PROCESS INSIGHT SOLUTIONS

MARCH 2022

40% OF YOUR CALIBRATION RECORDS INCLUDE ERRORS

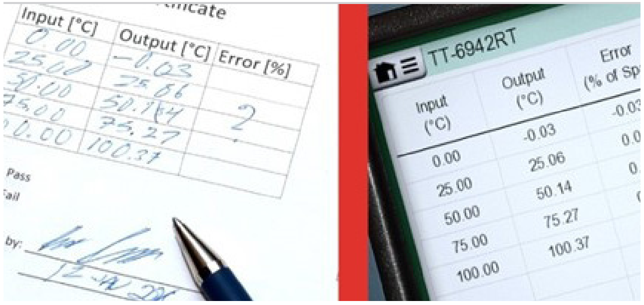
SELF-CALIBRATING TEMPERATURE PROBES

INTEGRATED ENERGY MEASUREMENT

Our Calibration ehandbook is for operators involved in verifying and calibrating measuring instruments used in systems and applications for assuring and managing industrial process measurement.

Instrumentation technicians need a handbook that clearly and completely explains calibration procedures for all the instruments for measurement in industrial applications: chemical, petrochemical, pharmaceutical, food, energy, and custody and transfer for water, oil, and gas.

The articles listed here are an aid to ensure that these needs are met, such as an examination of how manual data entry can contribute to 40 per cent of your calibration errors, and how to remedy that.



INDUSTRIAL AUTOMATION
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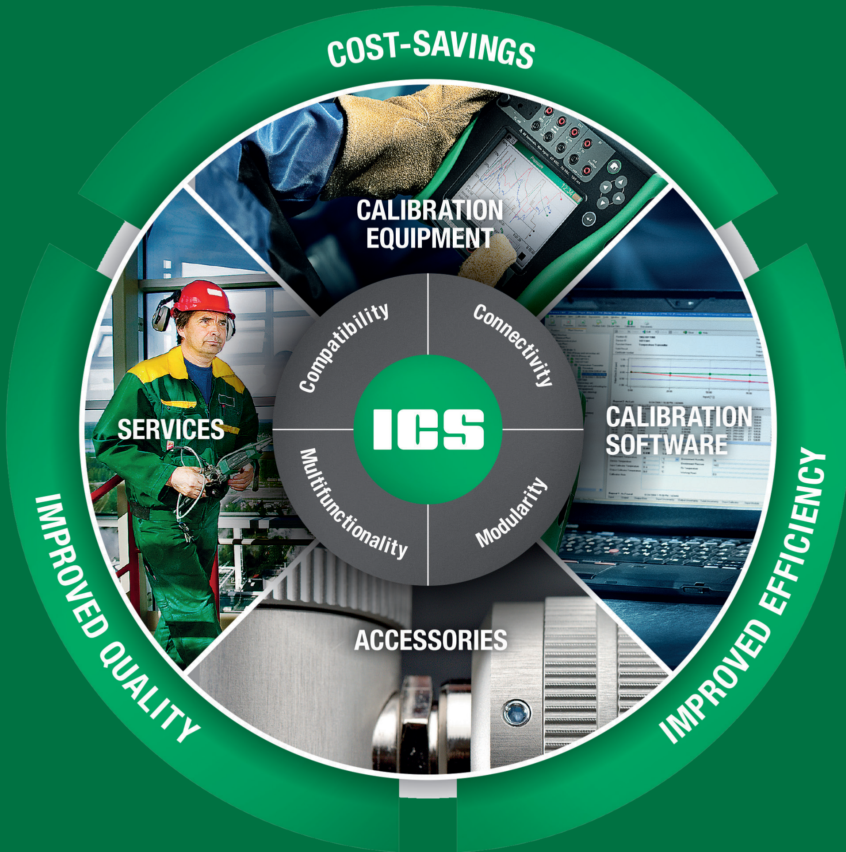


40% OF YOUR CALIBRATION RECORDS INCLUDE ERRORS AND WHAT YOU CAN DO ABOUT IT

Manual data entry is still commonly used in many industrial processes even though it's slow and labour-intensive. Why? Well, in short, that's the way it's always been done. If there isn't another way of handling the data, this is the only option.

But let's look at the scary truth behind manual data entry as it relates to the calibration process.

Handling calibration data

Before we dive into the quality issues that arise from manual data entry, let's review how data is handled in industrial calibration processes.

1. Pen & Paper

Paper forms are still a very common method for capturing calibration data in the field. Later, this data is manually typed into a computer – many times by another person. This leaves two potential error risks. First, the data is written incorrectly in the field. Second, the data is transposed improperly when typed into the system.

