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MODERN METHODS OF FLOWMETER DIAGNOSTICS IN THE FIELD

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Abstract

The process industry is undertaking great effort to ensure high levels of process reliability, consistent product quality and accurately priced billing of goods. There is also an increasing need to prove that operation is sustainable, for example by meeting environmental regulations. State-of-the-art process measuring technology is the key to ensuring these values, since it is well-known for ensuring highly stable measurement results over a long period of time. Despite this, it is today common practice to inspect quality or safety-related measuring points at regular intervals.

State-of-the-art flow sensors do not have any kind of moving parts that are subject to wear. They also feature measuring electronics with self-diagnosis. These two aspects together make it possible to reduce efforts for the asset management of these devices significantly by preventing unnecessary maintenance work or calibration cycles, for instance. Furthermore, the diagnostic information can support quick troubleshooting or – through constant analysis in a condition monitoring system – even help prevent unscheduled plant shutdowns. Further verification reports can be created based on device internal tests, which allow the device to document its health condition itself in a way. The automatically generated report can be used for quality documentation or as a documented evidence of conformity with legal standards.

By now, individual device manufacturers have integrated diagnostics, monitoring and verification functions in the flowmeter so that they can be used in a uniform manner for the entire installed base. An example for this is the Proline flowmeters from Endress+Hauser. Consistent handling and uniform functionality allow customers to simplify their operational workflows by standardizing operating procedures. Thanks to the standardized implementation in a wide variety of measurement technologies, users only need to learn how to work with the method once. Both result in cost savings through increased efficiency.

A device with high long-term stability, which is tested using highly stable, internal references with a redundant design, is a basic requirement for reliable device-internal diagnostic and verification methods. For devices with internal verification the traditional method of verification with traceable, external measuring instruments is no longer necessary. Often the intervals between labor-intensive recalibrations can be extended. The advantages of this process include the ease of use and the option for integrating into a higher-level control system or asset management system. All of this saves time and costs, while virtually eliminating the possibility of interference due to incorrect handling.

Industry requirements
The process industry is being confronted with increasing demands in the areas of quality and safety. At the same time, pressure is increasing to lower costs by utilizing resources more efficiently or by preventing unnecessary maintenance and repair work and avoid unplanned plant shut down. Another substantial cost driver is specialization: It increases complexity and increases costs as a result. Individual manufacturers of measuring technology for process automation recognized this trend years ago and, today, offer comprehensive solutions for reducing complexity. The objective here is simplicity obtained by consistent and uniform solutions and by omitting specialized expertise. The cost savings in maintenance and operation that can be attained this way are based on two factors:

Standardization
Standardization is based both on uniformity (doing the same thing the same way) and consistency (offering one solution for all products). Presenting functionality for all products in a uniform manner makes handling safer and simplifies the learning curve. The availability of solutions for all product technologies allows the functions to be used for the entire installed base in a uniform manner. This streamlines operational workflows. Consistency also means that the mapping of a function always has to stay the same in the product lifecycle, guaranteeing that products are compatible with one another. Standardization ensures the sustainability of established processes and acquired knowledge.

Seamless integration
The aim of seamless integration is to improve the flow of information between the device and its environment, for example by perfect interaction between device and host. Diagnostics integrated in the device constantly delivers information about the device status or provides notification of events, such as if the current process conditions are interfering with measuring performance. Rapid and specifically targeted troubleshooting is possible since each diagnostic event on the system displays an additional corrective action.

Once the device itself generates and stores the information necessary for documenting the device inspection, it is automatically available to all operating and integration interfaces. It can also be used for documented verification of the measuring point, such as in the form of a printed verification report to meet the requirement in ISO 9001. In addition, integration increases the safety of personnel since, under certain conditions, the customer can call up information in the field without access to the measuring point.

State-of-the-art flow measuring technology like the Proline flowmeters from Endress+Hauser already meets these requirements today and offers uniform, consistent and integrated solutions for diagnostics, monitoring and verification of measuring points . without interrupting the process and without access in the field.

