TRANSCAT WEBINAR

Differential Pressure Meter Gas Custody Transfer Calibration

Joel Hartel | Fluke Calibrations

In this “How to” webinar, Joel Hartel of Fluke Corporation details the critical instrument, measurement, and technique considerations when performing Gas Custody Transfer Calibrations with Differential Pressure Meters.

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Good morning, my name is Joel Hartel I work at the Fluke Corporation as a vertical specialist in our oil and gas group, and today I’m going to be discussing differential pressure meter gas custody transfer calibration and how to use your test tools in order to get the best custody transfer calibration you can.

So what we’re going to talk about today is 3 main areas. We’re going to have a quick introduction on why calibration matters in gas custody transfer, we’re going to talk a little bit about differential pressure meters vs. ultrasonic, and we’re going to mention a couple other meters while we’re at it. We’re going to spend the bulk of the presentation on test tool considerations. So, we're going to talk very deeply about pressure calibration test tools, temperature calibration test tools, and then we're going to go into an extensive discussion on the various types of specifications of calibrators and what they mean for the end user.

Last, we're going to cover what I call curriculum topics. This is primarily going to be a process overview along with some of the considerations for both unit under test and how to be safe under high-pressure circumstances. This will all only take about 10 to 15 minutes overall. Overall, this webinar should take about 45 minutes.

Why Does Calibration Matter in Custody Gas Custody Transfer?

So, let's jump right in. So, why does custody transfer matter? Why does calibration matter for custody transfer? Well, custody transfer is, as the presentation says, the cash register. Fundamentally is means that because we have such high volumes going through pipe lines, even small errors are going to have significant financial impact. And there's a lot of contracts written around custody transfer. They're written around either mass flow rate. They describe the btu value of the gas to transfer, and there is frequently a turndown specification, that is, how much the maximum flow can be from the minimum flow. These are all specified in legal documents.

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Dispute Resolution: Custody Transfer is the Cash Register

Typically, there will be multiple transfer meters at a particular location. And they all need to agree with each other. There will frequently be meter provers installed as well. And if everything doesn't agree, dispute will arise.

When that dispute rises, your calibration records are frequently very important inputs into resolving that dispute. Who's right? Who's wrong? Who pays who? Who owes what? So, the quality of your records matter a great deal, as well as, how did you calibrate? What are the procedures you used?

Things like the API standards can help you with the standards portion, but your calibration records are going to be critical inputs.

Well, obviously, I can't go into too much detail. We have seen several instances where calibration records were inspected as part of the dispute resolution process. And they are very crucial records.

I'll talk a little bit about documentation later. But primarily now at this point it's why you need your good calibration records in order to support your custody transfer claims.

Maintain your custody transfer measurement traceability by calibrating your equipment with Transcat’s ISO 17025 Accredited Pressure Calibration Services.

The focus of this talk is going to be on flow rate. Fluke specializes in pressure, temperature, and electrical measurements. We don't do a lot of work around gas sampling. There are, of course, many potential errors in your gas sampling, and as that btu value is frequently specified in the contract, that's a separate area, so that's going to be out of scope for this particular discussion.

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Differential Pressure vs. Ultrasonic

So what are the various types of meters that are out there? Why differential pressure? Why not ultrasonic? Well, ultrasonic flow meters are very well suited for interstate/intrastate pipelines, high flow rates. You're covering a long distance. You don't want large pressure drops. You really don't want to have to shut the pipeline down to do maintenance. And obviously, the fewer moving parts you have, the less likely that the unit will fail.

Looking for an Ultrasonic Flowmeter? Transcat offers the GE's Panametrics PT878 with Free Tools in a number of VIP Kits!

The other thing that's really nice about them is they have wonderful turndown characteristics. You frequently can get 50 to one in an ultrasonic meter, whereas a differential meter might only be three to one.

As I'm sure a lot of you have heard, there's a lot of buzz about ultrasonic meters, what they can do for you. And the manufacturers of these meters are pushing very, very hard for them to be introduced. And yet, after all of this effort, as much as 50% of the dollars spent in a given year are on ultrasonic meters. They are only 5% of the units.

