INSTRUMENTATION (PROFICIENCY LEVEL)

ORION Technical Solutions

DEVELOPMENTAL WORKBOOK #12

FLOW MEASUREMENT

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I. FLOW MEASUREMENT

A. DP BASED FLOW MEASUREMENT

The following table shows the expectations for a level 2 Instrument Technician in this area.

Technicians pursuing Tech 2 must also meet the Tech 3 KSA expectations.

In addition to completing the requirements below, the technician must take and pass a hands-on "Instrumentation Basics Course" covering the bulk of the material covered in the following expectations lists.

KSA Expectations
DP Based Flow Measurement (FAMILIARITY LEVEL) *Understand the relationship between flow and DP across a restriction.* *Be familiar with the flow profiles as flow velocity and pipe diameter changes.* *Understand the purpose and operation of flow straighteners used in DP flow measurement applications.* *Understand how gas density changes based on temperature and static pressure.* *Be familiar with common DP based flow primary elements used on the facility (V-cones, Orifices, etc.) and with mounting directions, importance of dimensional tolerances, and placement of sensing lines.* *Know where the specifications come from to dictate the URV and LRV settings for DP based flow transmitters (ie the primarily element spec or data sheet).* *Be familiar with common mistakes and problems with DP based flow measurements.* *Understand the impact that flow noise (vortex noise) will have on flow measurements and be familiar with ways that flow noise can be attenuated.* *Be familiar with approximate turndown ratios and applicable useful range of typical DP based flow measurements for V-cones, Orifices, etc.* *Be familiar with common applications and use of DP flow measurements on your facility.* *Understand square root extraction and know how and where it is performed for major systems on your facility.* *Be able to approximate the values of flow vs DP for 50% flow (based on square law) .* *Be able to find instrument DP ranges from applicable spec or data sheets.* *Know how to setup and use a typical DP pressure test rig for your facility (for liquid and for gases).* *Be able to perform a calibration checks for DP based level transmitters on your facility.* *Be able to determine if a flow accuracy problem is in the DP transmitter or a primarily element (such as an eroded or damaged orifice plate).* **DP Based Flow Measurement (PROFICIENCY LEVEL)** Understand the underlying principles of Bernoulli's Principle as related to flow and DP. Be familiar with why gas flow measurements require absolute temperature and absolute pressure measurements to be factored in to determine actual mass flow rates. Understand how to determine amount of density correction for an absolute temperature or absolute pressure change. Recognize the nonlinear relationship between HMI flow readings (square root extracted) and the output of the DP transmitter in a DP flow measurement application. Be able to determine the flow percentage at 0, 25, 50, 75 and 100% of DP range. Be able to determine the DP (given range) for 0, 25, 50, 75 and 100% flow. Be able to recognize situations where a DP flow signal is in inadequately and/or excessively filtered and know how to approach and solve this problem, including what is required to make changes, and where any filtering should be implemented. Be able to recognize problems caused by gas or liquid pockets in DP transmitter or tubing.

DP Based Flow Measurement (MASTERY LEVEL)
Understand the differences in turbulent and laminar flow and know which is required for DP based flow measurements and why.
Be familiar with Reynolds numbers and their relationship to turbulent or laminar flow, and how they change with flow velocity, pipe diameter, and viscosity.
Be able to determine the amount of density change (and therefore mass flow change) based on a change in temperature and/or pressure of a gas flow measurement.
Be able to calculate the DP or the Flow for any point in the calibration range - given DP calibration range, and corresponding HMI flow range of a DP flow element.
Be able to accurately factor in and resolve any issues with capillary lines used in DP flow measurement applications.
Complete a hands-on, detailed, formal training course covering general flow measurement principles. *Course should include common problems encountered in the field on site specific equipment and most of the KSA requirements listed in this section.*

Resources

What is a DP flow meter? – Web tutorial by InstrumentationTools.com (decent info but a bit math oriented for some). Numerous supplemental links at bottom of site on various primary elements such as orifice plates, v-cones, etc.

Basic DP flow tutorial per MRG (Accessible only to subscribers) – This tutorial presentation provides some basic info that is hard to find in simple format, but it needs animation and voice-over if/when time allows.

Flow Transmitter Calibration – Web tutorial by RealPars with embedded video that covers many of the key practical aspects of DP flow. Good info.

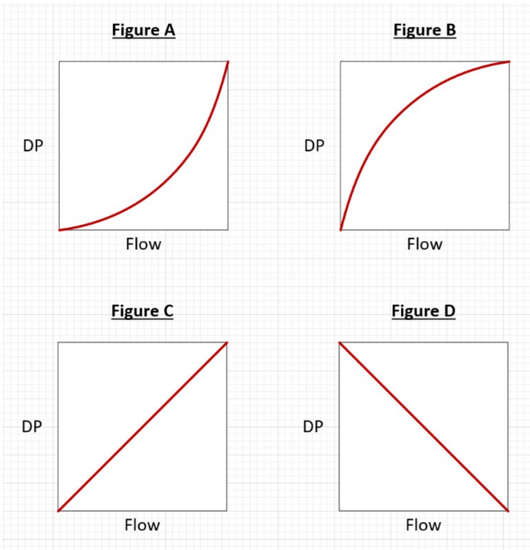
DP Transmitter Square Root Calculation Examples – 4:37 YouTube video by Calibration Academy on performing SQRT calculations on DP flow transmitters. Good info, but wordy. *Tip – don't just blindly follow the steps of the video above. Understand the reasons and the concepts behind the calculation.*

V-cone DP element tutorial - Web tutorial with embedded video by McCrometer on V-cone primary elements.