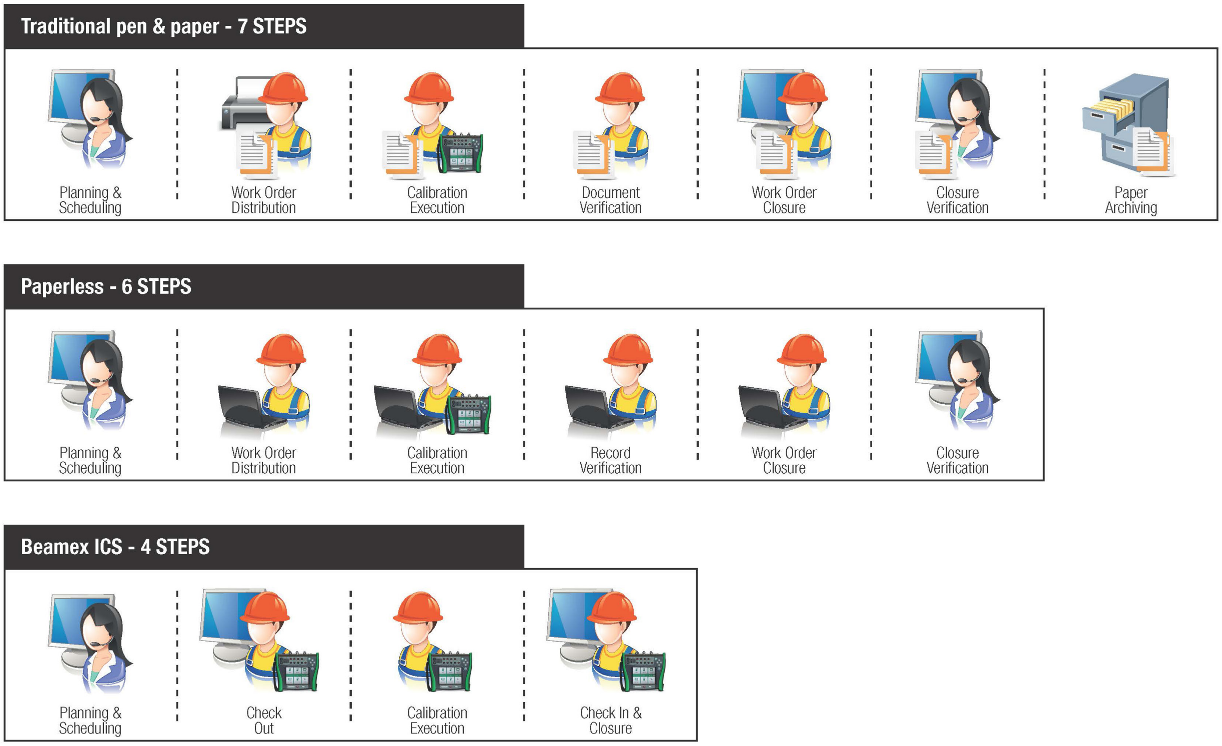
2. Manual entry into a calibration system

In some cases, calibration data is typed into either a Microsoft Excel file or a dedicated calibration software program. To do so, the technician must carry a laptop or mobile device into the field. This process for data entry limits the number of manual touchpoints to only one as opposed to two like in the pen and paper process

3. Electronic data storage

The fastest and most error-proof method for storing calibration data. Here calibration data is stored in calibration equipment electronically and then is transferred into the calibration software system. This process does not include any manual data entry steps and therefore can eliminate all the human error making it the ideal method for quality management.

For calibrations where there are gauges, indicators, displays, or similar that need to be read visually, there will still be some manual data entry however, some calibrators have a feature to check that the data entered is within accepted values and may also have



a graphical indication of the data quality for easy verification.

Now that we've looked at some of *how* calibration data is handled, let's dive into the ugly truth behind manual data entry errors.

The typical error rate in manual data entry is about 1%.

Based on some research, it appears that the average error rate in manual data entry is about 1%. While it is difficult to quantify that rate, it is reasonable to l assume that there is an error rate associated with manual data entry. The error rate can also fluctuate if the data being entered is complicated, if the user is tired or in a hurry, or if someone simply has handwriting that is difficult to read.

Here for example, in figure 1 on the left, we see calibration data that has been entered manually using a paper form. Possibly some of the numbers are incorrect, it is certainly not easy to read, manual error calculations have been left undone, it is difficult to tell if that was a pass or fail and if we wanted to find who signed off on that, it would be rather hard.

On the right side, however, you can see the same calibration data on a Beamex MC6 documenting calibrator. This data is stored automatically and electronically in the calibrator's memory, errors are calculated automatically, pass/fail is done automatically, results are sent electronically to the calibration software for storing and certificate printing, and so on. The calibration data is more reliable.