About 90% of the units sold today are some form of differential pressure calibrator. Why? Well, A, we've got a lot of history with them, so they're cheap and they're simple. There's a larger place in the market that comes from the previously existing installed base, and they're very well understood.

We have to a great deal of data as well as well-written and well-proven standards across the industry, across the globe that allows us to do that.

I've listed some of these standards here. [insert slide] I'm not going to put a tremendous amount of detail on those standards. Obviously, anyone who is a specialist or professional in this area should be very, very familiar with the standards.

One other portion about differential pressure is that, especially with what we're seeing in the fracking industry, differential pressure meters are relatively accurate with what gas. A group did a paper last year at the American School of Gas Measurement Technology, and they basically said they could correct within 2%, which is something that the average ultrasonic meter very much would struggle with.

So, they've got some very nice characteristics for gathering pipelines or things that are upstream of a processing plant where you might have water or other contaminants in your gas flow.

Test Tool Considerations

Pressure Calibrator Selection Considerations

So, let's talk now about selecting test equipment. Let's talk about the types of compressor calibration test tools that are out there and some of the advantages and disadvantages of each.

Electronic Pressure Calibrators

By far the most common are electronic calibrators. The big advantage for them is they are very easy to set up and read. They don't require a lot of specialized knowledge to use. There are a bunch of manufacturers in this space and several of them have given you a choice of percent for scale or percent reading plus floor. We'll go into that in some detail. There's also a lot of existing choices for pipes and fittings.

A lot of the manufacturers who make calibrators will also make the pumps and fittings to support it. Pretty much the two most frequent kinds you'll see will be pneumatic or hydraulic, and you can get any variety of fittings to meet your tubing and connection needs. So, there's a lot of good stuff available out there.

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Deadweight Testers

We'll talk a little bit about deadweight testers. Deadweight testers actually provide highest possible accuracy. So, obviously we talked before, because it's the cash registry, even small errors have an outsized financial impact. Deadweight testers can give you the best possible accuracy.

Compare Fluke's Most Popular Deadweight Testers with Transcat's Fluke Deadweight Tester Selection Guide!

The caveat to that is it's only under the correct conditions:

So, for example, the unit needs to be level. You'll need to make an adjustment for local gravity. Making an adjustment for local gravity can be quite challenging. If you are more than 3000 feet above or below where the unit was calibrated, or if you are more than three degrees outside of the latitude where the unit was calibrated, you will have to make an adjustment.

If both your altitude and your latitude have changed, there's actually a formula that you have to calculate in order to determine how far away you are if you need to make an adjustment, how big that adjustment needs to be.

It's very, very difficult for all but the most skilled techs to get this calculation and the leveling and all of the other things that need to be done exactly right in order to achieve this maximum accuracy. And frequently under field conditions, it's just not possible. You're working out of the back of the pickup truck, and even if you worked very, very carefully, it's virtually impossible to replicate the accuracies that you would find in a lab.

And so, frequently, even though deadweight testers has a great deal of potential, under field conditions, they are usually not as accurate as an electronic calibrator.

Two other small things. Because the unit will compensate for some leakages, there's actually a benefit when you're in the lab. It's actually a problem when you're in the field. It's harder to detect leaks in your setup and obviously when you're setting up and tearing down pretty frequently, it's easy the introduce leaks. And it doesn't account for the pressure drop in your test hoses, which you have to calculate that yourself.

The other thing it won't do is, because it's compensating, if you actually have a leak elsewhere, say for example, in your meter. If you can't really see that, if you haven't isolated it, and your leak check wasn't thorough enough when you reset it up, frequently the electronic pressure calibrator, you can watch the pressure drop. However, if you do it with a deadweight tester, you may have some trouble determining if you actually have a leak of not. And it's very expensive to have to go back out there and do another check because the person will catch your measurement balance engineer who will look at your data and say, "Wait a minute. Why is this unit drifting over time?

Temperature Calibrator Selection Considerations

Moving on to temperature calibration test tools. We're going to talk about three main types. The main one that people use is a precision thermometer. They basically will be a specialized tool, although some manufacturers have actually integrated a precision thermometer into a electronic pressure calibrator to make an all-in-one tool. They'll primarily use an RTD probe. The probes are -- assuming they were designed for an industrial application -- are usually quite rugged, however, it is quite possible to damage them. And you should spot check them periodically.

