THE WHY, WHEN AND HOW OF CALIBRATION

If you need to calibrate, what do you need to think about? In many different industries the flow in pipelines needs to be measured with different accuracies. Accuracy is defined based on the importance of the amount of liquid, gas or a combination of these, measured in a process. A process can be for safety; for example a minimum amount of cooling water in a nuclear plant or quality control in a dairy factory to make sure the product is safe to consume. Next to safety and quality control, a measurement process can be for billing the amount of fluid passed through a custody transfer application; for example natural gas crossing the border of two countries. If you are responsible for maintaining flowmeters within the required accuracy for these processes, would you calibrate these meters?

Improved measurement technologies

Flowmeters are initially calibrated to prove accuracy, but flowmeters are also calibrated when standards, legislation, contracts or other written documents require mandatory calibrations to demonstrate possible drift or other expected changes to the flowmeter reading. Over time, flowmeter measurement technologies have improved and newer types have been developed and put into operation. The question is when improvements are made if an annual calibration is still needed, especially if built-in diagnostics can predict when a calibration is needed. Would you wait for a calibration until the flowmeter tells you it needs to be calibrated, do you strictly follow annual calibration requirements or do you do something else?

Re-calibration period

In the past, attempts have been made to create a standard, recommendation and/or guideline to determine re-calibration intervals for flowmeters. End users, manufacturers, metrology institutes and calibration companies worked together, but the commercial interests of all these parties are different. Many of us in the flow

Erik Smits, VSL, The National Metrology Institute of the Netherlands,
details the factors to be considered when calibrating flowmeters on pipelines.

measurement community have participated in committees to develop standards and we know compromises are needed to come to a common goal: namely, what would be the best solution for your applications and the investment needed for calibrations. It may be that fully independent organisations like universities, that base the re-calibration period on scientific evidence of independent testing and data provided, would be required to write such a standard.

The one thing we need to ensure is that the flowmeters we control keep performing within the accuracies and/or tolerances the companies we work for set in their procedures. As in the examples above, where not enough cooling can cause a major accident, bad quality control can lead to customers getting ill or where a lot of money can be lost. Once we have determined a re-calibration interval there are other things to consider. For simplicity, from this point forward we will focus on custody transfer of liquids in pipelines.

Custody transfer

Pipelines can be smaller than one inch or larger than one hundred inches. Typical custody transfer applications are not this large and in a case of a larger pipeline it is often split up into more pipelines. This makes it possible to use flowmeters that can be calibrated at their maximum flowrate. With multiple meters it is a good practice to have an additional meter that can be rotated through for normal operation. Then every flowmeter can be sent for calibration to a calibration facility/laboratory without interruption of the process.

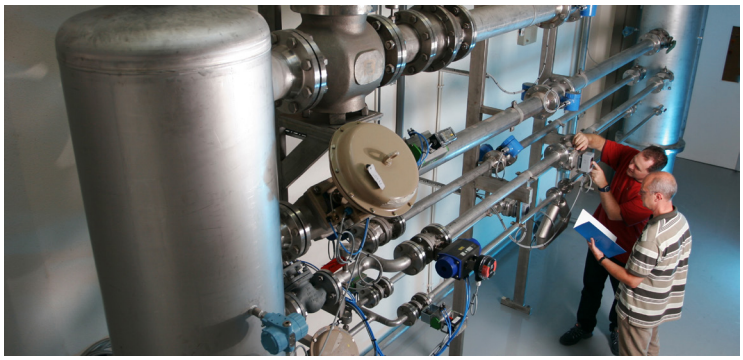

Figure 1. Master meter section in VSL flowmeter calibration facility.

Figure 2. VSL LNG flowmeter calibration facility.

How to calibrate

So now you know your flowmeter needs calibration and you need to know how to calibrate it. In some cases, the application the flowmeter is operating in was designed for a calibration possibility. In case of a natural gas application, this can be a master meter in a so-called Z configuration. The to-be-calibrated (or proved) flowmeter is set in series with the master meter in the Z configuration. Be aware that the master meter needs to be sent on a regular basis to a calibration facility/laboratory. If the master meter is of the same type, size, manufacturer etc, it might change in the same direction as the flowmeter used in the application for the custody transfer, so regular calibration is an essential step. Also be aware that the master meter needs a much better accuracy, preferably three to five times better depending on the standard to be applied. What happens a lot of times is that companies who sell these applications claim the master meters have the same accuracies defined in standards and provide recommendations for which accuracies the duty flowmeters should be working at. All standards about calibration tell us that instruments and measurement standards need to be used with better accuracy to prove the instrument to be calibrated.

In liquid flowmetering applications next to a master meter it is possible to have a pipe prover available for the calibration or even a proving tank. In this case the volumes of the pipe prover and proving tank need to be calibrated on a regular basis based on standards. The calibrations of these volume instruments can be done both at the location of the application or in a calibration laboratory. One thing to consider is that no damage can occur for transport if calibrated on location. The good thing about these instruments is that they are a different technology than the flowmeter.