What does a 1% error look like in the calibration process

First off, calibration data includes a lot of numbers, often with decimals. It is very rare to see calibration data entered as an "even number" (20mA is more likely to be 20.012 mA). In fact, seeing round numbers in calibration data is something that would cause some agencies, such as the Health Products and Food Branch (Federal Government), to question during an audit.

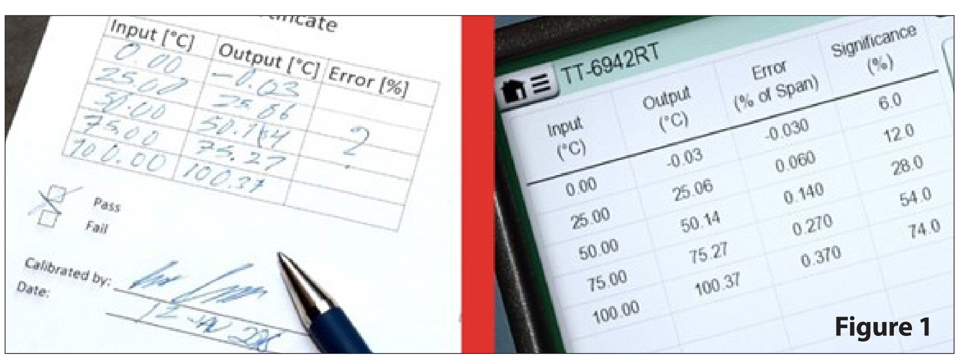


Figure 1

Secondly, when calibrating a process instrument, for example, a transmitter, the input, and output data should be captured at the same time, which is difficult. If the values are drifting, an additional error will be introduced if the numbers are not recorded at the same time.

And finally, in process instrument calibration, there are typically five calibration points (25% steps with 0%, 25%, 50%, 75%, and 100%), and both the input and output need to be recorded. That makes 10 calibration data points. Plus, other data such as reference standards used, environmental data, date, time, etc. also must be entered.

On average, approximately 20 data points need to be entered during the calibration process. With a 1% error rate, this means every fifth calibration will include incorrect data. Because, if one calibration includes 20 data points, then five calibrations include 100 data points. A 1% error rate means that data would be entered incorrectly once every 100 data points and therefore every fifth calibration will include faulty data.

However, as mentioned above, in a paper-based system, calibration data is often manually entered twice. Once in the field by the technician and then again in the workshop when being entered into the system. This means that each calibration has 40 data points instead of 20 and that, statistically, 40% of calibrations made will include faulty data. Told you this was ugly.

The implications of data errors

If you do manual calibration data entry using the two-phase system (written down in the field and entered manually in the workshop) **about 40% of your calibration records include errors!**

In a typical process site that performs 10,000 calibrations annually, all manually entered using the two-phase data entry process, statistically, they will have 4,000 calibrations with faulty data!

Now that we know the possible number of errors that can be found in manually entered data, how do we address the significance of these errors? That, of course, will depend on the situation.

If the manually entered data is wildly inaccurate, for example, if a nominal 4 mA zero point of a transmitter is entered as 40.02 mA, it will most likely be noticed at some point. But when it's noticed, what do you do? Just move the decimal point? Repeat the calibration?

If the error is small, the transmitter's zero point is erroneously recorded as 4.02 mA when it was actually 4.20 mA, that error may not be noticed at all. If the transmitter's current of 4.20 mA would be out of tolerance and require correction, then entering the data as 4.02 mA will mean the transmitter passed and it will continuously measure with a too-large error.

In this worst-case scenario, a data entry error will lead to a situation where a faulty calibration is being considered passed.

How to avoid calibration errors

Now that we've looked at the implications of these errors and how a small 1 % error rate can grow exponentially when taking into consideration the sheer amount of data points required for each calibration, you may be surprised (or perhaps not) to know that manual data entry is still being used in many calibration processes, even in highly regulated industries such as pharmaceutical, food and beverage, oil & gas, and many others.

As we move to a more digital world, data is becoming more important than ever. Many of the decisions we make on a day-to-day basis are based on the data we see. Data quality and integrity should be paramount to all facets of the process industry.

What if you could avoid all human errors related to manual calibration data entry?

What if, at the same time, you could make the data entry process much faster, saving time?

What, you may ask, would be the cost for such a system? Can you afford it?

In return, I would ask what are the costs of all the errors in your calibration data? What would be the value of such a system to you? Can you afford to be without it?

There has to be a better way.

Integrated calibration solutions can eliminate data entry errors

With an integrated calibration solution, you can replace manually entering calibration data with the most highly automated calibration data collection on the market.

In a nutshell, an integrated calibration system comprises calibration software, documenting calibrators, and mobile data-entry devices communicating seamlessly. Also, the calibration software can be integrated with your computerized maintenance management system (CMMS) to enable a paperless automated flow of calibration work orders from the CMMS to the calibration software and acknowledgment of the work done from the calibration software to the CMMS.