The easiest way to spot check them is some with like a dry block calibrator, so the dry block calibrator here I've got pictured, you actually can insert your RTD probe and verify that it's reading a correct amount and set the dry block calibrator to hold a particular temperature. And then you'll verify that your precision thermometer or RTD probe system are working properly.

Actually, the unit that is shown here can also verify installed probed on the pipeline. If you use this one, for example, is conjunction with a documenting process calibrator, it actually can auto-control the dry block and you can insert your transmitter into one of the wells and basically allow the unit to auto-calibrate. So, it's something you can actually set up and walk away from and have the unit basically verify that the transmitter is correct. Excuse me. That the probe is correct prior to reinstallation of the lines.

Last but not least, we'll talk a little bit later about low flow conditions. But under certain low flow conditions, you can't trust the RTD probe meter. You actually have to simulate it. So, I've got a picture here of a RTD simulator. They will actually simulate the signal into the flow computer. That will basically allow you to complete the calibration despite the fact that you can't get an accurate temperature measurement or a representative temperature measurement.

However, it does not act to verify that your RTD sensor is actually functioning properly. So, if you're going to use a simulator, having a dry block calibrator can be a very handy thing to ensure that both the probe and the transmitter are effectively calibrated.

The last thing is the latest version of these electronic simulators are every bit as accurate now as decade boxes. So, they are a very high-accuracy tool, and they are very useful.

Percent Full Scale vs. Percent Reading + Floor

So, we're going to talk a little bit now about percent full scale versus perfect reading plus floor. So, in the old days, analog sensors were all specified in percents full scale. Well, digital is a different technology, and it's basically allowed manufacturers to try other ways of specifying. And one of the more common ways you'll see is to specify a percent reading plus floor value. And the idea here is that it allows you to get away from one of the big disadvantages of percent full scale which is as you move higher in the range, your accuracy will effectively increase.

The reason I say that is that when you have a low value, a percent full scale will have a constant error across its range. Whereas a percent reading plus floor will actually have a lower error value. So, what that gives you is it basically allows you to say, "Okay. I don't need to worry as much about picking the lowest possible range for the work that I'm doing. I can pick a unit and use it across." For percent full scale, that's not an option, however, there are some other strategies that you use for percent full scale that you can use.

So, for percent full scale, as we discussed, because the error relates to the full-scale value of the unit, basically you want to pick the lowest possible value that you can get away with. What we'll frequently recommend for people who are looking for a unit like this is to say, pick the unit that is about 80-90% of the work that you do.

So, let's say you primarily are working at 12-1400 psi, and then every once in a while -- one out of every 20 transmitters -- you might get up to 1850. We'll recommend picking a pressure value of 1500 for most of your work and then having a separate pressure module that will cover that higher scale on the rare occasions that you actually need it. This will give you better overall accuracy most of your work. And then when you do need that additional work in those higher ranges, you can get it done.

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Disadvantages of Percent Reading Plus Floor

So, what's the disadvantage of percent reading plus floor? Well, the bottom line is that the percent floor spec is not always achievable. There are many things that can influence the total error that you actually see. So, even though it would appear that the unit is very accurate, it's very easy to get outside of either the operating conditions or perhaps you have a leak and there are other problems and you can't achieve that floor spec.

A great example of this is if you take the unit, and in a lab, there's no question that a unit will be able to achieve the floor spec. But if you just take it into your living room or your kitchen, you turn the unit on, place it on the table, hit the zero button, and walk away.

If you sit there, you can actually watch the zero shift. And your living room is nowhere near as rugged as the field can be. And so, it can be very, very hard to really achieve these values in the real world.

So, what's the bottom line?

Basically the more accurate and precise a calibrator is, the better it is. But the real requirement actually relates to how accurate your calibrator is compared to the transmitter that you're trying to calibrate. Keep in mind that raw accuracy isn't enough. It's the relative accuracy between your calibrator and the unit under test that really, really matters.

Percent Full Scale vs. Percent Reading + Floor Example

So, let's compare some two calibrators that use these different specification methods in order to determine which one is more accurate at various points.