1) Question (DP Based Flow Measurement – DP Flow Relationship):

Answer the following. Then discuss your answers with a knowledgeable individual (mentor or peer assessor):

a) Which of the following curves best represents the relationship between flow and DP across a primary flow element? Click or tap here to enter text.



b) If the flow rate across an orifice or V-cone element doubled, the resulting DP would increase by a factor of: Click or tap here to enter text.

c) If the flow rate across an orifice or V-cone element tripled, the resulting DP would increase by a factor of: Click or tap here to enter text.

d) **[MASTERY LEVEL]** If the flow rate across an orifice or V-cone element increased from 30% to 75%, the resulting DP would increase by a factor of: Click or tap here to enter text.

Answer Key

a. **Figure A;** $\Delta DP \; \alpha \; \Delta Flow^2$ (Note – Most techs remember that the DP to flow relationship is nonlinear, but many get confused whether figure A or B is the correct representation. The easy way to keep this straight, is to think about what Figrue B would mean; It makes no sense that DP would stop increasing as flow increases, so the only viable 'curved' option, is Figure A, where DP increases exponentially as flow increases.

b. If flow across a primary element doubled, the resulting DP would go up by factor of **4**, because **$\Delta DP \; \alpha \; \Delta Flow^2$ = $\Delta DP \; \alpha \; (x2)^2$ = x4**

c. If flow across a primary element tripled, the resulting DP would go up by factor of **9**, because **$\Delta DP \; \alpha \; \Delta Flow^2$ = $\Delta DP \; \alpha \; (x3)^2$ = x9**

d. If flow across a primary element increased by factor of 2.5 (75/30), the resulting DP would increase by factor of **x 6.25,** because **$\Delta DP \; \alpha \; \Delta Flow^2$ = $\Delta DP \; \alpha \; (x2.5)^2$ = x6.25**

Note - It is important to understand this relationship since it causes many mistakes and problems in instrumentation calibrations and troubleshooting efforts. Many applications and systems have problems related to the DP-Flow relationship that go unsolved for years or decades…

2) Question (DP Based Flow Measurement – DP Flow Calculations – Advanced):

A DP transmitter is measuring DP across an orifice element with gas flowing through it. The transmitter is calibrated for 0-8 inches H_2O which equates to 0-24,000 BPD (barrels per day) on HMI. Answer the following based on this system?

a) If the transmitter is at 50% output, what will the HMI flow read (in BPD)? Click or tap here to enter text.

b) If the transmitter is at 25% output, what will the HMI flow read (in BPD)? Click or tap here to enter text.

c) If the transmitter is at 75% output, what will the HMI flow read (in BPD)? Click or tap here to enter text.

d) **[MASTERY LEVEL]** If the transmitter is at 2.0 inches H_2O, what will the HMI read (in BPD)? Click or tap here to enter text.

e) **[MASTERY LEVEL]** If the transmitter is at 7.5 inches H_2O, what will the HMI read (in BPD)? Click or tap here to enter text.

Answer Key

Note - Based on the simplified formula for finding DP or Flow % given the other parameter (per slide 3 of the basic DP flow presentation) we can determine the HMI flow % and them multiply that factor by the full scale flow to determine flow at the particular DP.

a. $F\% = \sqrt{DP\%}$ x 10 = $\sqrt{50}$ x 10 = 7.07 x 10 = 70.7% Flow
0.707 x 24000 BPD = **16968 BPD**

b. $F\% = \sqrt{DP\%}$ x 10 = $\sqrt{25}$ x 10 = 5 x 10 = 50% Flow
0.5 x 24000 BPD = **12000 BPD**

c. $F\% = \sqrt{DP\%}$ x 10 = $\sqrt{75}$ x 10 = 8.66 x 10 = 86.6% Flow
0.866 x 24000 BPD = **20,784 BPD**

d. 2”/8” = 0.25 = 25%. Then same as problem (b). **= 12,000 BPD**

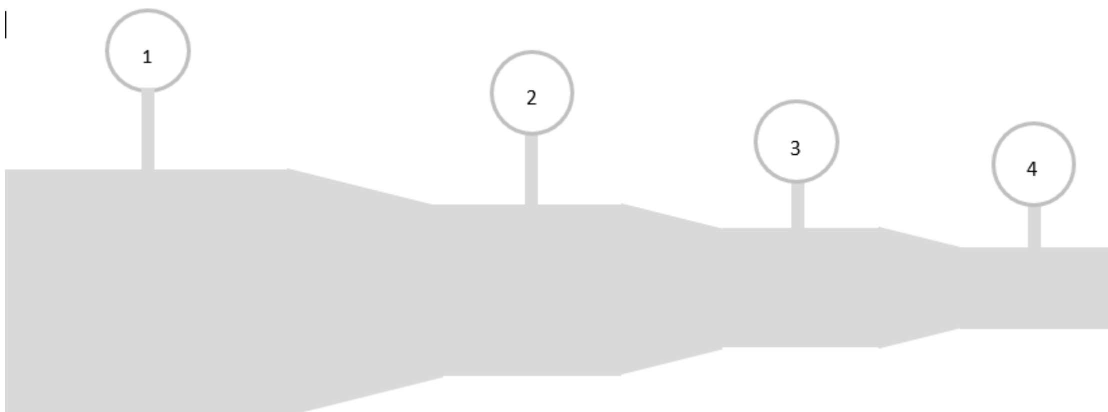
e. 7.5/8 = 0.9375 = 93.75% DP;
Then: $F\% = \sqrt{DP\%}$ x 10 = $\sqrt{93.75}$ x 10 = 9.68 x 10 = 96.8 % Flow
0.968 x 24000 BPD = **22,232 BPD**

Note - It is important for senior instrument technicians to understand this relationship since it causes many mistakes and problems in instrumentation calibrations and troubleshooting efforts and because it is so often confused by operations personnel and lesser skilled techs.

