How to guide GD/ANAINST/001-EN

How to check whether your installed instrumentation is in need of a health check

Advice and guidance for keeping instrumentation in good working order

Measurement made easy

Introduction

It is easy to take the efficiency of your installed instrumentation for granted. After all, if it's measuring, it must obviously be working. Yet the reality is that this assumption could actually be losing you money. Not only could you be losing potential revenue through impaired or lost production, but the cost of rectifying an instrument problem could often end up costing you more than if you had simply serviced the device throughout its lifetime. Moreover, an impaired measurement could also affect your ability to comply with environmental and safety legislation, exposing your organisation and its representatives to legal action and potentially ruinous financial penalties.

Every reputable instrument manufacturer will provide guidance on the ideal operating conditions for their products, including advice on how, why and when they should be maintained.

In the real world, however, this guidance can often be overlooked. Constraints on costs, limited in-house technical resources, a lack of technical expertise or installations being located in hard to reach areas are just some of the common factors that can lead to instruments not being maintained in accordance with a manufacturer's guidelines.

Furthermore, where sites have had multiple owners or frequent changes in maintenance teams, for example, it is not unknown for documents for specific instruments to be lost, or for users to lose track of where devices are installed.

Consequently, it can be difficult to make an accurate appraisal of an instrument's performance or to assess where it currently is in its overall lifecycle.

The importance of maintenance

The importance of accurate and reliable measurement cannot be underestimated. By helping to ensure that the process is operating within the correct parameters, and warning if it is not, instrumentation has a valuable role to play in both process efficiency and safety. A number of high-profile safety failures have their root cause in poorly or incorrectly maintained instrumentation. For the companies involved, there are the very serious consequences not only of stiff financial penalties running into millions, but also serious injury and loss of life.

It is therefore easy to see why performing regular health checks on installed instrumentation should be a priority for any user operating processes where measurement is a key requirement.

How to check whether your installed instrumentation is in need of a health check

How to start

At first glance, it can be difficult to know where and how to start, especially where there may be little or no information available about the installed instruments. The following are some suggested pointers to help you assess whether an instrument may be in need of a health check, which may highlight the need for servicing, upgrading or replacement with a better alternative.

Calibration – are you doing it properly?

Correct calibration of an instrument is vital to ensuring accurate and repeatable measurement performance. Instruments such as pressure and temperature sensors and transmitters and flowmeters will all have been calibrated when they were manufactured to check their performance under a known set of operating conditions.

Although this calibration will be valid when the instrument is first installed, it cannot be assumed that it will remain valid throughout the life of the instrument. Factors such as wear and tear, degraded electronics, sensor plugging, vibration, ambient temperatures and exposure to the elements can all cause the performance of an instrument to stray from its original calibrated values.

Arduous processes in particular will cause instruments to drift, such that a failure to routinely take a device out of service and calibrate it could lead to a measurement error. Drift is also more common on older instruments compared to the new generation of instruments, which feature improved electronics, with self-checking routines built-in, and a more robust mechanical design. Even these devices will still need to be checked, as their electrical components can undergo a change in performance due to small chemical and / or physical changes with time, resulting in unavoidable long term drift.

The calibration of an instrument can also often be compromised as soon as it is installed. In most cases, installers will calibrate a device to the installation using their own devices, effectively over-riding the original factory calibration. The resulting new calibration will only be as good as the devices they are using, to calibrate it against, which may themselves not be properly calibrated.