So, here you see a graph of two calibrators, A and B. Calibrator A is specified as a percent of full scale. Calibrator A is the yellow line. Then you have calibrator B. Calibrator B is specified as a percent of reading plus a floor spec. It's the red line. On the y-axis you'll see the spec error. So, the higher the number, the worse it is. So, the line that is lower is better. And this is done over a range of units from zero psi all the way up to 1500 psi.

These two unit are real calibrators. I'm not going to mention who manufacturers which one because the point is to compare the specs and the advantages and disadvantages of both. So, if you look at... You're trying to look at the lower line as the better unit. So, here you'll see that calibrator B, specified as a percent of reading plus floor, actually is better over the bottom third of the range. However, calibrator A, specified as percent full-scale, is actually better over the upper two-thirds of the range.

So, depending on the values that you're trying to calibrate, it actually will change which calibrator and which specification type you'd like to have. This is why when you're picking a calibrator that's specified as percent full scale, it's so important to pick the lowest one that will cover the majority of your use cases. It gives you a better error, and it basically moves this yellow line down and allows the calibrator to actually have higher accuracy over a larger portion of the range.

This graph is pretty easy to understand and is pretty well defined. But as I'll show you in the next graph, which is also from the same two calibrators, things get a little stranger when you get into very low pressures and into vacuum.

So, here are the same two calibrators. Again, calibrator A is percent full scale. It's the yellow line. calibrator B is percent reading plus floor, which is the red line. Again, the y-axis is a spec error and psi. And so, the lower line is the more accurate line. Right around zero psi, calibrator B is more accurate. However over most of the rest of the range, calibrator A is more accurate.

And so, things are not always as obvious as the previous graph. <span >**And frequently, especially if your work is right around zero to one atmosphere, either a vacuum or pressure, you really have to draw these graphs in order to understand which one will be better for you.** This is something you shouldn't expect a technician in the field to do. This is something that your measurement staff should really be doing for you and helping you decide.

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Gas Custody Transfer Procedural Overview

So, let's go over a high-level procedural overview, and we're going to re-visit calibrator A and calibrator B and talk more about test ratios. So, at a very high level, the custody flow calibration looks very much like this. There's a setup, you isolate the valve and do a leak check. You'll take three measurements -- differential pressure, static pressure, and temperature. The key thing to note is the two pressure measurements are very different scales. Differential pressure is frequently just a couple hundred inches of water. Whereas, static pressure is anywhere from zero -- or even vacuum -- up to 2000 psi.

So, frequently what will end up happening is that you'll need different ranges in order to do these measurements. There's also a temperature measurement. Pipelines tend to be in the ambient range, whereas wellhead temperatures can vary quite a bit, depending on how deep the formation you're pumping out of.

Last but not least, there's return to service and clean up. So, we'll talk a little bit more about what all of that. Oh, the other thing I'd like the mention very quickly. The key measurement is the differential pressure measurement. It supplies the largest component of error into the flow equations that would be in the back of those standards that we talked about earlier in the presentation.

Unit Under Test Considerations

So, let's talk a little bit about the unit under test. So, the pressure device under test has a range -- it's usually determined at the time of manufacture -- and it's also specified as a percent of input full scale. So, we talked a little bit before about picking your calibrators to say, okay, it has to be as low as I can possibly get it. Well, the optimal thing to do is to actually match the range of your test equipment because that is the lowest possible range.

So, if you're going to say, do your calibration from zero the 1500 psi on a Rosemount 3051, well the best calibrator you would have would also be from zero to 1500.

Again, I talked before, if you have two pressure ranges, you need two tools. One of the things manufacturers have done, is they've actually combined two pressure ranges into the same tool. So, there will be two ports, and there will be a low-pressure port for the differential pressure measurement and a high-pressure port for the static pressure part of the measurement. These are frequently referred to as dual-port electronic pressure calibrators. I'm not even going to try to make the acronym pronounceable, but there are several manufacturers who do those.

Test Uncertainty Ratio (TUR)

I'm also going to define something called test uncertainty ratio here. The test uncertainty ratio basically looks at the entire measurement system and says, okay, what are all the sources of uncertainty in this system, everything from the accuracy of the transmitter to the accuracy of the unit I'm testing. What about the skill of the person doing the calibration? What about the ambient temperature conditions? What about electromagnetic interference? There are all kinds of possible sources of error.

