Top Notch Technology in Flowmeter Verification

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The water industry is undertaking great effort to ensure high levels of process reliability, consistent quality and accurate billing of water.

There is an increasing need to prove that operations are economically and environmentally sustainable. State-of-the-art 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 related measuring points at regular intervals.

Main application segments and related requirements in the water and waste water industry:

• Municipal waste water • Potable water • Utility water • Water reuse • Desalination	• Quality related measuring points • Accounting (inlet/outlet) • Billing of water • Regulated by ISO 9001
Periodical, traceable calibration or verification is a must!	

General requirements

The general requirements for accounting and billing of water as well as quality related water and waste water applications are:

- Flowmeters have to be verified in regular intervals
- Verification has to be performed by a qualified third party and with an accepted inspection method based on quality regulations (ISO 9001)
- A test report needs to be provided (documented proof of evidence)

To meet quality regulations verification must be performed by a qualified third party and accepted inspection method based on quality management. In waste water treatment plants inlet and outlet measurement is required to meet environmental regulations.

The generally accepted method of traceable flow calibration with calibration rigs accredited to ISO 17025 is costly and sometimes not feasible at all – mainly due to the logistics involved with removing the flowmeter from the pipeline. For this reason users look for an economical alternative to recalibration. However, any calibration or verification must be traceable to national or international measurement standards and provide process-independent references. A seamless document trail is required causing the need for detection of any modification to the device and a tamper proof documentation by verification or calibration protocol.

Consequently, in order to serve as a viable alternative to recalibration, verification methods must improve the confidence in flowmeter performance. Therefore verification results must include a declaration of the total test coverage in direct comparison with calibration.

Challenges when calibrating flowmeters

Applications in the Water and Waste water industry often use large line sizes (larger than DN300/12"). Recalibration of these flowmeters is very costly. In some cases a certified local reference standard (calibration rig accredited according to ISO 17025) is not available at all. Additionally in water supplies any interrupt of service or supply is not acceptable.

• Requires calibration rigs accredited according to ISO/IEC 17025	Challenges • Complex and costly logistics • Lack of local calibration rigs, especially for large line sizes • Interruption of supply often not feasible

These challenges are the main drivers for the acceptance of verification solutions as an alternative to calibration or as a means to extend calibration intervals.

Flowmeter 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).

External and internal verification

ISO 9001 requirements also provide the impetus for today's common

practice of requiring an independent reference system for device inspection through verification.

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 traceable references that are stable on the long term. Here the factory condition of the device-internal references is captured during factory calibration and securely saved in the flowmeters memory. This reference is the basis for consecutive verifications in the lifetime of the flowmeter.

For electromagnetic flowmeters, verification methods have been established for many years. 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 a qualified external verificator. Now, with the latest generation of flowmeters, a reliable internal verification technology has become available for the very first time.

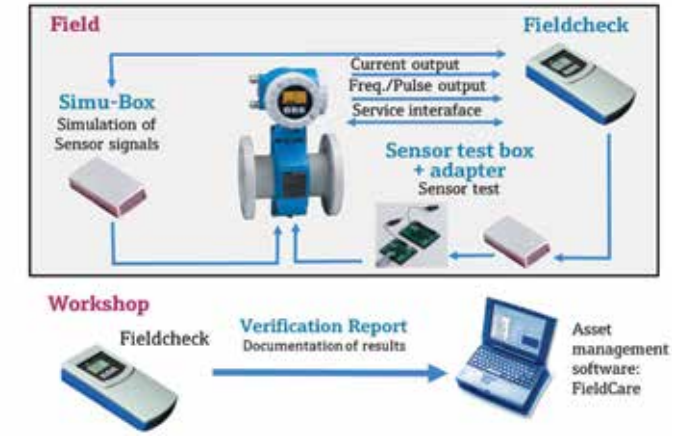
> *With total test coverage in the order of 95%, Heartbeat Technology ensures the flowmeter works within its specified accuracy.*

External verification

Here 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 calibrated reference signals and observing system response. The reference signals for transmitters are fed in via a simulation box and the reference signals to the sensor by means of a sensor test box. In both cases, electrical characteristics of the system are tested. The results can be compared to the limit values defined by the manufacturer. The picture below shows an overview of how an Endress+Hauser Promag electromagnetic flowmeter is verified by means of a Fieldcheck verificator.