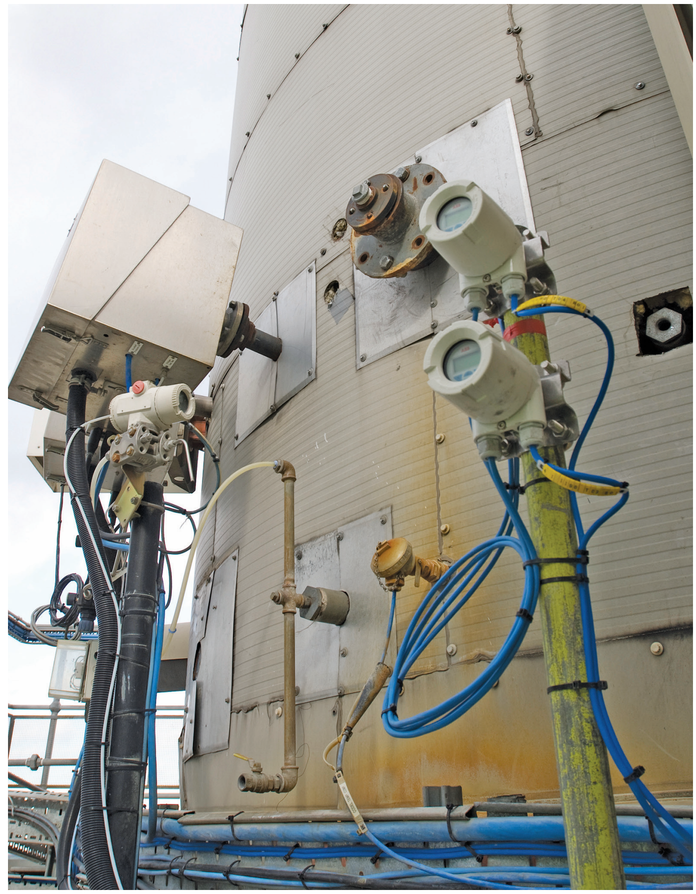

Fig. 1: Prolonged exposure to the elements can affect instrument performance

It is important to be aware that any of these factors could affect a manufacturer's guidelines when it comes to the frequency of calibrating their instruments. Even where a manufacturer recommends a longer period between calibration checks, the characteristics of the installation conditions can impact on the performance of the transmitter and/or primary sensing element. In such applications, more frequent calibrations, or at least inspections, may be necessary.

In the case of pressure transmitters, for example, the frequency of calibration will depend on a combination of three things, namely: the nature of the application it is being used in, the performance the user needs from it and the inherent operating conditions. This involves a five stage process, encompassing the following approach:

1. Determine the performance required for the application – for example, is it a safety critical application requiring high accuracy or a more straightforward application where accuracy is less important?
2. Determine the operating conditions – operating conditions such as static pressure and ambient temperature can have an impact on transmitter performance, resulting in potential errors that need to be factored in
3. Calculate the Total Probable Error (TPE) or Total Performance – this is determined by a formula which is used to calculate the potential difference between the device's quoted base accuracy and the likely effects of static pressure and ambient temperature on measurement performance
4. Determine the stability for a month – calculating the stability on a monthly basis will provide a benchmark for measuring ongoing performance
5. Calculate the calibration frequency – using the results of steps 1 to 4, the calibration frequency can be calculated using the desired performance minus the Total Probable Error divided by the stability per month.

The resulting figure from this calculation can then be used to set the frequency with which the calibration needs to be checked in order to achieve the desired accuracy.

Standards such as section 7.6 of ISO 9001:2015 oblige companies to maintain and calibrate their measurement instruments on a regular basis, the frequency of which should be dictated by the specific requirements and demands of the application. Additional requirements include the need for instruments to be clearly labelled with information including its calibration status and the date when the next calibration is needed, and the need for protection against accidental damage and deliberate interference.

It is also important to ensure that your device was calibrated by a properly qualified testing and calibration laboratory. ISO/IEC 17025 stipulates key management and technical requirements for ensuring that laboratories are operating the correct quality management systems and that any tests and calibrations are performed to the correct levels of accuracy and reliability.

This includes the need to demonstrate their competence supported by evidence of a documented quality management system. Any facility purporting to offer testing and calibration facilities must be able to prove that they are accredited to the standard in order for their results to be considered valid.