And these are the sorts of things that your measurement staff or your metrologist will be working on. Now, in the metrology world, historically a long time ago, ten to one -- that is, your calibrator needed to be 10 times more accurate than the unit you were testing -- was the standard ratio. Over the years as both calibrators and the units under test got more accurate and more reliable, that number has dropped to four to one. You see it's very common now in bench testing. So, if you go into your measurement labs, you'll frequently see TURs for around four to one. It's very common in nuclear and in the military, so the labs that they have will be in the four to one.

Unfortunately, it's (4:1 TUR) frequently not possible. What we're actually seeing is, as that as the transmitters get more and more accurate, it's harder and harder for the calibrators to maintain that spacing. And so, frequently, you'll actually see TURs in the two to one or three to one range.

So, what does that mean? Basically, a lower TUR means that you are less certain in your results. So, let's say that you perform a calibration and the unit is just barely out of calibration. It's just out of tolerance. So, normally you'd say we have to do an adjustment. Well, if the unit has a low TUR, or if the calibration has a low TUR, you actually might not be out of calibration. The lower your TUR, the less certain you are that the unit...that your calibration was actually correct.

So, if you ran that same calibration again, there is a reasonably good chance that you might actually find that the unit is in calibration. And now you have a problem because you have an in tolerance reading and an out of tolerance reading. Which one is correct? And so, then it becomes very, very difficult to figure out what do I do next. Is this reading valid, or should I make an adjustment? This can be a very significant problem and it's getting worse all the time.

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mA Output Considerations

The last thing I want the mention -- and we're going to talk quite a bit more about TURs, and I'm going to introduce a new term called a TAR here in a second. The last piece I want people to keep in mind is that if you have to a flow computer with a milliamp input, rather than a direct pressure or temperature input, you actually need to look at the accuracy of your transmitter's milliamp signal and your calibrators milliamp signal as well, because you actually have that additional translation step that's occurring. And if your calibrator isn't accurate enough of the milliamp side, you're going to lose a lot of the advantage of your more accurate pressure measurement.

High Pressure Test Considerations

So, let's talk a little bit about high-pressure test considerations.

Cleanliness of Test Instruments

So, one of the things that a lot of people, a lot of technicians we see in the field struggle with is keeping their units sufficiently clean. It's very easy to damage the seals. Manufacturers try to make them as rugged as they can, but a lot of times technicians will you process pressure or flow pressure in order to pressurize that units up because they don't really want to do the pumping because, you know, the pumping is no fun. But it's easy to contaminate your unit. If you're very, very careful, you can use things like drains and other traps in order to keep your unit clean, but it's frequently very, very difficult to do.

One of the other things we'll often see is, especially on things like wet gas, is that you'll actually end up with liquids in the calibration cavities. And if you don't properly drain them, you'll end up with strange results, sometimes unrepeatable results.

High Pressure Nitrogen Bottles with Regulators

One thing we'll see a lot of people using, it varies very much by both region and by company, is that we'll see portable nitrogen bottles used to actually regulate the pressure. The idea here is it makes the technician faster because they don't have to pump the unit up to pressure. They can just use the nitrogen bottle and the regulator to move between the various points. The downside is that the bottles do need to be recharged, and if you find yourself out in the field with a bottle that's not fully charged, and you're trying to get to a relatively high pressure, you may not be able to get there. So, it doesn't really give you any benefit.

Some companies actually simply forbid it. They don't want the nitrogen bottles in the backs of trucks rolling around. So, we've seen all types, but the one thing that's really important is you really need to keep that bottle charged. The other thing that's going to happen is that nitrogen has a different Reynolds number than methane and so you're going to have to make a different adjustment for that. And during your calibration. Again, you're trying to eliminate every possible source of error.

Hydraulic Test Pumps

The other type of thing that I want to talk about very briefly is a hydraulic test pumps. Hydraulic test pumps are another way of getting to very high pressures. Many of these hydraulic test pumps can get up to 10,000 psi, assuming you're strong enough to get there. But it's very, very useful in that it's portable, lightweight. It's always kind of ready to go as long as you have the DI water or the mineral oil that you'll need in order to accomplish what's getting there.