3) Question (Bernoulli's Principle Basics):

Answer the following. The system below is a representation of a circular pipe that reduces from 36 inches diameter down to 6 inches diameter.

a. Based on Bernoulli's principle, how would the pressure gauges compare (which is highest and which is lowest pressure)? Click or tap here to enter text.
b. Explain why this happens in terms of potential vs kinetic energy. Click or tap here to enter text.
c. Which side of the system has the highest POTENTIAL energy? Click or tap here to enter text.
d. Which side of the system has the highest KINETIC energy? Click or tap here to enter text.
e. Related to a Venturi element, where would the lowest pressure be in a venturi element? Click or tap here to enter text.



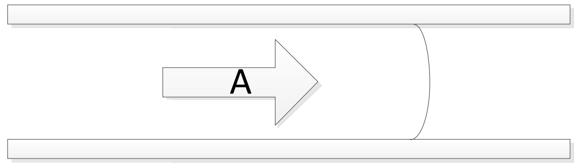
Answer Key

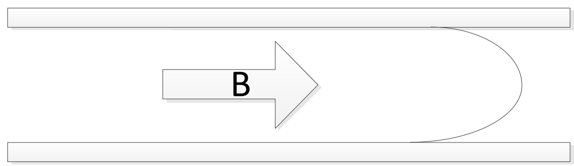
a-e)
The fluid accelerates as the pipe diameter decreases. This increases the KINETIC energy (like momentum) of the material flowing through it and reduces the POTENTIAL energy (pressure). To visualize this, water coming out of a hose at extremely high velocity has so much kinetic energy (momentum) that it does not immediately flow in all directions – it continues straight. The gauges would show a gradual drop at each reduction. Pressure gage #4 would be the lowest pressure, with #1 being the highest pressure. In a Venturi the fastest velocity is in the narrowest portion (the throat). This is the spot where we would typically find the lowest pressure. This pressure would typically be compared to the upstream pressure (highest pressure) for the maximum DP to increase sensitivity of the measurement.

4) Question (Turbulent vs Laminar Flow Basics):

Which of the following flow profiles would be preferred in a DP flow measurement application? Explain your answer:

Click or tap here to enter text.





Answer Key

Profile A – This is the flattest profile across the width of the pipe (meaning the flow at the walls will have close to the same amount of flow as the main-stream of the pipe). Since DP flowmeters measure the velocity at the DP tap (which is usually located at the sidewall), it makes sense that if the velocity at the sidewall is lower than the main stream flow, that the meter would ultimately read below the actual value.

This error mismatch between wall and mainstream of pipe will be more equal with a flatter flow profile across the pipe.

As flows decrease the profile becomes more curved like profile B with higher velocities in the center than on the sides where it is being measured. This will cause the indicated flow to be lower than the actual mainstream flow. This error will become more significant as the flow continues to drop.

5) Question (Flow Straighteners):

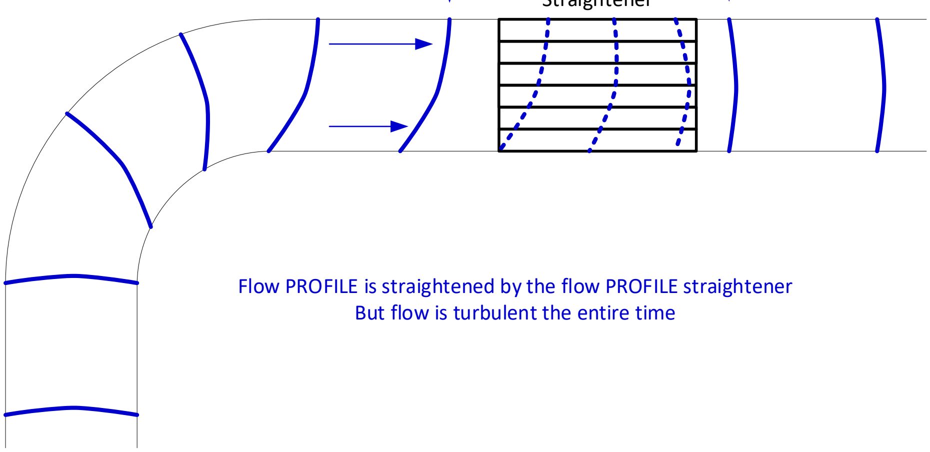
Which of the following statements is most correct concerning FLOW STRAIGHTNERS in DP based flow measurement systems?: Click or tap here to enter text.

a. The flow straightener helps turn a turbulent flow into a laminar flow which is needed for accurate DP based flow measurement.

b. The flow straightener does not alter the laminar or turbulent characteristics of flow in a pipe – it merely corrects the skewing of flow that occurs as flow goes around a bend (flow gets faster on the outside of the flow axis). Without flow straighteners, this skewing of the flow profile would result in serious errors in the readings.

c. The flow straightener helps ensure that the flow is laminar and going in very straight lines when approaching the DP element so that there is no turbulence.

d. Is the diagram below technically correct and true?