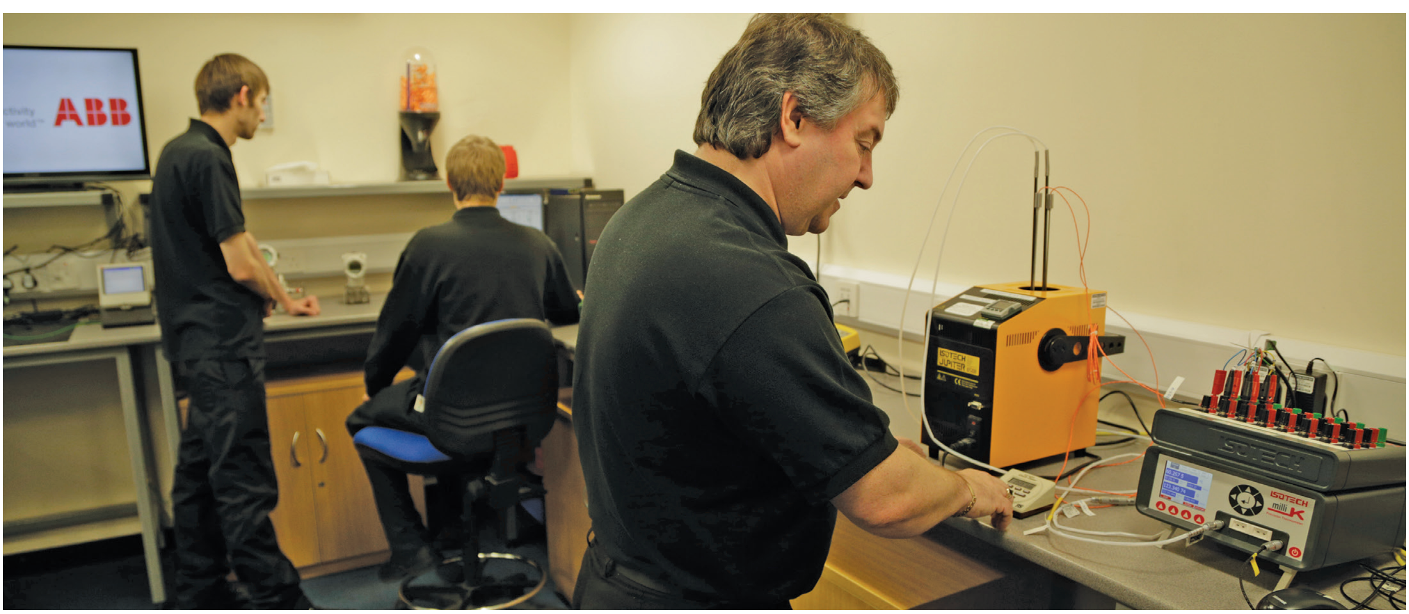

Fig. 2: ABB's temperature, pressure and electrical measurement device calibration laboratory at Stonehouse has been accredited to ISO 17025 by UKAS

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Where multiple instruments are used, for example for redundancy in safety critical processes, it is also advisable to check the calibration of each instrument and recalibrate if necessary, with the frequency of checking being determined by the characteristics and operating requirements of the application. This will avoid measurement discrepancies between each instrument and ensure that each instrument is operating accurately and safely.

Calculating the calibration error of a device can be summarised by the following basic equation:
ERROR = ACTUAL READING - 'TRUE' READING

In this equation, the 'true' reading is the original specified or desired accuracy for the application. The error produced by the equation will provide the basis for the correction of the device to a properly calibrated state.

Depending on the type of instrument and the nature of the production process in which it is being used, it can be desirable to be able to check and adjust its calibration without having to remove it from the line. This not only prevents disruption caused by removing and replacing the instrument, but also helps to avoid the introduction of any external factors that could affect its calibration.

The calibration of many types of instruments can be verified in-situ. ABB's WaterMaster and ProcessMaster flowmeters, for example, feature on-board verification, which checks the performance of the meter sensor and transmitter and compares it to a fingerprinted value taken at the point of original calibration. This makes it possible to see whether the meters are continuing to deliver accurate measurement or whether they need to be recalibrated.