It does not, however, prevent you from having to clean. You still have to clean up when you're done. It's possible to get mineral oil or water into the unit, and then you'll have to clean it.

Test Accuracy Considerations

So, this I chart, this large graph, is actually what's called a TAR. We talked a little bit before about TURs, which look at all the various types of uncertainty. A TAR, a Test Accuracy Ratio, really only compares the unit under test and the calibrator. Both of those things are specified by their respective manufacturers. And if you can actually calculate a TAR quite easily without really thinking a great deal about the field conditions.

Transmitter				
Pressure reading	6	30	250	1500
Rosemount 3051C range	Range 2	Range 3	Range 4	Range 5
Upper Range Limit (URL)	9.035	36.135	300	2000
Calibrated span (5:1)	7.228	28.908	240	1600
Ambient temp (°C)	23	23	23	23
Pressure Uncertainty				
Pressure range psi	16	36	300	3000
Reference uncertainty FS	0.025%	0.025%	0.025%	0.025%
Pressure accuracy floor (psi)	n/a	n/a	n/a	n/a
Reference pressure accuracy	0.004	0.009	0.075	0.75
Temperature effect	0.00	0.00	0.00	0.00
Total pressure accuracy	0.004	0.009	0.08	0.75
mA Measurement Uncertainty				
Full Scale (mA)	24	24	24	24
Reading (mA)	13.282	16.604	16.667	15.000
Accuracy (%rdg)	0.015%	0.015%	0.015%	0.015%
Accuracy floor (mA)	0.002	0.002	0.002	0.002
mA Accuracy	0.004	0.004	0.005	0.004
Temperature effect	0.000	0.000	0.000	0.000
Total combined mA accuracy	0.004	0.004	0.005	0.004
Total combined mA accuracy (equivalent pressure units)	0.002	0.008	0.068	0.425

Total Accuracy				
Total pressure accuracy	0.004	0.009	0.075	0.750
Total combined mA accuracy (equivalent pressure units)	0.002	0.008	0.068	0.425
Total Uncertainty (psi)	0.004	0.012	0.101	0.862
3051 Total Performance ±0.15% span (psi)	0.011	0.043	0.360	2.400
Test Accuracy Ratio	2.500	3.600	3.600	2.800

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TAR vs. TUR

One thing to keep in mind is that because the TAR doesn't take into account a lot of the sources of uncertainty that a TUR does, a TAR is almost always better than what you'll actually see in the field. Again, remember we were saying that four to one is kind of the standard, although in the field three to one or two to one is more common. This is going to be... The graphs I'm about to show you are actually not as good as they appear.

Again, this particular graph is for one calibrator compared to a particular transmitter. In this case, it's calibrator A, which you may remember was specified as percent full scale. I'm not showing you the graph for calibrator B. The purpose of showing you this is just to say this can actually be fairly complex. This one was built by one of our metrologists to compare calibrator A with four different ranges, and you can see along the top here, range 2, range 3, range 4, range 5 with a Rosemount 3051C in this particular case.

And basically we ran through in order to demonstrate a point, and that point is these four graphs here. So, these are the four ranges and calibrators A and B, and where they fall out. And so the x-axis is the pressure all the way from zero up to the upper range. So, 10 psi, 40 psi, 350 psi, 2500 psi.

And then the y-axis is the TAR. So, what you're looking for is... In an ideal world, you're looking for better than four to one. However, in the field, that's frequently not possible. So, what you're looking for is the best over your entire range. But you're also looking for some other things. You're looking for simplicity.

So, you'll notice here that calibrator A, which is specified as percent full scale, is a flat line, more or less. The line may have a slope, and there are some points that aren't quite as good as others. But in general, it's a pretty flat line across the entire range.

Whereas calibrator B, which is specified as percent of reading plus floor, actually its TAR changing quite a bit over the range. And so, while at the low end of the range you actually have very good TARs. At the high end of the range, your TARs are significantly worse than calibrator A.

In many cases, they are actually below two to one. Keep in mind also that the TAR is better than what you'll see in the field. And so, if you're calibrating at the high end of the range, especially if there are other sources of uncertainty, you're operating near the edge of the temperature range of the the calibrator, you are trying to make a very careful measurement and you have other sources of error, it's very, very possible that you could end up with a result that has a 30% chance of being incorrect.