The described functions are based on an integrated self-monitoring system. Devices of next generation process automation fulfill these requirements with the aid of highly reliable on-board diagnostics and verification such as Heartbeat Technology.. Heartbeat Technology. is based on continuous monitoring of all relevant internal parameters and components such as mechanical, electromechanical and electronic components. Reliable measurement and diagnostics requires long term stability of components. For state-of-the-art devices long term stability is ensured by highly stable, factory traceable internal references in a redundant design. Consequently, their long-term stability is also continuously monitored during ongoing operation.

The following chapter explains this in detail and gives an insight into today's cutting-edge flow measuring technology.

Measurement with consistent quality
Measuring with consistent quality requires…

1. Measurement technologies with high long-term stability

Modern flowmeters, which operate based on a Coriolis, electromagnetic, ultrasonic, vortex or thermal measuring principle, do not have any kind of moving parts that are subject to wear. They have been tried and tested in thousands of applications and are well-known for guaranteeing highly stable measurement results over a long period of time.

The reason for this long-term stability stems from the technologies' resistance to wear provided by the lack of moving parts in the sensor. Therefore, for these measuring principles, it is assumed that they will exhibit long-term stability if they are properly selected, sized and installed. Good engineering practice eliminates the possibility of systematic errors, such as from selecting a material that leads to corrosion of the sensor element in conjunction with the fluid to be measured.

The integrated self-monitoring system allows safety-related or quality-related conditions to be identified in a timely manner if these measurement technologies are used in applications where the process conditions influence measuring performance or harm the integrity of the device.

That is to say, the aforementioned measurement technologies provide other secondary measured variables in addition to the primary measured variable (flow), which are useful for monitoring and documenting the measuring point. In comparison to the primary measured variable, the secondary variables provide information on the function or integrity of the device (state of health of the measuring point) and provide information if the measuring performance deviates from normal conditions (quality of the process control).

2. Comprehensive Diagnostics

Diagnostics is primarily based on constantly monitoring the function of device-internal components during ongoing operation. Diagnostics, therefore, allow for a rapid response in a timely manner. You are immediately warned if the device has reached a critical condition. These messages are typically interpreted in accordance with NAMUR recommendation NE 107 and are displayed by the device as a diagnostic event. This also includes direct instructions for action for what to do next.

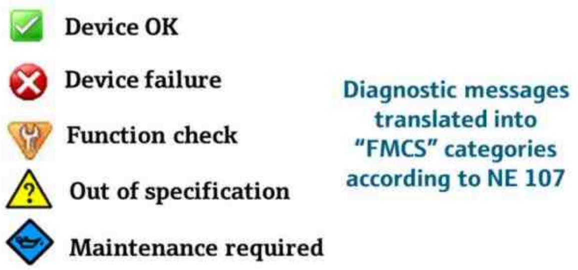

Fig1: Diagnostic messages

This ensures that the process can be up and running again quickly in the case of a shutdown, while preventing unnecessary maintenance measures.

Additionally, diagnostics offers the ability to detect process-specific interference in the device. This is usually illustrated by the "Out of specification" or "Maintenance required" events. The "Function check" message is used to signal that a function check - such as verification - is being carried out on the device and that the device cannot currently supply a valid measured value. The device provides all this information via the system integration interface. Analysis of the events in the higher-level system allows the facility's owner-operator to react to a specific diagnostics event with a specific response.

3. Condition monitoring

In essence, diagnostics enable quick and targeted responses to interruptions during operation in case of an error or a device failure. This is enough to guarantee safe, reliable operation for most applications. Faults during operation that go undetected or are not detected in a timely manner can result in an unexpected plant shutdown, product loss or a reduction in product quality. This specifically applies to applications where process-related faults during operation are to be expected due to the demanding operating conditions (formation of buildup, multiphase media) or where the device is subject to programmed wear (corrosion, abrasion). Condition monitoring is recommended for these types of applications. Condition monitoring recognizes if the process conditions, the measuring performance or the integrity of the device are impaired. The secondary monitoring values described above are transmitted to a condition monitoring system. It recognizes trends in the secondary measured values and can also evaluate the relationships between individual parameters. Constant monitoring reduces the risks of an unexpected failure.