It should be emphasised that in-situ verification is not the same as calibration, and should never be considered as a replacement. If the verification reveals that the calibration of the device being checked has wandered significantly, then it must either be returned to the manufacturer for recalibration or replaced.

Calibration – things to look for:

- Variations in product quality – product quality can be affected if instruments are not providing the correct data needed to help control the process properly
- If two or more instruments are used for the same measuring point, are the readings consistent?
- Unexpected readings – are the readings from the device exceeding the expected measurement parameters?
- Is there anything to show when the device was last calibrated? If there is and the device is out of calibration, it will need to at least be verified and/or recalibrated if necessary. If there is nothing to show when calibration was last performed, then the device should be calibrated in order to ensure it is performing properly
- Has the device been damaged or subjected to a shock or vibration? If so, the calibration could have been affected.

Fig. 3: Being able to access data from process instruments enables users to achieve significant operational and maintenance savings

Are your instruments giving you the data you need?

Another area to look at is whether your installed instruments are delivering the right information. A study by the ARC Advisory Group estimates that global process industry losses due to unscheduled downtime and poor quality are in the order of $20 billion, or five percent of annual production. Of these losses, almost 80 percent are avoidable and 40 percent are attributable to operator error.

ABB's own studies highlight that as many as 35 percent of trips into the field are for routine checks, 28 percent are for non-existent problems, 20 percent are for calibration shifts, six percent are for 'zero off' issues and six percent for plugged lines.

Only four percent are actually for failed instruments. From these figures, it is easy to get an idea of the potential savings that could be achieved by equipping engineers with the knowledge and equipment they need in advance, rather than having to visit one or more devices to diagnose a problem.

Think smarter

One way that this can be achieved is through the use of smart instrumentation.

Developments in communications technologies have helped to unlock new possibilities for gaining quick and easy access to an expanded range of instrument data.

In particular, the latest generation of smart instruments offer a range of capabilities that were not previously possible in conventional 4-20 mA analogue devices.

Foremost amongst these is the ability to obtain a clearer picture of what is happening in a process. The ability to convey a greater range of data from a device at faster speeds over a digital network enables real or near real-time data to be obtained on process conditions, which can then be used to identify areas for possible improvement. When connected to a process visualisation system such as ABB's System 800xA distributed control system, smart instrumentation can provide an immediate overview of conditions, making it easier to make informed decisions about areas for greater efficiency.