Answer Key

a. Wrong – we actually want turbulent flow in a DP flow measurement system. Turbulent flow results in a flat profile, meaning the flow velocities are fairly equal across the full diameter of the pipe, which means that our DP measurement at the sidewall will better represent the main-stream of flow.

b. Correct – It would be better if they called flow *straighteners flow "un-skewers*" to help people better understand what they really do and to stop confusing the straight lines that are integral to laminar flow with the straight tubes of flow straighteners. Since most flow textbooks graphically emphasize the 'straight' lines of laminar flow, it often gets confused with flow straighteners in the diagrams - but anything that caused laminar flow in a DP flow measurement system would be undesirable. Flow straighteners simply fix the problem of media accelerating on the outside bend of a pipe turn (and thereby skewing the flow profile) by equalizing the pressure via numerous tubes so that the flow profile at each side of pipe is the same again.

c. Wrong – per above.

d. Yes – this is the central concept of flow straighteners. It is important not to confuse flow profile straightening with the generally straight flow lines of a laminar flow system. Flow straighteners realign (ie 'unskew') the flow PROFILE – they do NOT cause laminar flow. Laminar flow in DP flow systems is bad, for reasons mentioned previously, so we would never try to cause laminar flow. *But this is often the source of confusion and the reason that many people mis conceptualize that we are trying to 'produce' (or want) laminar flow in DP flow measurement systems.*

6) Question (Common DP Flow Errors):

If a DP flow transmitter configured for 0-24 IWC = 0-3000 GPH, had a +0.5 IWC zero error across it's full calibration range, determine which calibration check point would have the highest error between indicated and actual flow because of this error, and explain the reasoning. (Options: 0, 25, 50, 75, 100%): Click or tap here to enter text.

Answer Key

Referring back to the trend in figure A in question #1, the DP increases more from a 5% change at the high end, than a 5% change near the lower end. Therefore, if you had a small (0.5 IWC) zero error throughout the calibration range of the DP transmitter, it would have a larger impact at the lowest flow ranges. You can see this graphically by looking at the curve and superimposing a small error at the low end and at the high end. You'll see that because the DP/Flow curve is so steep at upper end, a small DP change does not result in a significant change in flow – but it does as you get closer to the bottom of the DP calibration range.

For this reason (and others), we typically have to limit the turndown ratios of DP flow systems. An orifice system typically has a turndown ratio of only 3:1, whereas a V-cone often has a turndown ratio of 10:1. This means even with a quality V-cone primary element you could only measure between say 10-100% dependably and only 33-100% for typical orifice element systems. If the flow gets too low, the measurement becomes unreliable.

When calibrating, troubleshooting, or solving problems on DP based flow measurement systems it is important to factor in the realistic limitations of the systems so that you don't chase your tail or try to calibrate out problems that are not actually calibration problems. Instrument techs need to understand these types of concepts well enough to explain them to applicable operators, managaers, engineers, and other technicians.

7) Question (DP Flow Troubleshooting):

[MASTERY LEVEL] If a DP flow transmitter configured for 0-24 IWC = 0-3000 GPH, inadvertently has SQRT enabled on transmitter with the DCS system also providing a SQRT function on the input, what would the symptoms be? Specifically, what would the (theoretical) HMI flow indication be at 0, 25, 50, 75, and 100%?

DC Input (%)	DP input (IWC)	mA	HMI indication (GPH)
0	0 IWC	Click or tap here to enter text.	Click or tap here to enter text.
25	6 IWC	Click or tap here to enter text.	Click or tap here to enter text.
50	12 IWC	Click or tap here to enter text.	Click or tap here to enter text.
75	18 IWC	Click or tap here to enter text.	Click or tap here to enter text.
100	24 IWC	Click or tap here to enter text.	Click or tap here to enter text.

Answer Key

DC Input (%)	DP input (IWC)	mA	HMI indication (GPH)
0	0 IWC	0 (0%)	0 (0%)
25	6 IWC	12 (50%)	2121 GPH (70.7%)
50	12 IWC	15.31 (70.7%)	2520 GPH (84%)
75	18 IWC	18.86 (86.6%)	2793 GPH (93.1%)
100	24 IWC	20 (100%)	3000 (100%)

If you *duplicate the* square rooting in a system, it effectively sharpens the curve or the bend, making it appear that you get much more flow.. The zero and 100% points will still be at 0 and 100%, but there will be a large error in between, especially lower in the range.

There are many ways to calculate this, but as an example on how to calculate this (for the 50% DP test point):

For mA, you need to find the percentage. The SQRT of 50% is 7.07, which multiplied by 10 gives 70.7%, which is 15.31 mA;

For the HMI indication, you find the percentage the same way. The SQRT of 70.7% is 8.4, multiplied by 10 gives 84% which results in flow of 2520 GPH.

See the respective tutorial for more information and examples on solving these types of problems.