It all starts with you planning the work in the CMMS or the calibration software. When it is time to perform the calibration the work orders are synchronized to documenting calibrators or to mobile devices (phones or tablets). In the field, when you do the calibration the calibration data is stored automatically in the documenting calibrator or manually entered on a mobile device.

If you work in a highly regulated environment, mobile devices can be provided with additional data security functions to ensure the integrity of the data. The Beamex calibration solution fulfills the requirements of the Food & Drugs Act, Division C.02 and other relevant regulations for electronic records, electronic signatures, and data integrity.

This lowers the risk of ALCOA (data integrity) violations by identifying those using offline mobile devices by their electronic signature and by protecting the offline data against tampering, eliminating the possibility to falsify calibration records.

From the mobile devices, the calibration data can be synchronized back to the calibration software for storage, analysis, and certificate generation.

The calibration software can also send an automatic notification to the CMMS when the work is done.

What is the best way to handle YOUR calibration data?

Now that you know the scary truth about manual data entry, can you trust your current calibration process? If you are still using a pen & paper method, or even manually entering data into a calibration system, it may be time to wonder if that is the best way to handle your data or just the way it's always been done.

To learn more about the Beamex integrated calibration system, and how it can help you avoid costly errors related to manual data entry, please visit https://www.beamex.com/solutions/integrated-calibration-solution.

The Beamex Integrated Calibration Solution described in 1-minute – **WATCH THE VIDEO**

SELF-CALIBRATING TEMPERATURE PROBES PROVE THEIR WORTH IN THE FIELD

Endress+Hauser invented the concept and early adopters are validating the benefits

As with any game-changing new technology, when Endress+Hauser unveiled the hygienic, compact iTHERM TrustSens – the world's first self-calibrating RTD temperature sensor – there was a great deal of interest in how it would perform in everyday use. Is it as good as it sounds? It is reliable? Is it as accurate as conventional RTD probes? Is it a cost-effective alternative for the food+beverage and pharmaceutical production? Are there other benefits? Four years later, early adopters are reporting back, and the answers are yes across the board. The technology is extremely accurate and highly reliable. In performing self-calibration, the TrustSens dispenses with the eternal struggle of identifying the optimal calibration interval, where too short may be the low-risk approach but means wasted effort and expense, and too long saves money but heightens the risks of temperature drift, contamination and even embarrassing recalls. Automated self-calibration represents a material enhancement.

Tarang Patel, Product Manager, Level Temperature & Pressure at Endress+Hauser Canada explains: "Let's say you've got stable measurements that are unlikely to drift. If you are tied to a fixed schedule for manually calibrating the instrument, at some point you may inadvertently take it out of calibration. Fixed scheduling often employs a very conservative calibration interval to be on the safe side. Adhering to it will, at the very least, entail some unnecessary expense (mainly manual labour and process downtime). It also creates a non-zero risk of damaging a device that was working perfectly fine. Instruments that auto-calibrate in place perform more frequent calibrations, so accuracy is assured, but do so without the unique costs and potential risks of a manual calibration event."

TrustSens can be an enhancement over any manually calibrated RTD sensor, but provides the greatest economic benefit when performing in-situ, auto-calibration where process temperatures regularly exceed 118°C or in equipment that undergoes SIP (Sterilize in Place) on a regular basis. For example, in the case of

SIP, as steam is introduced into the process, the temperature passes through the 118°C threshold that triggers an automatic inline calibration and reports any deviations to the control system using the HART protocol. (Operators whose process never reaches that 118°C threshold can induce the self-calibration process using an external heat source. It still saves time and money.) The benefits of the TrustSens inline self-calibration include early detection of temperature drift, straightforward visual monitoring of success by LED, short calibration intervals that reduce the risk of incorrect temperature measurements, and safety and ease of handling with little or no production downtime. And the iTHERM TrustSens is FDA 21 CFR Part 11 compliant.

Here are some reports from early adopters who have incorporated TrustSens probes into their operations and compared it with the performance and calibration support required of their manually calibrated standard RTD (Resistance Temperature Detector) probes.

Case study

Pharmaceuticals – Germany – Use in medical autoclaves to reduce risks in batch sterilization

Standard practice in medical autoclave operation is to monitor the temperature in the coldest part of the process by placing a sensor instrument in the drain or near the bottom of steam sterilization equipment. As measuring instruments are inevitably subject to aging-induced drift phenomena or mechanical damage, periodic recalibration is necessary to guarantee reliable process monitoring. Should an instrument fail, there is no reliable way to quickly pinpoint the timespan and batch(es) affected in between calibration cycles, triggering a lengthy and costly troubleshooting process.