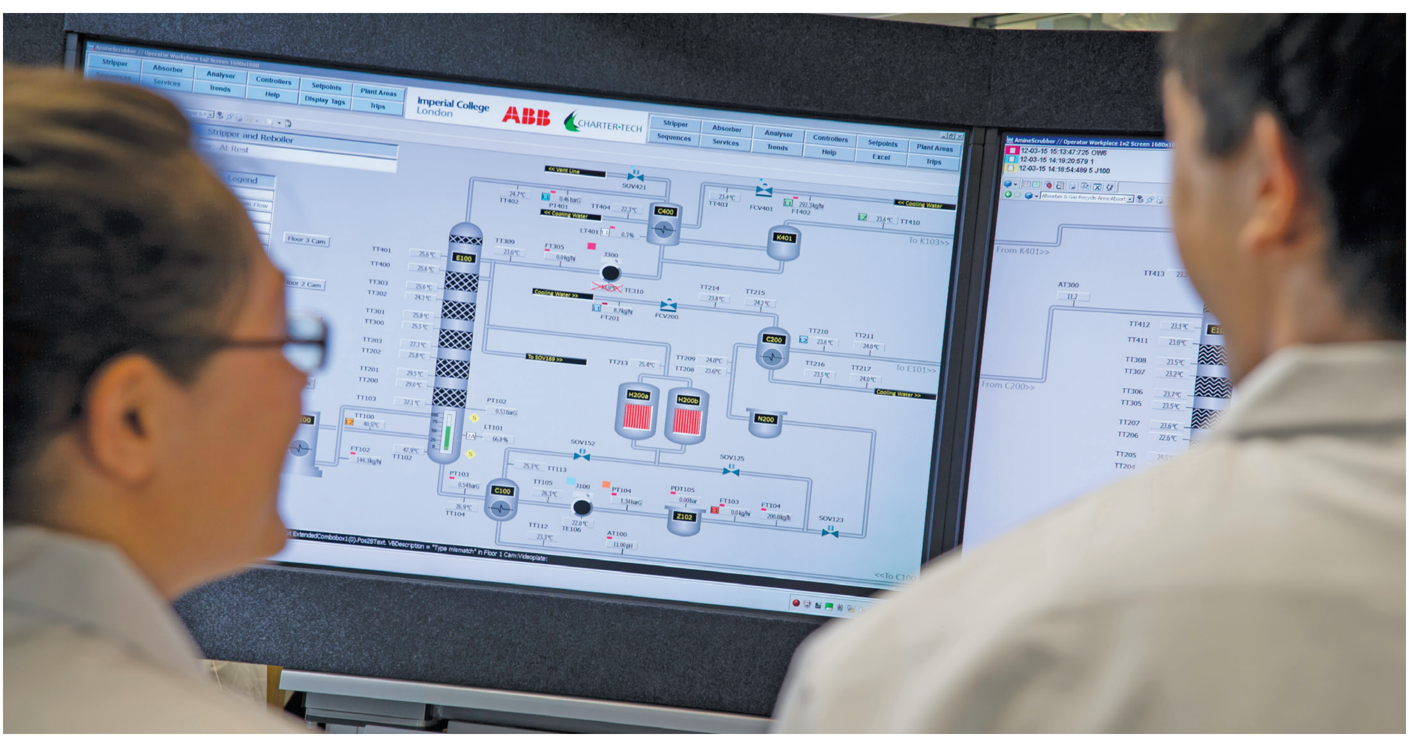

Fig. 4: Smart instruments, together with process visualisation systems such as ABB's System 800xA, can help plant operators gain a deeper understanding of their process

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Exactly how much added value can be derived through intelligence and improved efficiency depends on the characteristics of the application and the products being processed. However, estimates point to potential efficiency improvements of up to two percent during normal operations, with additional savings possible during plant start-up.

Another benefit of smart instruments is their self-diagnostic capabilities, which can help to greatly reduce the cost of ownership through a smarter and more effective maintenance routine. By assessing every aspect of the instrument's performance and pinpointing potential issues before they develop, this technology can help eliminate the frequency of maintenance visits, enabling improved deployment of engineering resources.

It is true that the added time and effort needed to configure and connect smart instruments to fieldbus systems means that they can cost comparatively more to install than their analogue counterparts. It is therefore necessary to understand in advance the potential scale of savings that could be achieved by using smart instruments, which can then be weighed against the cost of installing them.

Fig. 5: Wireless technology is opening up new possibilities for remote monitoring of devices

Go wireless

Extra possibilities for digital communication are also presented by WirelessHART technology. Currently, potentially valuable information acquired by process instruments is often left stranded in the field. This information could be monitored if a communications pathway back to the host control system could be created.

Typically, the existing installed instruments on many industrial sites have a built-in HART communication protocol, normally used during instrument commissioning. The arrival of wireless standards, such as WirelessHART, has allowed instrument manufacturers to develop wireless adapters that can be fitted to these instruments to provide a cost-effective and secure communication pathway back to remote condition monitoring applications.