8) Question (Re-ranging DP Flow systems):

A DP flow transmitter on an oil production facility is configured for 0-24 IWC = 4-20mA and that input is fed to a DCS that does the square rooting and K-factoring to produce 0-3000 GPH. But a new production well is able to flow beyond this value. Engineering calculated it is safe to operate at 0-4000 GPH and has an MOC to modify the system to measure between 0-4000 GPH. Explain any problems with any of the solutions below and choose the solutions that is best overall.

a. We simply need to reconfigure the DP transmitter for 0-32 IWC. The square rooting and K-factors are already setup so there is no need to reconfigure them. Click or tap here to enter text.
b. We need to spec out a new flow element that is engineered for 4000 GPH and reconfigure the DP transmitter for the calibration ranges shown on the spec sheet. Click or tap here to enter text.
c. We need to add a multiply block in the DCS to multiply the final flow number by 1.333 (based on 4000/3000 ratio). Click or tap here to enter text.

Answer Key

a. This is not correct. Unless a primary flow element has been specifically engineered / tested for a certain flow range it cannot be used. Also, the ratio between DP IWC and flow is NOT linear – it is exponential! - Therefore we can't simply bump the ratio up to solve the problem.

   Note - This is a very common misconception even with engineers and must be carefully guarded against by instrument techs whenever being tasked to change or alter the configuration or calibration of a DP flow transmitter (and/or PLC/DCS block parameters for Automation).

b. This is the best answer. Any new flow measurement setup requires an engineered spec sheet that specifies the proper calibration range for the desired flow range. The DP transmitter should always be based on the spec sheet data.

c. Flow vs DP is not linear – so multiplying is not a solution. It may seem easy to do it that way – but that is not how DP flow works. *This is a common misconception / mistake.*

B. CORIOLIS FLOWMETERS

The following table shows the expectations for a Proficiency Level Instrument Technician in this area.

Technicians pursuing Proficiency Level must also meet the Familiarity Level KSA expectations.

In addition to completing the requirements below, the technician must take and pass a hands-on "Instrumentation Basics Course" covering the bulk of the material covered in the following expectations lists.

KSA Expectations
Coriolis Flowmeters (FAMILIARITY LEVEL) *Have a basic familiarity with the operation of Coriolis flow meters as used on the facility.* *Be familiar with applications that utilize Coriolis type flow meters on the facility.* *Recognize the Coriolis flow meters used on the facility.* **Coriolis Flowmeters (PROFICIENCY LEVEL)** Understand the operation of Coriolis flow meters as used on the facility. Know which applications utilize Coriolis type flow meters on the facility. **Coriolis Flowmeters (MASTERY LEVEL)** Understand the basic setup and configuration of a Coriolis flow meter as used on the facility.

Resources
http://encyclopedia.che.engin.umich.edu/Pages/Flowmeters/Mass/Mass.html - Web tutorial on Mass flow measurements, including Coriolis flowmeters Coriolis Flowmeters – how do they work? Website and good embedded 2:49 YouTube video showing operational concepts of typical Coriolis flowmeters Disregard the parts specific to Bronkorst overall assembly and focus on the actual Coriolis sensor section. What is a Coriolis Flow Meter and how does it work? Webpage and embedded 2:26 video by Omega.

1) Question (Coriolis Flowmeters – Principles of Operation):

Answer the following questions related to Coriolis flowmeters.

a) Explain the basic principles of operation of a Coriolis flowmeter. Be sure to expound upon the difference in phase of the sensors on each side of the tube. Click or tap here to enter text.

b) Why can Coriolis flowmeters measure mass flow directly without needing to perform density measurements or corrections? Click or tap here to enter text.

Answer Key

a) Per tutorial (in short, the momentum of fluid, which is proportional to mass flow rate, causes the downstream tube to be slightly behind phase of the upstream tube as the piezo element vibrates the tube. The difference in phase shift is proportional to mass flowrate.

b) Because the physics of momentum that induces the phase shift between upstream and downstream tube sensors is directly proportional to mass x velocity of the fluid inside (which is mass flow rate). More dense fluid, or faster fluid equals higher mass flow and bigger phase shift. This meter is extremely accurate because it utilizes pure physics and a time base as the basis of measurement and time technology is extremely accurate – resulting in extreme accuracies.

2) Assignment (Coriolis Flowmeters – Demonstration of Skills):

Do the following for a Coriolis Flowmeter selected by mentor or observer:

a) Specify the tag number of transmitter assigned (and briefly describe vendor, model, and application) Click or tap here to enter text.
b) Find spec / data sheet for the transmitter. Click or tap here to enter text.
c) List the range of product specs allowed in the instrument. Click or tap here to enter text.
d) Walk the system down with mentor and discuss typical maintenance, troubleshooting, and explain principles of operation.

Answer Key

Per Observer

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

C. ULTRASONIC FLOWMETERS

The following table shows the expectations for a level 2 Instrument Technician in this area.

Technicians pursuing Tech 2 must also meet the Tech 3 KSA expectations.

In addition to completing the requirements below, the technician must take and pass a hands-on "Instrumentation Basics Course" covering the bulk of the material covered in the following expectations lists.

KSA Expectations
Ultrasonic Flowmeters (FAMILIARITY LEVEL) *Have a basic familiarity with the operation of Ultrasonic flow meters as used on the facility.* *Know which type of Ultrasonic flow meters are used on your facility (Doppler or Time of Travel) and where each is used.* *Be familiar with applications that utilize Ultrasonic type flow meters on the facility.* *Recognize the Ultrasonic flow meters used on the facility.* *Be familiar with the problems that can occur with Ultrasonic flow meters used on your facility.* *Identify the brands and models used on the facility.* *Be able to troubleshoot basic problems on Ultrasonic flow meters on the facility.* **Ultrasonic Flowmeters (PROFICIENCY LEVEL)** Understand the operation of Ultrasonic flow meters as used on the facility. Know which applications utilize Ultrasonic type flow meters on the facility. Know the problems that can occur with Ultrasonic flow meters used on your facility. **Ultrasonic Flowmeters (MASTERY LEVEL)** Understand the basic setup and configuration of a Ultrasonic flow meter as used on the facility.

