPI Table to compare and evaluate instrument suppliers.

4.7 FUTURE-PROOFING

"Future-proofing" involves anticipating future technologies, including field instrumentation, then identifying ways to minimize the impact of these changes on overall plant efficiency and production.

▼ Expect New Technology

Future-proofing a plant and its operations mitigates increased operating costs due to equipment or technology changes that are likely to occur. The Industrial Internet of Things is one trend to watch carefully. The IIoT is a broad network of devices, instrumentation, and people all connected to communicate better, monitor, streamline, and drive innovation based on insights derived from many sources.

Recommendations

As an example, Edge Computing and the IIoT are about moving control physically near or at the process, which requires building greater computational capability into field instruments. Complemented by virtually unlimited storage and scalable, High-Performance Computing (HPC) in the cloud, the current process control hardware and software architectures in both Distributed Control Systems (DCS) and Programmable Logic Controllers (PLCs) could undergo dramatic changes over the next decade. These new technologies have the potential to provide a more cost-effective, peer-to-peer process automation infrastructure with greater capabilities that can leverage AI and Machine Learning in process and manufacturing control. Ensuring that a supplier is aware of the possible future landscape and that they can offer products which better fit these changing needs is crucial when determining which supplier and products to select.

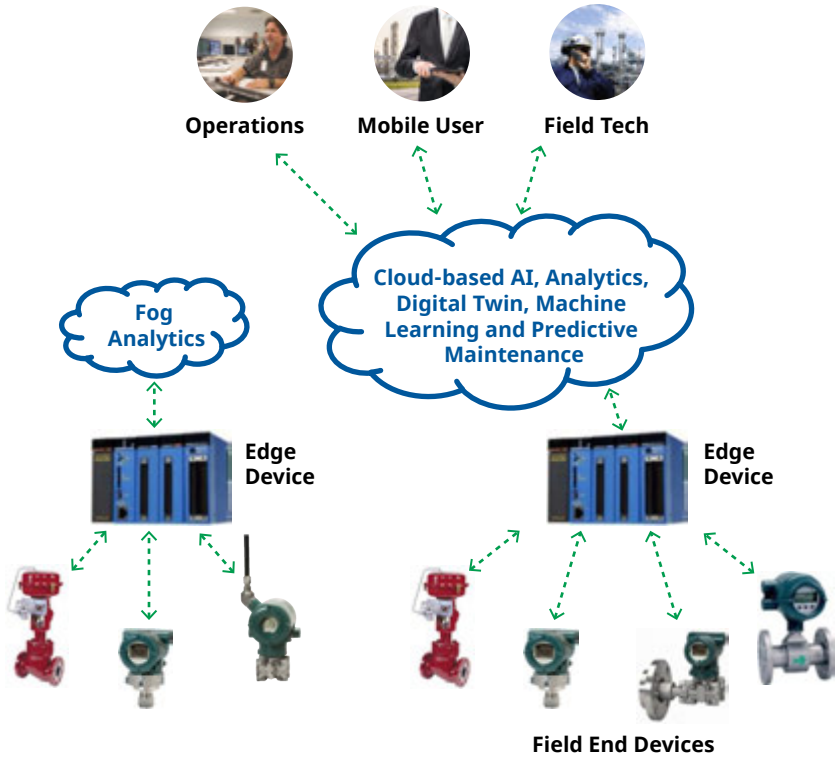


Figure 6 – Edge devices transport information from sensors to the cloud for analytics, predictive maintenance and other "IoT" applications. In case of limited bandwidth, Edge devices can run their own analytics independent of the cloud—this is "fog computing."

Allied to cloud computing is a concept called "fog computing," as illustrated in ***Figure 6*** above, which is a type of hybrid architecture designed to avoid communication congestion by establishing a "fog" distributed computing layer between the cloud and devices in the field. Fog computing eliminates communication delays and fluctuations by locating the processing of specific data near the field devices and sending only essential information to the cloud. This technology is expected to lead to several new IIoT applications, so it is increasingly vital to bear this possibility in mind when choosing a supplier and its ability to future-proof a plant's operations.

Part 5 Conclusion

This paper highlighted some of the key criteria and issues that may arise for selecting instrumentation that measures and transmits pressure, temperature, flow, and level. While the technology to measure these physical parameters continues to improve, having the appropriate instrument for a given application has a profound impact on process performance, capital expenditures, and operating cost. One of the most critical aspects to consider when selecting suppliers and products is the lifecycle cost, as the cost to operate and maintain instruments over time is far higher than the initial purchase price.

Process control architecture is changing, perhaps dramatically, with concepts such as cloud, IIoT, Edge computing, and Fog computing, but all control architectures will require the ability to measure the current state of process conditions. Instrumentation can be expected to take on more computational work in the drive to reduce the cost of control infrastructure and create instrumentation that is self-servicing, increasing safety and decreasing downtime or shutdowns. Keeping this trajectory and the multitude of concerns outlined in this paper in mind, the selection of both product and supplier carries great importance and the potential to ensure CAPEX and, in the longer term, OPEX are predictable and manageable.

> *"One of the most critical aspects to consider when selecting suppliers and products is the total cost of ownership.*

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