The first interoperable wireless communication standard for process industry applications, WirelessHART enables a full range of data to be remotely extracted from HART devices located anywhere in a plant. Depending on the instrument in question, this information could include:

– Multivariable process data
– Instrument condition monitoring
– Valve performance
– Sticking valve notification
– Analyser calibration required
– Low level of pH calibration buffer stock
– Instrument over-pressure counter
– Mass flow and totaliser
– Mass flow and density / temperature
– Diagnostic / fault reporting to NAMUR

Where a site is already using HART 7 devices, WirelessHART will be compatible with its existing devices, tools and systems. This presents the opportunity for major cost savings, since it eliminates the time and effort associated with installing the cabling required in a conventional wired system. Not only that, but the time needed to configure new instruments within the plant-wide network can also be reduced. Wireless HART also presents the possibility of adding temporary instruments in order to gain additional process data.

Could your measurement devices be causing you problems?

Frequent or unexplained plant breakdowns can often be symptomatic of a measurement problem. Whilst an instrument may appear to be in good working order, it may actually be generating spurious information that can impact on equipment or processes further down the line. A good example of this is a pumping system, where blockage or deterioration of a flowmeter, for example, can generate spurious flow readings that can affect the performance of the pump, causing it to fail to deliver the expected flowrate.

In the same way, faulty sensors in pressure, level, temperature or combustion control systems can all have an impact on overall system performance, leading to problems ranging from premature failure of plant through to excessive emissions of restricted pollutants.

Corrosion of a thermowell in a temperature measurement application in a food and beverage or pharmaceutical process, for example, can effectively insulate the temperature sensor, causing its performance to become impaired. This can reduce its speed of response and lead to drifting accuracy, resulting in a measurement error that can slowly build up over time. In critical control processes, this accumulated error can lead to whole batches of products being rejected due to incorrect temperature control during production.

Such issues can be avoided through performing regular inspections of instruments, particularly where the measurements are critical to a production process. These inspections should include both a physical examination of the instruments themselves, and also, where possible, any recorded data that can be used to check for deteriorating measurement performance.

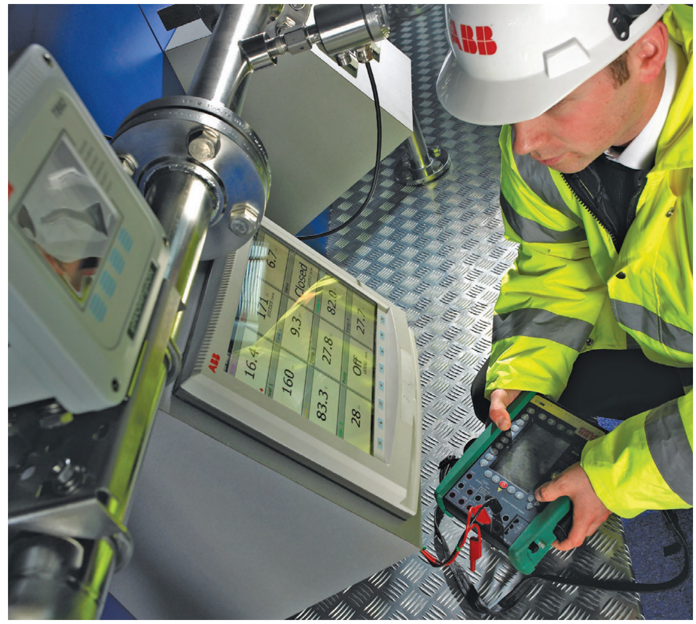

Fig. 6: Checking recorded process data can help to detect signs of deteriorating instrument performance

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In installations using older instruments, it may also be advisable to either upgrade or replace them with the latest technology. ABB's TTF350 field-mounted temperature transmitter, for example, will automatically switch over to a standby sensor in the event of the primary sensor assembly starting to fail or drift. An alarm can also be set to notify the operator in the event of a fault occurring, providing added security against the risk of impaired production performance.

Equally, problems with instrumentation may also be due to the characteristics of the installation environment. High vibration, extreme ambient temperatures and continuous exposure to the weather, can all impact on instrument performance.