Condition monitoring also makes it possible to display temporary, process-specific faults that neither calibration nor verification can detect, since the latter only take a snapshot of the device status.

4. Verification

Verification can be used to take and store a snapshot of the device status. Verification is used to demonstrate that the flowmeter meets specific technical requirements defined by the manufacturer or customer (i.e.: the process application).

During verification, the current conditions of the secondary parameters are compared with their reference values, thereby determining the device status. Verification produces a "pass" or a "fail" statement, depending on whether the assessment is positive or negative. A traceable and redundant reference, contained in the verification system of the device, is used to ensure the reliability of the results. In the case of a Coriolis flowmeter, this is an oscillator, which provides a second, independent reference frequency.

Verification results in a verification report. This report includes a qualitative assessment of the checked parameters: Pass/fail.

The verification report is generated by means of a web server or asset management software. It can be implemented either as quality documentation (for compliance with ISO 9001) or, in safety-related applications, as documentation of the proof test (for functional safety - SIL).

Requirement for reliability

The demands are high: A flowmeter is expected to demonstrate constant, and therefore, unchanged measuring performance throughout its entire lifespan. This is necessary to..

- Guarantee safe plant operation
- Ensure high product quality
- Increase system availability and productivity

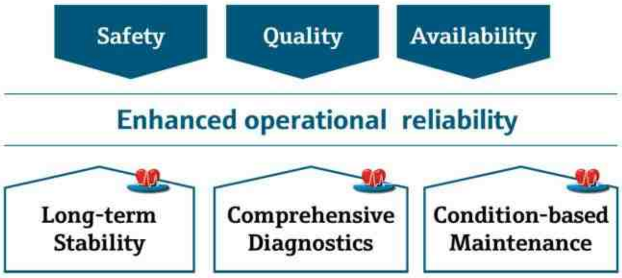

Fig2: Enhanced operational reliability

A number of requirements must be met to enhance operational reliability. These requirements are met best by comprehensive diagnostics of the measuring point in running operation and methods for condition based-maintenance. As we have seen Condition Monitoring and Verification provide efficient methods for measuring point maintenance during the system's lifecycle.

The requirement for long-term stability requires additional prerequisites. One aspect is the application of measuring technology with high long-term stability which is also not sensitive to interference. Another important aspect is the reliability of self-monitoring techniques applied in modern flowmeters. The NAMUR recommendation NE107 . Self-Monitoring and Diagnosis of Field Devices states .The most important requirement is that the diagnosis results must be reliable to enable the user to take the appropriate action. In this sense, a bad diagnosis is worse than none at all.. Unreliable diagnostics are worse than none at all, since faulty signaling of the process and device status reduces the safety of the processes and the availability of the systems. In this case, the faulty diagnostics would in fact disrupt the operational process instead of stabilizing it. The same applies to the measurement output. Plat safety, and product quality can only be assured if flow measurement is reliable.

In the following chapter the prerequisites for reliable self-monitoring and flow measurement are discussed.

Traceability and long-term stability

To measure means to compare an actual value to a reference value. In a flowmeter the actual value reported from the sensor is compared to a reference value in the transmitter electronics. In order to produce accurate measuring results, the reference value needs to be reliable. For this purpose integrated self-monitoring of the reference value is applied.

To be effective, such integrated self-monitoring must be based on a traceable reference system with proven long-term stability. This allows a high level of stability . even without verification by external measuring instruments.

Traceability

The term "traceability" is defined with respect to calibration. Traceable calibration means: "Property of a measurement result to be related to a reference through a documented and unbroken chain of calibrations".