Resources
Time of flight ultrasonic flow meter – 3:47 YouTube video covering basic principles of Ultrasonic time of flight style flow meters. Doppler vs Transit Time based Ultrasonic Flow Meters – 1:42 YouTube video by Omega covering basic differences of each type of ultrasonic flow meter. Important to know the differences to avoid confusion between meters. Ultrasonic flow meter explained – Detailed 8:22 YouTube video by RealPars. Good detailed info. This presentation covers all types of US flow meters, but is good to understand to avoid confusion that often occurs between the different types.

1) Question (Ultrasonic Flowmeters – Principles of Operation):

Answer the following questions related to Ultrasonic flowmeters.

a) List the types of ultrasonic flow meters used on your facility. Include tag numbers, and describe application, as well as the brand and models used.
b) Explain the basic principles of operation of the type of ultrasonic flow meters used on your facility. Click or tap here to enter text.
c) Do ultrasonic style flow meters need to be corrected for density to determine mass flow? Explain. Click or tap here to enter text.

Answer Key

a) Per site – varies.
b) Per video / tutorials – be sure to explain time of travel concepts and know how the higher end models compensate for density impacts on speed of sound.
c) Yes – they need to be corrected for density because they are only determining the velocity (essentially the volumetric flow) of the media (not the mass flow). They are often used in applications where the density is a known constant.

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

2) Assignment (Coriolis Flowmeters – Demonstration of Skills):

Do the following for a Coriolis Flowmeter selected by mentor or observer:

a) Specify the tag number of transmitter assigned (and briefly describe vendor, model, and application) Click or tap here to enter text.
b) Find spec / data sheet for the transmitter. Click or tap here to enter text.
c) List the range of product specs allowed in the instrument. Click or tap here to enter text.
d) Walk the system down with mentor and discuss typical maintenance, troubleshooting, and explain principles of operation.

Answer Key

Per Observer

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

D. VORTEX FLOWMETERS

The following table shows the expectations for a level 2 Instrument Technician in this area.

Technicians pursuing Tech 2 must also meet the Tech 3 KSA expectations.

In addition to completing the requirements below, the technician must take and pass a hands-on "Instrumentation Basics Course" covering the bulk of the material covered in the following expectations lists.

KSA Expectations
Vortex Flowmeters (FAMILIARITY LEVEL) *Have a basic familiarity with the operation of Vortex flow meters as used on the facility.* *Know which type of Vortex flow meters are used on your facility.* *Be familiar with applications that utilize Vortex type flow meters on the facility.* *Recognize the commonly used Vortex flow meters used on the facility.* *Identify the brands and models used on the facility.* *Be able to troubleshoot basic problems on Vortex flow meters on the facility.* **Vortex Flowmeters (PROFICIENCY LEVEL)** Understand the operation of Vortex flow meters as used on the facility. Know which applications utilize Vortex type flow meters on the facility. **Vortex Flowmeters (MASTERY LEVEL)** Understand the basic setup and configuration of a Vortex flow meter as used on the facility.

Resources
Introduction to Vortex Flow Meters – 4:49 YouTube video by Rosemount. Good info.

1) Question (Vortex Flowmeters – Principles of Operation):

Answer the following questions related to Vortex flowmeters.

a) List the types of vortex flow meters used on your facility. Include tag numbers, and describe application, as well as the brand and models used.
b) Explain the basic principles of operation of the type of vortex flow meters used on your facility. Click or tap here to enter text.
c) Do vortex style flow meters need to be corrected for density to determine mass flow? Explain. Click or tap here to enter text.

Answer Key

a) Per site – varies.
b) Per video / tutorials – be sure to explain time of travel concepts and know how the higher end models compensate for density impacts on speed of sound.
c) Yes – they need to be corrected for density because they are only determining the velocity (essentially the volumetric flow) of the media (not the mass flow). They are often used in applications where the density is a known constant.

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

2) Assignment (VortexElect Flowmeters – Demonstration of Skills):

Do the following for a Vortex Flowmeter selected by mentor or observer:

a) Specify the tag number of transmitter assigned (and briefly describe vendor, model, and application) Click or tap here to enter text.
b) Find spec / data sheet for the transmitter. Click or tap here to enter text.
c) List the range of product specs allowed in the instrument. Click or tap here to enter text.
d) Walk the system down with mentor and discuss typical maintenance, troubleshooting, and explain principles of operation.

Answer Key

Per Observer

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

E. MAGNETIC FLOWMETERS

The following table shows the expectations for a level 2 Instrument Technician in this area.

Technicians pursuing Tech 2 must also meet the Tech 3 KSA expectations.

In addition to completing the requirements below, the technician must take and pass a hands-on "Instrumentation Basics Course" covering the bulk of the material covered in the following expectations lists.