And so, one of the benefits of a specified as a percent full scale is that when you get an out of tolerance, you have a fairly good idea of how likely it is that that calibration is actually the correct one. Whereas if you are using percent reading plus floor, you're actually going to need to calculate what the TUR was for that particular point. If you're near the upper range, you know what's worse, but you'll notice that the graph is curved. It's not linear. So, you can't just calculate two points and interpolate it. You've got to calculate the whole thing.

So, this is one of the key disadvantages of percent reading plus floor. While it gives you a great deal of accuracy at the low range, it takes it away at the upper end. And so, that's kind of the tradeoff you have to make. As the transmitters themselves become more accurate and the calibrators are closer and closer to the line of good enough, what ends up happening is that this is starting to be something that an individual technician really needs to start asking for his measurement staff and his design staff to say, look. **The calibration tool that you are using really needs to be specified when the transmitter is selected because the measurement staff needs to support the design engineers with these kinds of accuracy and uncertainty analyses that actually allow the design engineer to say okay.**

Then the technician needs to understand that the measurement team has actually looked at this and said yes. This is the best possible tool combination that we can get. And we're going to go with this going forward. And you really have to kind of build your procedures around it.

We're not seeing a lot of this in the field. It's one of the biggest misunderstandings we run into.

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Orifice Play Style Flow Computers

So we're going to go on to sort of what I would call the curriculum topics here at the end. So, we'll talk a little bit about flow computers. The main thing I want to cover on this page is that there are two types: Direct and indirect. We kind of already touched this before.

Direct computers will have pressure and temperature measurements made directly into the device. You're going to need your laptop if you're going to do an adjustment. Frequently it's easy to do your "as found". This is the most common type that we see. There are a fairly large number of installed base of indirect input computers that actually will convert those measurements into a milliamp signal. And milliamp signal is what's sent into the flow computer. And therefore, you actually have to acquire an accurate measure of your milliamp signal.

The other thing about the indirect method is that it's not uncommon to see ones that will require HART. So, if you need HART, you need to make sure you pick a... Either bring a HART communicator like an Emerson 475, or have a unit that can at least communicate HART and do to work that needs to be done for you.

Precautions and Preparations

So, let's do a sort of high-level overview of what a procedure would look like for custody transfer calibration. So, obviously your local procedure will dictate what kind of safety equipment, PPE, other steps that you need to take prior to going into the area. We're not going to cover that because every company is different. But it's important to mention and keep in mind.

Isolation and Leak Checking

The very first thing you're going to do is isolation and leak checks. And unit will have valves that will isolate it from the process. You'll close those valves. You'll wait. Usually you'll attach a gauge or something similar to the unit. You'll wait at least 30 seconds. And what will happen is you're looking to see if the pressure changes. You're going to look at the DP, and if the DP goes negative, at least under most circumstances you'll actually have a high side leak. And it will be positive if you have a low side leak.

This is only when the unit is isolated from the process. If you have low or no flow, you may have other problems, especially for a differential pressure meter. They are really not designed to go much out of their three to one or so turned down ratios, and if your flow conditions drop outside, it's very easy to zero drift.

So, this rule of thumb only operates when the unit is isolated and you're doing a leak check. You're going to do a little bit of data recording. So, pretty much you're going to do your as found zero. A lot of times this will be with your laptop if you have a direct method. And then you want to record this as quickly as you can, move into your test. You don't want to have to lot of time between when you record the data and when you perform the test because it allows for errors.

Pre-Test & Post-Test Data Recording

You're going to record your transmitter data after each particular verification or adjustment step because you really want to not forgot it. If you forget it, you're more likely to write down the wrong thing and make a mistake.

There are certain calibrators documenting process calibrators that will actually do all of this recording for you automatically. Fluke does make one Fluke 754. There are other manufacturers that make them as well. These things give a couple of advantages. One is that it means you don't inadvertently skip any steps in the procedure. Two, it insures A) the technician doesn't have to write the data down, which makes his life easier, but also that the data is not... There are no errors is recording.