The verification system is based on a reference signal and a corresponding reference value. The reference value is permanently stored in the device during the production of the device. The reference system is calibrated for traceability at the factory.

In the case of a Coriolis flowmeter - and other time-based measuring principles like vortex or ultrasonic - this is a frequency reference (oscillator) used for analyzing the frequency of the measuring tubes. For electromagnetic flowmeters, this is a reference voltage, since, for these, the measured value is determined by comparing the voltage on the electrodes to this reference voltage.

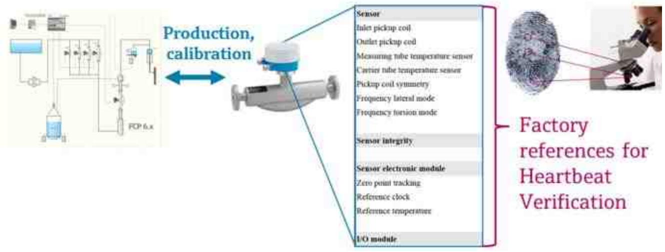

Fig3: Heartbeat verification

The reference operating condition at the time of the factory calibration is stored in the flowmeter's non-volatile and secure memory module, called HistoROM, and at the same time, stored in the electronic "CER" device documentation. In the "CER" or "Common Equipment Record", Endress+Hauser reliably stores the lifecycle data from all devices and enables customers to access them online as needed by using W@M Portal.

The starting point created for the purposes of factory calibration represents the documented condition of the device when it is new, i.e. before delivery to the customer. For this reason, this information is also valid for the entire product lifecycle and does not need to be re-created during re-calibration.

Long-term stability

The primary reference is monitored by a second (redundant) reference system to guarantee that it does not change during the device lifecycle. The two reference signals from the primary and secondary reference (i.e. voltages and frequencies) are continuously compared against each other. A drift or deviation of the two systems from each other is immediately detected and reported by the device diagnostics.

Independence of process and environmental conditions

Flowmeters are often used for many years in industrial applications. References with long-term stability ensure that deviations due to aging or external influences are extremely improbable. However, if this should occur, it is immediately detected by the continuous monitoring system integrated in the device. This ensures highly reliable operation and, by detecting errors in a timely manner, prevents the device from working outside of the factory specifications. This increases the safety of plant operation and ensures consistent product quality.

Verification of flowmeters

To ensure the conformity (quality) of the product, the ISO 9001 requires to "determining the monitoring and measurement to be undertaken and the monitoring and measuring instruments needed to provide evidence of conformity of product to determined requirements. In order to ensure valid results, the measuring equipment shall be calibrated and/or verified at specified intervals or prior to use, against measurement standards traceable to international or national measurement standards. Records must be kept on the results of the calibration or verification".

In terms of flow measuring technology, the volume or the mass of the medium represents the above mentioned measurement. The flowmeter, which provides this measurement, represents the measuring instrument that must be periodically calibrated or verified. Calibration is the only method for directly inspecting the actual quality parameter, i.e. the mass or volume flow.

The described requirements are only completely met using the traceable and accredited calibration of flowmeters. Accreditation means the formal recognition of authority to execute a specific service as described in the scope of accreditation (in our example: calibration of flow meters) and is the key to transparency, confidence and comparability. Measuring uncertainty claims coming from non-accredited calibration rigs are generally regarded as not credible.

ISO 9001 requirements also provide the impetus for today's common practice of requiring an independent reference system for device inspection through verification. However, this does not verify the primary measured variable (flow), but rather the device function.

In practice, reliable verification of flowmeters can be fulfilled in two ways: Either via an external verificator whose references can be traced along the life cycle by re-calibrating the verificator at periodical intervals, or by an internal verification which is based on factory-traceable references that are stable in the long-term.

Since in the past a method to assure the long-term stability of an internal verification system has not been available, it was always required to use some external verificator. Now, with the latest generation of flowmeters, a reliable internal verification technique became available for the very first time.