KSA Expectations
Magnetic Flowmeters (FAMILIARITY LEVEL) *Have a basic familiarity with the operation of Magnetic flow meters as used on the facility.* *Know which type of Magnetic flow meters are used on your facility.* *Be familiar with applications that utilize Magnetic type flow meters on the facility.* *Recognize the commonly used Magnetic flow meters used on the facility.* *Identify the brands and models used on the facility.* *Be able to troubleshoot basic problems on Magnetic flow meters on the facility.* **Magnetic Flowmeters (PROFICIENCY LEVEL)** Understand the operation of Magnetic flow meters as used on the facility. Know which applications utilize Magnetic type flow meters on the facility. Be aware of potential problems with electrode erosion / corrosion / degradation, conductivity change impacts, grounding problems. Be familiar with the grounding requirements and standards for Magnetic flow meters that are used on the facility per reference manuals. **Magnetic Flowmeters (MASTERY LEVEL)** Be able to determine proper grounding methods and resolve any problems with grounding on Magnetic flow meters on the facility.

Resources
The Electromagnetic Flow Measuring Principle – 4:42 YouTube video by Endress & Hauser (good info). Common faults in magnetic flow meters – Decent (not fully vetted) web presentation on common mag flow meter problems. Troubleshooting magnetic flow meters – Good (not fully vetted) presentation by InstrumentationTools.com

1) Question (Magnetic Flowmeters – Principles of Operation):

Answer the following questions related to Magnetic flowmeters.

a) List the magnetic flow meters used on your facility. Include tag numbers, and describe application, as well as the brand and models used.
b) Explain the basic principles of operation of the type of magnetic flow meters used on your facility (typically measuring seawater flow rates). Click or tap here to enter text.
c) Do Magnetic style flow meters need to be corrected for density to determine mass flow? Explain. Click or tap here to enter text.
d) What are some of the most common problems that occur on the magnetic flow meters used on your facility? Click or tap here to enter text.

Answer Key

a) Per site – varies.
b) Per video / tutorials – be sure to explain time of travel concepts and know how the higher end models compensate for density impacts on speed of sound.
a) Yes – they need to be corrected for density because they are only determining the velocity (essentially the volumetric flow) of the media (not the mass flow). They are often used in applications where the density is a known constant.
b) Per InsrumentationTools.com presentation in references – also discuss with mentor (and refer to manuals).

2) Assignment (Magnetic Flowmeters – Demonstration of Skills):

Do the following for a magnetic flowmeter selected by mentor or observer:

a) Specify the tag number of transmitter assigned (and briefly describe vendor, model, and application) Click or tap here to enter text.
b) Find spec / data sheet for the transmitter. Click or tap here to enter text.
c) Walk the system down with mentor and discuss typical maintenance, troubleshooting, and explain principles of operation.

Answer Key

Per Observer

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

F. TURBINE FLOWMETERS

The following table shows the expectations for a level 2 Instrument Technician in this area.

Technicians pursuing Tech 2 must also meet the Tech 3 KSA expectations.

In addition to completing the requirements below, the technician must take and pass a hands-on “Instrumentation Basics Course” covering the bulk of the material covered in the following expectations lists.

KSA Expectations
Turbine Flowmeters (FAMILIARITY LEVEL) *Have a basic familiarity with the operation of Turbine flow meters as used on the facility, including sensors / pickups, amps, measurement heads, and transducers, etc.* *Know which type of Turbine flow meters are used on your facility.* *Be familiar with applications that utilize Turbine flow meters on the facility.* *Recognize the commonly used Turbine flow meters used on the facility and each major part/component.* *Be familiar with Turbine flow meter K-factors.* *Be familiar with converting pulses per second to GPH or BPD or other flow conversions as required.* *Be familiar with common problems with Turbine flow meters used on the facility.* *Identify the brands and models used on the facility.* *Be familiar with each major component in the Turbine flow meters used on the facility.* *Be familiar with using pulse generation function of multifunction calibrator or process meters used on the facility.* *Be able to test and calibrate Turbine flow meters used on the facility.* *Be able to troubleshoot basic problems on the Turbine flow meters used on the facility.* **Turbine Flowmeters (PROFICIENCY LEVEL)** Understand the detailed operation of specific Turbine flow meters used on the facility. Be able to calculate and interpret Turbine flow meter K-factors and be able to convert pulses per second into GPH or BPD type measurements. Be aware of issues that can impact 2-wire (mag pickup) or 3-wire (induced prox) sensors and understand the operation of each type of pickup sensor used on Turbine flow meters used on the facility. Understand the operation of each major component in the Turbine flow meters used on the facility. Be fully proficient at use of pulse generation with standard I&C test and calibration meters. Be able to troubleshoot intermediate problems on the Turbine flow meters used on the facility. **Turbine Flowmeters (MASTERY LEVEL)** Be able to troubleshoot advanced problems on the PD flow meters used on the facility. **Complete a hands-on, detailed, formal training course covering general flow measurement principles. Course should include common problems encountered in the field for your facility, and most of the KSA requirements listed in this section.**

Resources
Turbine Flow Meter Explained – 8:04 YouTube video by RealPars. This site also has a link to a handy K-factor calculator file, which can come in handy.

1) Question (Turbine Flowmeters – Principles of Operation):

Answer the following questions related to Turbine flowmeters.

a) List the Turbine flow meters used on your facility. Include tag numbers, and describe application, as well as the brand and models used.
b) Explain the basic principles of operation of the type of Turbine flow meters used on your facility. Click or tap here to enter text.
c) Do Turbine style flow meters need to be corrected for density to determine mass flow? Explain. Click or tap here to enter text.
d) What are some of the most common problems that occur on the Turbine flow meters used on your facility? Click or tap here to enter text.