The smooth operation and accuracy of pressure transmitters, for example, relies on them having been properly specified for the ambient temperature conditions in an installation. This specification will determine the materials used both for the transmitter itself and its internals, including the fill fluid and the diaphragm.

Most electronic transmitters are suitable for ambient conditions ranging from lows of –20°C to –40°C to highs of 60°C to 85°C, although this may not always be the case for certain types, for example where special filling materials have been specified for the transmitter.

Changes in an application's ambient temperature conditions can significantly affect transmitter accuracy. This can include not just the inherent background temperature of the installation location, but also heat generated from a process or radiated from surrounding process equipment and piping.

High temperatures can have a detrimental effect, potentially causing premature component failure. Exceeding the device's parameters can have a significant effect on performance. Low temperatures, for example, can cause fill fluids to become more viscous, whilst high temperatures can cause them to vaporise. Variations in ambient temperature and pressure can also have an impact, particularly if the transmitter's calibrated span is a small proportion of its upper range limit.

Fig. 7: The accuracy of installed instruments should be checked as regularly as possible to ensure that measured data can be relied upon

To overcome these problems, the temperature of the transmitter should ideally be kept as close to room temperature as possible for maximum life expectancy.

Careful consideration also needs to be exercised when installing a transmitter outdoors. Atmospheric conditions such as direct sunlight or high winds can cause heating or cooling of transmitters, which can adversely affect their operation.

Are your devices as accurate as they could be?

In the context of measurement instrumentation and analysers, accuracy can be defined as the ability of a device to provide a true reading for a given measurement, taking into account any potential errors or tolerances.

In the same way as calibration, the long-term accuracy of a measurement instrument cannot be taken for granted. The cumulative impact of issues such as drifting, reduced speed of response, degraded electronics and corrosion can all conspire to reduce accuracy over time, affecting everything from production efficiency through to product quality and safety.

It is therefore essential that the accuracy of installed instruments should be checked as regularly as possible.

This can be done in a number of ways.

One way is to check the current performance against the original specified accuracy. Referring to your original specification and/or historical data collected from the device can help to pinpoint any divergences in measurement performance, which can then be addressed if necessary either by servicing the instrument. This may include recalibrating it, or, where the problem is due to wearing or failure of components, repairing or replacing it.

Another way to check the accuracy of a device is to verify it against a device with a known accuracy. This may be a device specifically for verification, such as ABB's CalMaster2 for its AquaMaster 3 flowmeters, or an identical 'mirror' device that can be set up to temporarily measure the same process, with the readings being compared to the device under test.

In assessing the performance of a measurement instrument, accuracy should not be confused with precision. As stated above, accuracy is the ability of the device to provide a true reading of the current conditions being measured. Precision, on the other hand, defines the ability of the device to repeatedly deliver the same results. If the device itself is inaccurate, it can still continue to deliver the same results again and again.

Are you compliant with the latest legislation and standards?

The volume of legislation affecting industry has grown exponentially, setting new standards and directives for everything from environmental emissions through to process safety.

The need to comply with the latest legislation is therefore essential in order to avoid the risk of financial penalties, plant shutdown and, in extreme cases, criminal prosecution.

Typical areas to look at when assessing the capability of instrumentation to meet legislation include:

- Is the equipment fit for purpose?
- Is the equipment considered as a best available technique?
- Is the equipment suitably certified for use in the application?
- Are there any special requirements relating to operation and/or maintenance of the equipment?
- Is the equipment covered by a documented maintenance strategy, stipulating the frequency of maintenance, the persons responsible and the scope and limits of any maintenance work?
- Is there a maintenance history for the installed instruments, detailing the frequency and nature of any work carried out?
- Does the measurement data need to be collected for reporting purposes?
- Is there a requirement for redundant measurement?

By considering each of these areas in turn, it is then possible to begin to formulate a health check strategy to help ensure that your installation can comply.

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Are your instruments delivering the right levels of safety?
Recent high profile incidents and accidents have highlighted the need to ensure more than ever that installed layers of protection on hazardous installations meet required reliability and safety integrity requirements.