And then that can be documented with tracking software, which feeds back into the main purpose of this, which is to maintain accurate calibration records in the case of a dispute. Your records can protect you from being accused of manipulating your transmitter.

Differential Pressure Transmitter Test

1. Pre Test Zero Test

So, let's move into the actual test itself. The differential pressure tests tend to come first. You're going to do, again, an as sound transmitter zero. You'll connect the unit to the low pressure side, so your calibrator will go to the low pressure side of the flow computer. So, you've got an example here of one particular set up. That particular diagram doesn't show a pressure source, but there would be a pressure source between the low port on the electronic pressure calibrator there in the transmitter.

2. Verification

You will... A lot of times you will have to -- if you're using a direct transmitter, you'll have to login via your PC, and then you'll basically use the pump in order to get through your various test point. It's usually three to five points, zero to 100 percent, and this would be a very small pump. So it would probably use a pneumatic pump for this. And you'll use a relatively small one. This is going to just be a couple hundred column inches of water.

3. Adjustment

Typically, what we find here is a 0.1 percent variance is going to give you an out of tolerance. If you are out of tolerance, you're going to have to adjust. You should have a local procedure that tells you how to do this adjustment. Again, each setup is different. I'm not really going to spend a lot of time to go into that.

4. Post Adjustment Verification

Static Pressure Transmitter Test

1. Verification

Moving on to the static transmitter test. It's going to look very similar. Instead of being on the low pressure side, you're going to be on the high pressure side of the cali. Then you're going to connect to the appropriate port or transmitter, depending on if you have a five or a three or any other types or varieties that you see.

If you're going to use a nitrogen bottle, you need to connect that. Otherwise you're going to use...probably for a hydraulic pump, it's pretty uncommon to see pressures --especially once you actually get into the pipeline world -- where it will be low enough that you can actually use a pneumatic pump. So, you'll have to make sure that's set up and attached.

Typically, what we'll see is that you're going to check zero and 50% of the span. And you'll basically compare that with the flow computer reading. If you're about 0.1% out of, away from what the flow computer says, you're going to get an out of tolerance. And then you basically have to go all the way, all five points from zero the 100.

2. Adjustment

You're going to end up doing an adjustment. Again, it's per the local procedure, depends very much on your particular flow transmitter, excuse me transmitter flow computer combination. And then you're going to repeat that verification in order to make sure that your adjustment was correct.

3. Post-Adjustment Verification

Temperature Transmitter Test

The last test in the temperature test. Temperature actually is kind of interesting in that despite the fact that it's the least important of the measurements in the gas custody transfer calibration measurement, it actually tends to be the most complex. It depends very much on your flow rate. If your process is shut down, you can check it directly using the RTD. If you have it shut down, you pretty much you're going to have to use an RTD simulator, and it's best if you can do it in conjunction with a dry block or a bath like we talked about earlier.

1. Verification

So, if you have good flow through the system, you’re going to simply use your RTD. Here you see I've got a picture in the lower right hand corner. That's actually an electronic pressure calibrator -- dual port electronic pressure calibrator that has an RTD input (Fluke 718), so you only have to carry one tool.

Really, what you're going to do is you'll compare that RTD reading with transmitter reading. If you see a variance, typically, we'll see about 0.2% Fahrenheit, but less than 0.5% Fahrenheit, you're going to end up re-zeroing the transmitter. But if you're more than 0.5% Fahrenheit off of what the transmitter says, you're going to actually need to go and do an adjustment.

Under low flow conditions, you'll use an RTD simulator. And then you'll do a three or five point check, depending on your local procedure over the full span of the transmitter. The variance criteria don't change, though. If you're less than 0.2, you're good. 0.2-0.5, you're probably going to re-zero the transmitter. Greater than 0.5. Yeah, you're probably going to have to make an adjustment.

2. Adjustment

You're adjustments for the local procedure....frequently, what you're going to do is you'll actually use something like a super thermometer, a very high accuracy thermometer in order to do that adjustment. It tends to not be as common. Usually where you get into trouble is the differential pressure measurement.

3. Post Adjustment Verification

Last but not least, if you did the adjustment, you are going to have to go in and do a post-adjustment verification in order to make sure that you have done your adjustment correct.

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