Answer Key

a) Per site – varies.
b) Per video / tutorials – be sure to explain time of travel concepts and know how the higher end models compensate for density impacts on speed of sound.
c) Yes – they need to be corrected for density because they are only determining the velocity (essentially the volumetric flow) of the media (not the mass flow). They are often used in applications where the density is a known constant.
d) Per InsrumentationTools.com presentation in references – also discuss with mentor (and refer to manuals).

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

2) Assignment (Turbine Flowmeters – K-factor Calculations):

Answer the following questions related to Turbine flowmeter K-factor calculations.

a) Go through a typical example of a turbine flowmeter used on your facility, and calculate / test / calibrate check the K-factors, including setting up the simulation, and understanding how and where the pulses are converted to mA or data (most sites use field mounted amplifiers and pulse-rate to 4-20mA signal converters). Click or tap here to enter text.

Answer Key

a) Per observer / mentor

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

3) Assignment (Turbine Flowmeters – Demonstration of Skills):

Do the following for a Turbine flowmeter selected by mentor or observer:

a) Specify the tag number of transmitter assigned (and briefly describe vendor, model, and application) Click or tap here to enter text.
b) Find spec / data sheet for the transmitter (find K-factor and explain how this is used). Click or tap here to enter text.
c) Walk the system down with mentor and discuss typical maintenance, troubleshooting, and explain principles of operation.

Answer Key

Per Observer

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

G. POSITIVE DISPLACEMENT FLOWMETERS

The following table shows the expectations for a level 2 Instrument Technician in this area.

Technicians pursuing Tech 2 must also meet the Tech 3 KSA expectations.

In addition to completing the requirements below, the technician must take and pass a hands-on “Instrumentation Basics Course” covering the bulk of the material covered in the following expectations lists.

KSA Expectations
Positive Displacement Flowmeters (FAMILIARITY LEVEL) *Have a basic familiarity with the operation of PD flow meters as used on the facility, including sensors / pickups, amps, measurement heads, and transducers, etc.* *Know which type of PD flow meters are used on your facility.* *Be familiar with applications that utilize PD flow meters on the facility.* *Recognize the commonly used PD flow meters used on the facility and each major part/component.* *Be familiar with PD flow meter K-factors.* *Be familiar with converting pulses per second to GPH or BPD or other flow conversions as required.* *Be familiar with common problems with Turbine/Paddle flow meters used on the facility.* *Identify the brands and models used on the facility.* *Be familiar with each major component in the PD flow meters used on the facility.* *Be familiar with using pulse generation function of multifunction calibrator or process meters used on the facility.* *Be able to test and calibrate PD flow meters used on the facility.* *Be able to troubleshoot basic problems on the PD flow meters used on the facility.* **Positive Displacement Flowmeters (PROFICIENCY LEVEL)** Understand the detailed operation of specific PD flow meters used on the facility. Be able to calculate and interpret PD flow meter K-factors and be able to convert pulses per second into GPH or BPD type measurements. Be aware of issues that can impact 2-wire (mag pickup) or 3-wire (induced prox) sensors and understand the operation of each type of pickup sensor used on Turbine/Paddle flow meters used on the facility. Understand the operation of each major component in the PD flow meters used on the facility. Be fully proficient at use of pulse generation with standard I&C test and calibration meters. Be able to troubleshoot intermediate problems on the PD flow meters used on the facility. **Positive Displacement Flowmeters (MASTERY LEVEL)** Be able to troubleshoot advanced problems on the PD flow meters used on the facility.

Resources
TBD

1) Question (Positive Displacement Flowmeters – Principles of Operation):

Answer the following questions related to Positive Displacement flowmeters.

a) List the Positive Displacement flow meters used on your facility. Include tag numbers, and describe application, as well as the brand and models used.
b) Explain the basic principles of operation of the type of Positive Displacement flow meters used on your facility. Click or tap here to enter text.
c) Do Positive Displacement style flow meters need to be corrected for density to determine mass flow? Explain. Click or tap here to enter text.
d) What are some of the most common problems that occur on the Positive Displacement flow meters used on your facility? Click or tap here to enter text.

Answer Key

a) Per site – varies.
b) Per video / tutorials and site specifics per mentor input.
c) Typically not needed (typically used with fixed density fluids) – but if density changed they would need to correct for it.
d) Per input from reference manuals and mentors.

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

2) Assignment (Positive Displacement Flowmeters – K-factor Calculations):

Answer the following questions related to Positive Displacement flowmeter K-factor calculations.

a) Go through a typical example of a Positive Displacement flowmeter used on your facility, and calculate / test / calibrate check the K-factors, including setting up the simulation, and understanding how and where the pulses are converted to mA or data (most sites use field mounted amplifiers and pulse-rate to 4-20mA signal converters). Click or tap here to enter text.

Answer Key

a) Per observer / mentor

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

3) Assignment (Positive Displacement Flowmeters – Demonstration of Skills):

Do the following for a Positive Displacement flowmeter selected by mentor or observer:

a) Specify the tag number of transmitter assigned (and briefly describe vendor, model, and application) Click or tap here to enter text.
b) Find spec / data sheet for the transmitter (find K-factor and explain how this is used). Click or tap here to enter text.
c) Walk the system down with mentor and discuss typical maintenance, troubleshooting, and explain principles of operation.

Answer Key

Per Observer

Observer (Name)	Observer (Signature)	Observation Date & Time
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.