The following is a comparison of the two methods, as well as an explanation of their pros and cons in practice. Both verification methods should, however, always be seen as a supplement to calibration. Device inspection through verification is not comparable to flow calibration and, therefore, does not eliminate the need for calibration.

External verification

The inspection of flowmeters is carried out by an external verificator. This verificator is used as a device-independent reference system and is, as defined by the ISO 9001, considered test equipment that must periodically undergo traceable calibration.

During the verification process, the verificator is connected to the flowmeter via test interfaces and a functional test is carried out by simulating reference signals and observing system response. The reference signals for transmitters are fed in via a simulation box the ones to the sensor using a sensor test box. In both cases, electrical characteristic of the system are tested. The results can be compared to the limit values defined by the manufacturer. The picture blow shows an overview of how an Endress+Hauser Promag electromagnetic flowmeter is verified by means of a Fieldcheck verificator.

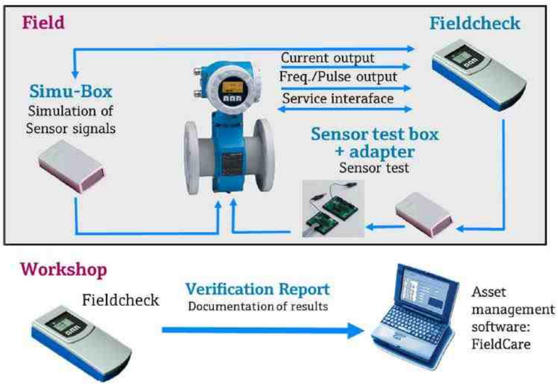

Fig 4: Verification process

The results of this simulation are automatically interpreted by the verificator: If it is within the limits, the algorithm produces a “pass” statement. If the limit is met or exceeded, a “fail” statement is produced. The status of verification and created data are subsequently used for documenting the results in a verification report. Modern verificators like FieldCheck from Endress+Hauser carry out the entire process automatically by controlling the flowmeter, simulating the measured values and documenting the data for further processing.

A documenting verificator is capable of verifying many different electrical signals, including frequency and pulses, and then automatically documenting the results by transferring them to a fully integrated asset management software. In case of FieldCheck verification the gathered information is archived in the asset management software FieldCare and a verification report is generated if needed. The operator does not have to write any results down on paper, which makes the entire process faster and consequently reduces costs. The quality of the verification results will also improve, as there will be fewer mistakes due to human error.

Since the verificator creates the measuring data in addition to the verification result, this data can be used for tracking trends in the lifecycle of the measuring point. This allows for timely conclusions regarding the measuring point's state of health and it assists in preventing unexpected failures.

The biggest advantage of verification is that it can be done without removing the device from the pipeline and, therefore, can be carried out without interrupting the process. This not only substantially reduces effort in comparison to calibration, it also prevents plant shutdowns.

Despite this, external verification is a very complex procedure that requires access to the measuring point in the field. During verification, the transmitter is opened to input external signals using a special testing adapter. Verification is carried out by a skilled technician and requires approximately 30 minutes. The process requires specific knowledge and relies on the assembly and maintenance of infrastructure. This is why external verification is usually always implemented in the form of a service, e.g. as part of a service contract.

Evolution to internal verification

Internal verification is based on the ability of the device to verify itself based on integrated testing, which is carried out on demand. This is why the most common question is: How can internal verification system achieve the same reliability and test coverage as an external verificator specifically created to do so?

We have already answered the first part of the question on reliability in the section .Traceability and long-term stability.. Integrated self-monitoring replaces the need for external test equipment only if it is based on factory traceable and redundant references. The reliability and independence of the testing method is ensured by traceable calibration or verification of the references at the factory and the constant monitoring of their long-term stability during the lifecycle of the product.

By eliminating additional components for inspection and preventing errors during handling, internal device inspection proves to be more reliable than external inspection in practice when viewed as a whole.