Transmitter and sensor signals are simulated automatically and independently from each other. The response from the flowmeter is measured and automatically interpreted by the verificator: If it is within the factory limits, the algorithm produces a 'pass' statement.

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 results for further processing. 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 implemented in the form of a service, e.g. as part of a service contract.



Evolution to internal verification – state-of the-art technology

Internal verification is based on the ability of the device to verify itself based on integrated testing, which is carried out on demand. 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 with integrated self-monitoring by Heartbeat Technology.

During flowmeter verification, the current conditions of secondary parameters are compared with their reference values, thereby determining the device status. Heartbeat Verification produces a 'pass' or a 'fail' statement, depending on whether the assessment is positive or negative. The individual tests and test results are automatically recorded in the flowmeter and used to print a verification report.

Reliability of internal verification methods

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 an electromagnetic flowmeter, this is a voltage reference, which provides a second, independent reference value.

• Integrated self-monitoring with high Total Test Coverage (TTC) • Internal flowmeter verification on-demand • High reliability due to factory-traceable redundant references	• Proven electromagnetic flowmeter technology and components with high long-term stability • Traceable factory calibration of flowmeters (ISO/IEC 17025)

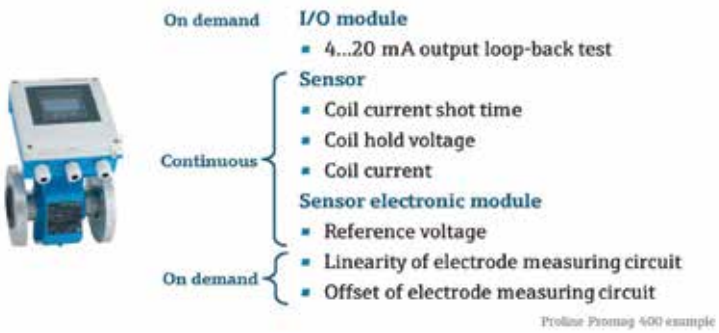
Integrated self-monitoring replaces the need for external test equipment only if it is based on factory traceable and redundant references. The reliability and independence of the testing method is ensured by traceable calibration or verification of the references at the factory and the constant monitoring of their long-term stability during the lifecycle of the product. By eliminating additional compo-

nents 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 example illustrates the test groups for a Proline Promag electromagnetic flowmeter. The entire signal chain from sensor to output modules is included in the flowmeter verification.

While most of the tests operate continuously during regular measurement operation, additional tests are added when the flowmeter is verified on demand (example Proline Promass W 400).



Tests that are part of the continuous self-monitoring are used for flowmeter diagnostics. They provide an immediate diagnostics event which allows it to react quickly and targeted to a device defect or an application problem. The on demand verification allows for tests which briefly interrupt flow reporting. These additional tests increase the over-all test coverage within the flowmeter. 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 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 flowmeter generally detects more than 95% of all potential failures (TTC > 95%). This test coverage is relevant for the documentation of tests in quality-related applications. With total test coverage in the order of 95%, Heartbeat Technology ensures the flowmeter works within its specified accuracy.

Additional 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 sensor 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. This reduces the time for maintenance and increases 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.

Conclusion

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 optimise their operational workflows through standardisation. This leads to reduced complexity for the customer and makes additional cost savings possible in engineering, operation, servicing and maintenance.

Frans van den Berg started 16 years ago with Endress+Hauser as a Project Engineer. After obtaining his technical diploma in Electrical Engineering, he started his career with African Explosive and Chemical Industries (AECI) as a technician and eventually progressing to a Project Manager. Currently he is employed as a Product Manager for Flow where all aspects of flow measurement from product marketing and technical support as well as application consultation and product selection is handled by him.
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