As operators improve their basis of safety as part of their process safety management obligations, there is an ever increasing need to develop assured methodologies that can link the hazard analysis with the confident development of credible layers of protection and in particular, embracing safety instrumented systems.

The overall operation, maintenance, repair, modification and retrofit phases of any safety instrumented system (SIS) poses significant challenges for process plant operators, particularly for those in the heavily regulated and highly hazardous processing sectors such as the offshore oil and gas sector.

Within the process industries today there are known to be a wide range of techniques and methods adopted by asset owners in their approach to SIS inspection and proof testing and the desire to comply with industry good practice standards such as IEC 61508 and IEC 61511. Regulatory authorities are increasingly showing an interest during their planned site visits in the SIS inspection and proof testing regimes being operated by duty holders.

For asset owners, operating, maintaining and modifying a SIS which is designed and engineered in accordance with minimum industry good practice requirements such as IEC61508/61511 poses both significant challenges and operational and process limitations. One of the fundamental requirements these standards place upon operations and maintenance (O&M) activities is to maintain the performance of the 'designed-in' functional safety and integrity of the SIS throughout its installed life.

Fig. 8: Ensuring that instruments are performing properly is vital in safety critical industries where a failure could have disastrous consequences

In particular, there to be an operations and maintenance planning process and schedule for each SIS. Appropriate maintenance ensures each safety instrumented function within the SIS continues to provide the required functionality with respect to its defined safety integrity level. Furthermore, there must also be consistent operational management to ensure that the SIS as a whole provides the required operational risk reduction.

Historically, the way in which SIS have been managed within the O&M lifecycle phases has varied significantly. Ultimate responsibility for SIS operations and maintenance and compliance to expected industry good practice falls to the asset owner. In many cases, however, the expertise of the supply chain may be called up to help manage and deliver SIS operations and maintenance strategy. In many cases, this may include the original OEM, integrator and maintenance contractor organisations.

Whatever resources and methodologies are deployed within the operation, the use of an inspection and proof test protocol is required to identify and expose any foreseeable unrevealed fail-to-danger fault conditions. If failures are detected during the inspection and proof testing routines, then adequate measures must be in place to manage any additional risk during the recommended repair time and records of any faults will need to be retained for analysis and potential rectification.

Similarly, management of change to the SIS during the operational and maintenance lifecycle phases is required to ensure that modifications are undertaken in a systematic way to prevent errors and potential failures being introduced in the operational SIS.

A preventative and corrective operations and maintenance process aligned to the IEC safety standards provides demonstrable compliance and the ability to retain and demonstrate functional safety performance throughout the O&M lifecycle phases of the SIS.

The benefits of compliance with IEC safety standards include:

- The provision of independent assurance that the organisation's preventative and corrective O&M strategy is in alignment with accepted industry good practice
- Demonstrating due diligence for the operations and maintenance of installed SIS
- Professionalism
- Establishing an efficient, systematic and repeatable safety management system (procedures, techniques, tools, etc.) to maintain functional safety performance
- Traceability and supporting documentary evidence covering the required O&M preventative, corrective, operational, inspection, change management and proof testing of the SIS

Summary

The secret to a long life is always good health and this is no less the case when it applies to instrumentation and analyser equipment. With cost pressures and a shortage of sufficient skilled staff to carry out regular maintenance and inspection, it can be difficult to give every installed device the attention it needs. In such situations, turning to the instrument supplier or manufacturer for help can often provide the answer. Their in-depth understanding of their equipment and the conditions under which it can be used, coupled with their expertise and knowledge of the latest standards and legislation, means they are well-placed to help you find ways to optimise the efficiency of your measurement devices.

ABB offers a broad range of health check and life cycle services to help you get the most from your installed instruments and analysers. For more information, email abb.service@gb.abb.com or call 03339 997 996, ref. 'Health checks'.

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