Test coverage

The question about test coverage can be best answered using a specific example: A requirement for high test coverage is a consistent product design in which self-testing has been developed as an integral constituent of the device from the beginning. The device function that makes this possible is Heartbeat Technology., which was developed together with the Proline devices. This concept embeds additional diagnostics tests in all electronic modules of the device.

The new Endress+Hauser Proline devices implement this concept so that the resulting test coverage is comparable to or higher than that of external verification. The crucial factor for this is the .total test coverage. (TTC), which indicates how efficient the tests are.

The TTC is expressed by the following formula for random failures (calculation based on FMEDA as per
IEC 61508):

- $TTC = (\lambda_{TOT} - \lambda_{du}) / \lambda_{TOT}$

λ_{du}: Rate of dangerous failures (dangerous undetected)

λ_{TOT}: Rate of all theoretically possible failures

Electronics failures labeled "dangerous" are those, which, when they occur, would distort or interrupt the measured value output. The integrated self-monitoring of Proline flow meter generally detects more than 95% of all potential failures (TTC > 95%). Example: For the Proline Promass 100 Coriolis flowmeter the total test coverage is 96%.

Use cases

High total test coverage enables the use of the verification function to check the measuring functionality (flow output) for quality related measuring points and for flowmeters used in functional safety applications (SIL).

Today it is common practice to confirm measuring performance of flow meters by periodical calibration, using one of the following methods:

- Checking the measured value with a calibration rig:
  The measuring device is recalibrated using a calibration rig that is certified in accordance with ISO 17025. This can be done on an installed device using a mobile calibration rig or using factory calibration if the device has been removed from the application.
- Checking the measured value using the installed totalizer:
  A calibrated measuring vessel is filled with the product at a flow rate which approximately corresponds to the limit value to be monitored. The change in the volume in the measuring vessel is read off before and after filling and compared with the totalizer installed in the measuring device.

Checking the measuring performance by calibration detects at least 98% of dangerous, undetected failures. In functional safety applications the achievable proof test coverage therefore is 98% (PTC = 0.98).

With internal verification, like the Heartbeat Verification function for Proline flowmeters, users can test a Proline device when installed in the application. Since the test is carried out by the device-internal verification a total test coverage (TTC) of >95 % can be achieved using this test method (TTC = 95% or more). This test coverage is relevant for the documentation of tests in quality-related applications.

Sensor verification

Additionally, the electronics is able to carry out an inspection of the sensor on demand. While doing so, the functionality and integrity of the sensor system is verified. In the case of Promass Coriolis devices, the electrodynamic excitation, electrodynamic sensors, temperature sensors, connectors, cables and the measuring tube are tested. The excitation system and the coil current are verified for Promag electromagnetic flowmeters. An inspection of the electrical and mechanical integrity of the DSC sensors and the temperature sensors is carried out for Prowirl vortex sensors. This enables systematic failures, caused by factors such as fluid properties or process operating conditions to be detected.

Advantages of integrated verification

The results of internal verification are the same as with external verification: Verification status (pass/fail) and the recorded raw data. However, since verification is now a part of the device technology, data acquisition and interpretation are also done in the device. This has the advantage of making the functionality available for all operating interfaces and system integration interfaces. The verification procedure depends on the measuring principle and can last anywhere from a few seconds up to approximately ten minutes. The true time saving, however, comes from the ease of use, since no complex interaction with the device is necessary to carry out the verification.

The integration of the verification function into the device provides numerous additional advantages, which are all based on the simplified handling of the integrated solution.

Safety and quality

Verifying the measuring point is done on demand and via all operating interfaces (local Display/HMI or web server) as well as the system integration interfaces (HART, PROFIBUS, FOUNDATION Fieldbus, Modbus or EtherNet/IP). The verification process can also be started via a higher-level system (Asset Management Software or PLC) and it reliably reports the device status. Therefore, access in the field is not necessary, which minimizes the risks for the personnel. The quality of the verification results will also improve, as there will be fewer mistakes due to human error.