Onsite calibrations

Mobile units for all three calibration methods are available in some areas of the world. Calibration services are provided by a variety of companies on the location of the application. They bring calibrated master meters, pipe provers or proving tanks to calibrate your meters. For onsite calibrations special connections need to be in place to connect the mobile equipment. Access to these connection points is essential as calibration units can be larger than you expect. Calibration in your application is a common practice in liquid flow operations but less so in gas flow.

Calibration facility

When onsite calibration is not possible you could choose to send the flowmeter for calibration to a calibration facility/laboratory or even back to the manufacturer. If you choose to send the flowmeter to a laboratory you need to make sure the laboratory can match or get close to the conditions your flowmeters are operating at. There are a variety of facilities available around the world so choose wisely. Most of the time there is more than one facility that you can use. There are enough cases where it will be difficult to find a facility that can match the field condition of your application. In the world few facilities are available

Figure 3. European Center for Flow Measurement, VSL.

for flow calibration at elevated temperatures or even cryogenic temperatures. The same is true for high pressure, low or high viscosities and high and low densities. In your application one of these parameters can influence your flowmeter. Make sure to investigate these influences a bit more when someone is telling you that it is no problem. This person might have a commercial interest and want to sell you a flowmeter or a calibration. Good advice can save your company a lot of money and problems in business operation. Always think about the accuracy you need, to prove at what kind of conditions and how many flow rates are needed to demonstrate this.

Metrological design

When you design a new custody transfer application, think ahead about what the best situation for your re-calibration needs would be. We call this the metrological design. The metrological design is a service many companies ask VSL to help with as an independent institute who can advise on metering. The initial cost for your calibration equipment and training of staff can be higher but your return on investment will be within a short reasonable period of time, due to the better results. The advice can result in a better solution to send flowmeters for calibration to a calibration facility or in having someone with a mobile unit to connect to your application. In many cases this independent advice can give insight into the correct decision at the time of the investment. This starts preferably at the moment you need to put the first lines on paper.

VSL

At VSL we have a long history in calibration of flowmeters (predecessors of VSL started around 1900) both with mobile units and in the laboratory. Next to flowmeters, the standards used for these calibrations as previously mentioned (pipe provers, proving tanks and master meters) are all calibrated by VSL, in our laboratories or at your location. Due to our role as the National Metrology Institute we have developed calibration facilities for ourselves as well as others. VSL maintains all the measurement standards for the Netherlands and this means the standards in flow measurement for high pressure natural gas flow up to 60 bar, a cryogenic standard that can calibrate flowmeters with LNG and liquid nitrogen and standards for gas flow calibration around atmospheric conditions.

The VSL LNG flowmeter calibration facility is a unique facility and the only one of its kind in the world. Flowmeters can be calibrated at temperatures as low as -190 °C or at -165 °C when we fill the facility with LNG. Due to the extreme cold temperature, flowmeters and other equipment behave differently from what you expect based on ambient conditions. Next to flowmeters, sampling systems for LNG are tested with this facility. There are still a lot of unknowns for flow metering and composition determination at cryogenic conditions so the facility is very important for R&D projects.

European Center for Flow Measurement

VSL's newest design is a brand new facility for liquid flow meter calibrations that will be realised in the port of Rotterdam, the Netherlands. It will replace the current facility in Dordrecht and will increase the flow to 2500 m^3/h. The new liquid flowmeter calibration facility realised in the "European Center for Flow Measurement" for high flow will be ready in the second part of 2022. In this facility, larger flowmeters can be calibrated independent with high accuracy. This is a good thing if you need mobile master meters to be calibrated. It is difficult for the industry to find independent calibration facilities for larger flowmeters. It is even more difficult to get these calibrations performed at National Metrology Institutes. With this facility VSL will fulfill these wishes from different industries, both end users in all kind of industries and the manufacturers of flow meters. A one stop shop for large and small flowmeters is essential for business operations of these companies. The facility will be using water as test liquid. Water has always been the main liquid for R&D purposes of newly designed flowmeters. It is also possible to test other equipment used in pipelines in this new facility.

Why would you calibrate your flowmeters?

Well, you calibrate only when it is needed for your business operation and when it will benefit your company. It will only benefit your company by choosing the correct calibration. For this calibration you need the best solution for your flowmeters. It needs to be suitable in terms of a correct location, the fluid, the calibration accuracy, etc. When designing an application for safety, quality control or custody transfer, do not forget to think about calibration in the future of all instruments in the application, 'metrological design'. With a solid metrological design calibration might not be needed as much as in an older design where the metrological aspects are not considered completely. Many times we see that an application that always needs to be in use and the flow or indication cubic meters per hour or kilograms per hour is crucial in the application, but the flowmeters can't be calibrated in the application or can't be taken out. In that case you can't calibrate until the application shuts down. This delay in calibration can have an impact on your safety, your health or the financial risks of your company.

If you do not know how to answer the question stated, feel free to contact VSL or another independent party to advise you about accuracies needed for your application and how to maintain this for as long as possible.