GMP rules do not prescribe specific calibration intervals; The frequency typically ranges from 6-12 months and is usually defined by company-specific SOPs. However, this involves process stoppage, manual intervention, instrument removal and associated risks such as mechanical damage. This Endress+Hauser customer, one of the biggest names in global pharmaceuticals, wanted a new approach for its operations at a sterile facility in Germany: replacing the manual calibration function by automatic in-situ recalibration between each batch (ie. each time goods are loaded/ unloaded). In the case of the steam sterilizer, the 118°C calibration point of the TrustSens is very close to the autoclave sterilization temperature of 123°C. The automatic calibration was therefore performed within the range of the desired sterilization process parameters.

TrustSens' self-calibration uses the embedded Curie temperature of a reference material as the built-in fixed point temperature reference. On average, during a one-month trial conducted in a medical autoclave, covering 600 operating hours, the test unit performed approximately 80 successful in situ self-calibrations.

On an annualized basis, that would lead to more than 1,100 calibrations, not including the manual standard calibration completed periodically as per the customer's SOP. The study showed overall process control was increased. From a cost perspective, it was determined that the return on investment would be reached after approximately 1.5 years, assuming all standard temperature sensors are replaced with TrustSens sensors.

For more on this story, **CLICK HERE**

Case study

Food+Beverage. USA. Temperature monitoring in beer-making

A regional brewery in North Carolina has over 100 standard RTD sensors in its operations. The brewery uses a combination of portable micro-baths and other calibrators to perform manual calibrations. Micro-bath calibrations use hot oil and an ITS-90 traceable reference thermometer. Each time the micro-bath is moved to a new location, the oil has to be heated to the appropriate temperature and allowed to stabilize prior to performing a single point calibration. The process takes the tech team around 45 minutes per thermometer. There is also a safety consideration, as transporting a hot oil micro-bath from sensor to sensor is hazardous if not done properly. With each calibration, production is stopped, then has to be brought back online carefully.

The brewery purchased a TrustSens thermometer for a trial to determine the time and cost savings and risk reduction it could provide. The brewery does not employ SIP, rather it uses a simple portable ceramic block heater in conjunction with TrustSens technology to perform single point calibration. The technicians remove the temperature probe from its thermowell and place it in the ceramic block heater. Once the temperature in the RTD exceeds 118°C, the sensor begins to cool and auto-initiates the recalibration cycle. The brewery tested the self-calibrating thermometer side-by-side with one of its conventional RTDs. Using the ceramic block heater, self-calibration of a TrustSens takes no more than 15 minutes, or about 30 minutes less per standard RTD. If the TrustSens is within the brewery's self-defined accuracy tolerance, a green light appears. The probe is re-inserted into the thermowell.

Replacing the standard RTDs with iTHERM TrustSens would save 80-plus hours of person-labour per year considering some sensors are calibrated annually and some twice a year. It would dispense with the hot oil bath and the inherent safety risk.

For more on this user's experience, **CLICK HERE**

Case study

Biopharmaceuticals, Switzerland, fluid monitoring throughout bioprocess

A well-known global manufacturer of vaccines and other pharmaceutical products wanted to cut down on production downtime while automating calibration to minimize the risks in bioproduction. The iTHERM TrustSens was installed in thermowells in a buffer tank inside a pilot plant fermenter as well as in the fermenter itself. The TrustSens sensor was used for test purposes over a period of four months. The average deviation proved to be only 0.03°C, which is 10 times better than the maximum permitted error at 120°C of a conventional Pt100 class AA sensor, proving the TrustSens' accuracy and reliability.

Such performance earned kudos from the customer. It noted the probe's capability for early detection of temperature deviations assures early fault detection. Short calibration intervals reduce the risk of incorrect temperature measurements, which is vital in such bioprocesses. It also provides traceable storage of the last 350 calibrations. Easy installation and straightforward commissioning meant the TrustSens would save the customer a great deal of time and money in installation, maintenance and monitoring.