Verification can be carried out much more often- including daily or before starting a production batch- since the function is so easily accessible and the entire process lasts only a few minutes without interrupting operation. This increases plant safety and availability and improves product quality.

Fig 5: Existing verification process

Higher plant availability
Devices with internal verification should be capable of storing multiple verification results in the transmitter. This is the case not only for the verification status (pass or fail), but also for the measured data. This has the advantage of making the data available for later documentation and makes it possible to create verification reports offline for quality documentation. Furthermore, by comparing the data of multiple consecutive verifications, trends can be detected and systematically tracked during the lifecycle of the measuring point. This allows for timely conclusions regarding the measuring point's state of health or process-specific influences on the measurement result and assists in preventing unexpected errors. And lastly, this data allows for better maintenance planning. This allows for cost savings on account of higher plant availability and increases the efficiency of service and maintenance.

Calibration and verification

The accuracy of all measuring devices degrade over time. This is typically caused by normal wear and tear. However, changes in accuracy can also be caused by electric or mechanical shock or a hazardous manufacturing environment (e.x., oils, metal chips etc.). Depending on the type of the instrument and the environment in which it is being used, it may degrade very quickly or over a long period of time.

To overcome this issue a comparison between a known measurement (the standard) and the measurement using your instrument will be carried out at the calibration lab, in order to check the deviation and rectify the same. Typically, the accuracy of the standard should be at better than two times the accuracy of the measuring device being tested. The bottom line is that, calibration improves the accuracy of the measuring device. Accurate measuring devices improve product quality.
But, calibration has its own pros and cons. To perform each calibration process the instruments needs to be taken out of the process. This means higher process downtime and maintenance cost. Instrument manufacturers brought in a safer and easier option which was external verification. External verification helps in checking if the instrument requires calibration at all.

Verification is an ideal addition to flowmeter recalibration. This is particularly true for applications where systematic errors can be ruled out. "Systematic" here means that a defect or error in the device was facilitated or caused by the manner of the device's use. An example of this would be corrosion on the sensor because the sensor material is not suitable for the fluid in question. Increased uncertainty on account of the influence of process conditions, incorrect design or faulty installation also falls into this category. The causes are always due to the interaction between the device and the application.

Furthermore, the causes are usually already present at the time of device installation or can be detected at the time of device commissioning. Systematic errors can be prevented through proper design and commissioning of the device, which is why most of the flowmeter installed base is not affected by these errors in practice. If errors appear despite this, they are frequently detected and remedied at the beginning of the product lifecycle.

This fact is also the basis for the "bathtub curve", which illustrates a product's probability of failure
within its lifecycle:

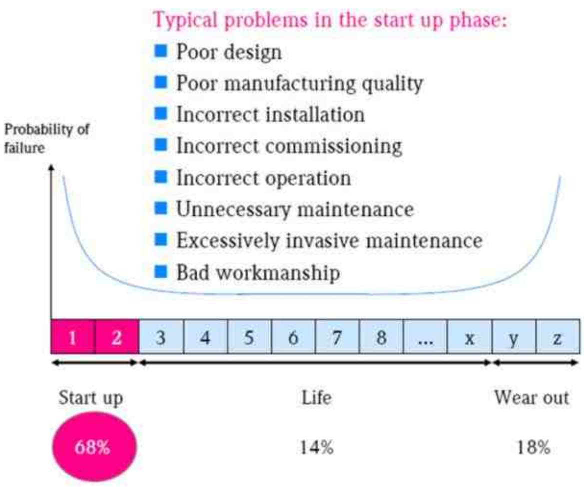

Fig 6: Bathtub curve

The above curve suggests that almost 70% of all failures in the life cycle of a product occur in the first phased of its life cycle. While the probability of failure is high in the initial phase, it decreases quickly in the second phase and then stays at a constant and low level for a long time. The probability of failure does not increase again until the product nears the end of its technical service life. At that time, failure occurs on account of natural component aging instead of due to systematic errors.