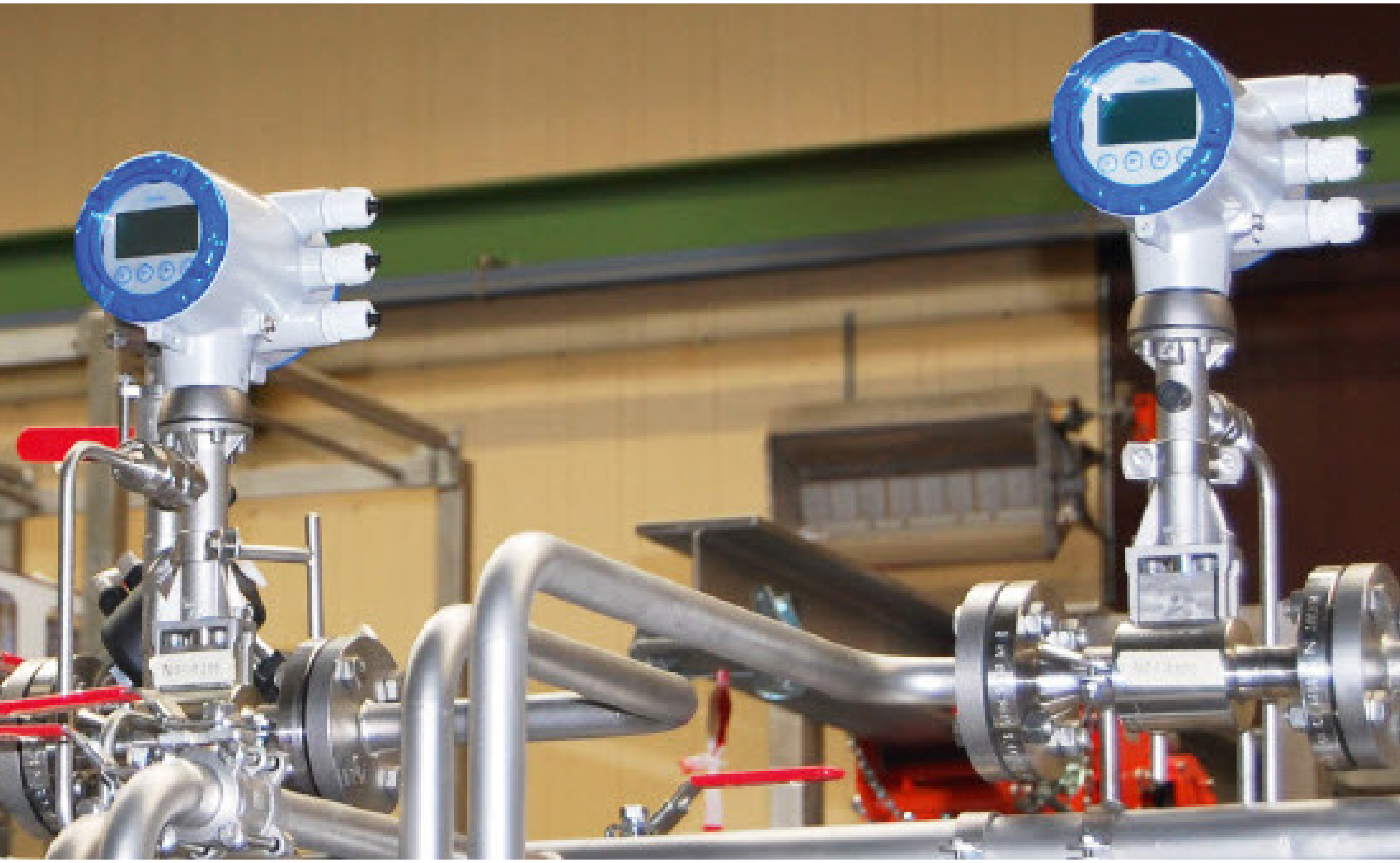
For more on this customer's experience, **CLICK HERE**

Another benefit of TrustSens is facilitating SOP and regulatory compliance. When employing the TrustSens temperature transmitter with Heartbeat Technology™, calibration results are captured after every successful self-calibration. When technicians need the calibration history, they connect to the transmitter via a laptop, or download the data from the control system. Printable calibration certificates can also be produced via TrustSens' DTM in preparation for audits. The TrustSens probe eliminates the risk of undetected non-conformance issues without impacting existing, validated procedures or GMP.

For more information on the Endress+Hauser iTHERM TrustSens series, **CLICK HERE**

Or for a deeper dive into how the iTHERM TrustSens works, **WATCH THIS VIDEO**

INTEGRATED ENERGY MEASUREMENT FOR HEATING AND COOLING, COMPRESSED AIR, STEAM AND CUSTODY TRANSFER



Did you think energy costs would stay steady?

By Alec O'Keefe,
KROHNE Inc.

Regardless of what point in the energy cycle we are at, continuing global volatility of oil and gas prices is a given. Accurate energy measurement is needed in process applications that involve heating and cooling; compressed air; steam production and distribution; heavy fuel oil consumption; energy monitoring; and custody transfer.

In the past, instruments that together measured energy use might include a flowmeter, temperature sensor, pressure sensor and flow computer.

Recently developed technologies integrate tasks that used to take several different devices to perform. The measurements taken are more accurate than those of the older systems as well.

One innovation example is a vortex flow meter featuring integrated pressure and temperature compensation. With accuracy of 1.5 percent, it is two to three times more accurate than older systems in which the individual measurement devices have accuracies between 3 and 5 percent.

Let's look more closely at why each area needs accurate measurement and at solutions and practices that increase energy measurement precision.

Heating and cooling

A further incentive to accurate measurement in heating and cooling of industrial workspaces and office buildings involves regulatory concerns related to reducing CO2 emissions.

Many different type solutions are installed, involving wide ranges of pressure, temperature or flow.

For example, a heat meter installation includes supply and return lines equipped with temperature measurement devices. Flow measurement is inline and clamp-on options are available, regardless of whether heating or cooling is involved. Figure 1 is an example of a heat meter configuration, along with devices available for each measurement task.

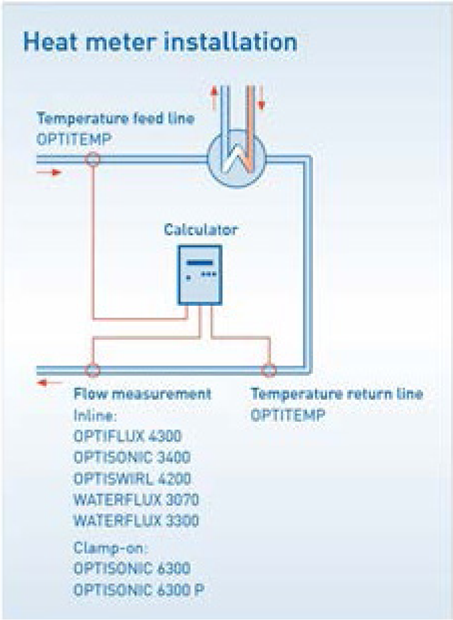
Also common is the need to measure heat quantities consumed in industrial production areas by equipment like steam generators, clean-in-place systems, heating-circuit production, or ventilation systems. Here, both the flow rate of the heating fluid (typically water) and the difference in temperature before and after each consumption point must be precisely measured. Operators are looking to determine both individual and total heat demand for allocation of operating costs to appropriate consumers and to establish total heat balancing.

Ultrasonic flow meters are meant for these type heat measurements. Clamp-on options retrofit to existing heating and cooling applications when processes cannot be interrupted.

Compressed air

Virtually every production operation has a compressed air network but rarely are these networks monitored for actual consumption rates. This is a major, and costly, oversight. Easy, significant cost reduction is possible if the compressors providing compressed air are controlled against actual consumption. Even with energy prices below 10 cents per kilowatt-hour, it is worth monitoring the compressed air system since annual costs created by leaks or untapped output can easily run up into the five-figure range. Only when consumption rates are measured can processes be controlled and optimized.

Figure 1



Studies show even a flawless compressor with maximum efficiency achieves only 85 percent of rated efficiency. Oil filters, air filters, motor speed and humidity at the inlet of the compressor and inlet filters are among factors that contribute about 8 to10 percent of this efficiency reduction. That is why it is extremely important to measure the compressor's free air delivery (FAD), which is defined as the amount of atmospheric air (free air) that can be sucked in by the compressor at the inlet condition (suction side) under the following conditions:

- Atmospheric pressure of 1 atmosphere
- Atmospheric temperature of 20 °C/15 °C
- Relative humidity of 0 percent (100 percent dry air)
- Motor speed (rpm) of 100 percent of its rated speed

For example, the KROHNE OPTISWIRL 4200 vortex flow meter is used to identify leaks, as well as monitor compressor efficiency, consumption profiles and peak consumption through integrated temperature and pressure compensation and free-air delivery (FAD) software. It essentially measures the amount of free air that meets the stated air conditions, providing an assessment of compressor efficiency.

Suppose for example a compressor is set to run at 800 rpm, and should suck in 8,000 cubic feet per hour, which represents the compressor's highest state of efficiency. If the meter says it is sucking in only 7,500 cubic feet per hour, this signifies that the compressor is not as efficient as it could be.

Daily wear and tear

There is a certain amount of wear on a compressor that runs every day, and efficiency goes down gradually. Every compressor has a maintenance interval after which it is shut down for maintenance. A typical production line shuts down every four to six months, during which the crew maintains the compressor and changes parts.

Using a vortex meter allows maintenance crews to report actual compressor efficiency and adjust maintenance intervals accordingly. Let's say there was a maintenance shutdown two months ago, but the device shows compressor efficiency falling rapidly. The maintenance crew can shut down and maintain the compressor before it breaks and time is wasted waiting for spare parts.

On the other hand, let's say compressor efficiency is excellent. Instead of shutting down, one can leave the compressor running and schedule the maintenance to take place only when the meter indicates reduced compressor efficiency. Working this way allows plants to reduce maintenance intervals.

Operators want the compressor to work efficiently so less energy is needed for the same output Many companies have compressed air systems with leaks everywhere in the plant; each leak fixed may save a plant as much as $250 a month.