Experience shows that state-of-the-art flowmeters, which have no moving parts in the sensor and operate wear-free as a result, have the same lifecycle curve. Their technical service life can continue far beyond 10 years.

Customers can take advantage of this knowledge by optimizing the calibration and verification cycles of their devices. If a device is in fact tried-and-tested in operation - we see this is typically the case after one to two years of operation - we can rule out the potential for systematic errors to a large extent, particularly those caused by the influence of process conditions on the sensor. Then we find ourselves in the flat portion of the graph curve. In this phase, flowmeter verification offers reliability comparable to that of recalibration. The reason for this is: Spontaneous errors are most frequently caused by electronic components in this phase, and diagnostics on the electronics in the transmitter can be run easily. This allows inspections to be conducted on the basis of verification in addition to calibration. Calibration is usually not omitted entirely; the intervals between instances are extended instead – from one to three years, for example. This saves on costs during operation, since calibration costs mainly depend on the individual process and logistics required to perform it and the cost of process shutdown.

Procedures are established by conducting the first device verification right during commissioning. This documents the “as new status” of the flowmeter and helps eliminate potential systematic errors. In the first phase of the lifecycle, the measuring performance and integrity of the flowmeter are monitored by recording the results of calibration as well as verification. If the calibration shows that the measuring performance remains unchanged after several such cycles, systematic errors can be ruled out - the device is now tried-and-tested in the application.

Now the calibration intervals can be extended in a second step, while the verification interval is maintained. More frequent monitoring of the verification parameters (such as daily or after every production batch) allows easy identification of changes to the device and also increases trust in the measurement:

- A device test by means of verification improves quality assurance, since deviations in the operation are more quickly detected.
- By observing trends over time corrective measures can be made early, before an actual device defect occurs. This reduces maintenance costs and prevents an unplanned plant shutdown.
- Since inspection through verification takes less effort than calibration, it can be carried out more frequently. This improves the reliability of the measurement results and helps to ensure product quality throughout the entire lifecycle.
- Since verification is available for all measuring principles, it is available for the entire installed base and can also be used for measuring points where a calibration is not economically justifiable.

Summary
Flowmeters in which self-monitoring have been developed as an integral part of the device from the beginning offer the highest reliability. This benefits the customers in three ways.

- Continuous self-monitoring is used for diagnostics, in order to react quickly and targeted to a device defect or an application problem. Since the diagnostics delivers specific messages and corrective actions to the device and its functions, quick troubleshooting is possible.
- If the information identified as part of self-monitoring is exported from the device, it can be used for condition monitoring. This continuous observation of the device and process status also allows proactive measures through early identification of trends, thereby preventing unplanned maintenance or plant shutdown.
- Reliable methods of self-monitoring are based on factory traceable references and have high, proven long-term stability. Only methods fulfilling these criteria, are suitable for internal verification of flowmeters and can be used to create proven documentation in the areas of quality (ISO 9001) and safety (SIL . recurrent function test), and to verify metrological requirements.

In order to fulfill the prerequisites of the most widely varying applications and requirements in the lifecycle of a measuring point, all three features are needed. The modularity of the solution makes it possible to adapt the functions to the demands of the application in a targeted manner. The consistency, ensured for a wide variety of devices through uniform functionality, supports ease of use.

Since, Proline with Heartbeat Technology. is now making a solution for the entire installed base available for the first time in the field of flow measuring technology, customers can optimize their operational workflows through standardization. This leads to reduced complexity for the customer and makes additional cost savings possible in engineering, operation, servicing and maintenance.

(The author, Mr Hemal Desai is graduate in Instrumentation Engineering and has over 24 years of experience in process control and automation business. Currently he heads the Marketing Group at Endress+Hauser India Pvt. Ltd.)