Steam production and distribution

Every major production process, including pasteurization, brewing, sterilization, washing and cleaning requires steam for heating. Supplying steam consumes energy because boilers are fired with liquid fossil fuels or natural gas. Accurate measurement of steam produced is a prerequisite to efficient burner control.

Steam generation is dependent on temperature and pressure. As pressure changes, steam changes from super-heated to saturated and then to condensate; a change can come with every valve or pump or elbow in a process line.

Steam processes are inconstant, and steam is affected each time a process changes. To regulate steam, operators must be aware at all times. Unfortunately, many plant operators do not understand steam regulation importance, or lack the right equipment. With the pressure- and temperature-compensated vortex flowmeter, operators always know if it's at super-heated steam, saturated steam or condensate steam.

Figure 2

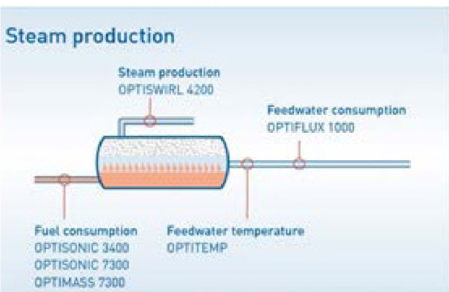


Figure 2 shows devices used to measure fuel consumption, steam production and distribution, and boiler feedwater consumption, to fully analyze steam system efficiency.

Even though steam boilers are efficient, the steam system as a whole is considerably less so, due to non-insulated steam lines, leaks, contaminants or faulty condensate separators. Often operators overlook the pressure and temperature fluctuations that can occur during the process. These fluctuations impact the measuring error of a system, which can result in a high loss of energy. Exact measurements help identify losses and increase efficiency.

Figure 3 shows energy costs when measuring saturated steam and superheated steam. Small changes in steam temperature or pressure make a huge difference in what customers pay. As noted, a classic system with a variety of devices has an accuracy of between 3 and 5 percent, while one with integrated pressure and temperature compensation like the vortex flowmeter in question has an accuracy rate of 1.5 percent. Depending upon application and design, use of the standard measurement configuration could be as much as $50,000 more a year than use of a system with integrated pressure and temperature compensation.

Figure 3

Energy costs when measuring saturated steam and superheated steam

	Saturated steam		Superheated steam		
Operating pressure	75 psi	250 psi	25 psi	40 psi	65 psi
Temperature	+320 °F	+406 °F	+350 °F	+330 °F	+350 °F
Measuring error at pressure deviation ±15 psi	16 %	5.50 %	39 %	28 %	19.50 %
Measuring error at temperature deviation ±18 °F	21 %	18 %	2.50 %	2.50 %	2.50 %
Unaccounted energy costs* at pressure deviation ±15 psi ($) p.a.	$ 163,764	$ 127,152	$ 165,176	$ 170,302	$ 169,613
Unaccounted energy costs* at temperature deviation ±18 °F ($) p.a.	$ 218,658	$ 415,027	$ 9,989	$ 15,249	$ 22,228

(**Nominal pipe size 4", 60 % capacity, energy costs $ 12.85/1000 lbs)

Fuel oil consumption

Oil is used for energy and heat in industrial production. Often combined coal-oil burners can be used. To start the combustion process and support the coal fire, oil is used for the booster and supporting burner. Also, fuel oil is used to start natural gas turbines.

To get the ideal fuel ratio between oil and air, operators need precise mass measurement in the oil and air lines. Because of heavy oil use, a circulation line is used to heat the oil and reduce viscosity. To get the correct consumption value, the supply and return lines to the oil tank must be monitored.

One way to measure the consumption of heavy fuel oil (HFO) on each boiler is with a Coriolis mass flow meter. Accurate measurement allows operators to monitor the usage of HFO closely and precisely and to evaluate the plant efficiency.

When oil or gas is transferred from one party to another, the parties have to agree on the product quantity and quality. This type of custody transfer involves assurances for both parties. Devices must be calibrated and certified according to international standards, such as Organization Internationale de Métrologie Légale (OIML), API (American Petroleum Institute), AGA andNational Type Evaluation Program (NTEP).

Calibration should be done in accordance with ISO/IEC 17025, accredited and traceable to international and national standards. Regular inspections by national metrology institutes, round robin tests and alignments with national and international metrological standards according to ISO 9000 and EN 45000 should be made to guarantee the quality and comparability of calibration rigs used for these meters.

Depending on line size, the length of straight run and simple customer preference, either a Coriolis mass flow meter or an ultrasonic meter is used here.

Savvy plant operators are looking for ways to make processes more efficient. Appropriate technology solutions and best practices can lead to significant energy savings for plants of all kinds.

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