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Agenda

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- Installation effects testing was performed at CEESI Iowa on two brands of 12" SCH 40 meters in April 2026
- The two USM manufacturers included EHS (SICK) and Rosemount (Daniel)
- Four gas velocities were chosen: 90, 60, 30 and 10 FPS, and tested in that order
- Baseline testing for both meters means CEESI used straight piping upstream of the "Metering Package"
- The 6 "Metering Packages" were as follows: **10D+50E+10D** **10D+55E+10D** **50E+10D+50E+10D**
50E+10D+55E+10D **5D+55E+5D** **50E+5D+55E+5D**
- Only one upstream installation effect was used: DEOOP (double elbows out of plane) + Blind Flanged Tee
- All test results shown are relative to baseline piping conditions (**no baseline data shown**)
- Meters had no calibration coefficients installed (were not previously calibrated)
- Tests included FWME values computed per OIIML R137 - 40% of Full Scale (FS) (90 FPS), and 100% of FS
- A total of 15 tests (30 counting both meters) were performed

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Agenda (Continued)

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- Results for 12 tests will be presented (3 were R&D and may be presented in the future)
- Each test was labeled with a number (1-15) and then an "A" or "B" depending upon meter brand
- This numbering system was chosen to simplify keeping track of each test for each manufacturer
- Each test included Maintenance Reports for each velocity, and the manufacturer's have these
- All piping, both the upstream and "Metering Package", was supplied by CEESI
- A comparison of the 50E at **10D** vs. the 55E at **10D** will be shown
- A comparison of the 50E at **5D** vs. the 55E at **5D** from TCC is included
- Repeatability results for **three 55E conditioners** for each manufacturer is included
- A CFD discussion on pressure drop using one or two flow conditioners has been added
- Diagnostic data from a previously published AGA paper using a dual-tee package will show profile issues
- Previously AGA published CPA 50E interchangeability data will be presented (**time permitting**)

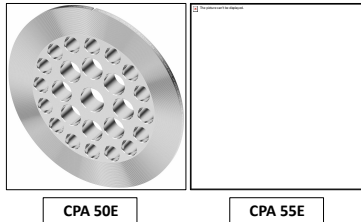
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Discussion Comparing the CPA 50E to the CPA 55E

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- The key difference between the 50E and 55E is plate thickness. With the 50E all the holes are the same length.
- The 55E is twice as thick (outer 16 holes) to improve swirl reduction. Hole lengths depends on location. The outer are longer, middle are less, and the middle hole is much less in length.
- The "50" means 50% porosity (50% opening by cross-sectional area, not 0.5 Beta). Hole diameters, based on location, are the same for 50E & 55E.
- Pressure drop is essentially the same, but the 55E is noticeably acoustically quieter.

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Test Protocol Discussion

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- Test 1 – Baseline with 10D + 50E + 10D + USM
- Test 2 – Baseline with 10D + 55E + 10D + USM
- Test 4 – DEOOP + Tee with 10D + 50E + 10D + USM
- Test 5 – DEOOP + Tee with 10D + 55E + 10D + USM
- Test 7 – DEOOP + Tee with 50E + 10D + 50E + 10D + USM
- Test 8 – DEOOP + Tee with 50E + 10D + 55E + 10D + USM
- Tests 10, 11, 12 – Baseline with 5D + 55E + 5D + USM (three 55E units tested and results compared)
- Test 13 – DEOOP + Tee with 5D + 55E + 5D + USM
- Test 14 – DEOOP + Tee with 50E + 5D + 55E + 5D + USM
- Test 15 – 10D + 55E + 10D + USM (used to verify meter and facility repeatability / reproducibility (**Test 2**))
- Note:** Three **50E** units were tested on 3 meters and published at the 2017 AGA Conference

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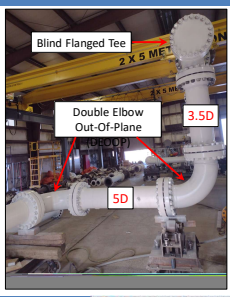
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Piping Disturbance - Double Elbows out-of-Plane (DEOOP) + Tee

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- The upstream and downstream installation effects piping consisted of double elbows out-of-plane (DEOOP) flowing into a blind-flanged tee as shown on the right
- This design was selected to somewhat simulate what may be encountered in the field
- The spools between the two elbows, and the spool between the elbow and tee, will reduce the flow profile distortions, specifically **swirl**, when compared to all being close-coupled
- Many clients like to have a tee on the inlet and outlet of the meter run for inspection and cleaning
- It most certainly doesn't create an extremely distorted profile like the OIIML R137 discusses (two elbows close-coupled with a half moon plate in between)




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Downstream Tee + DEOOP Piping



This is a view of the outlet Tee + DEOOP piping which replicates the inlet piping. All piping was supplied by CEESI.

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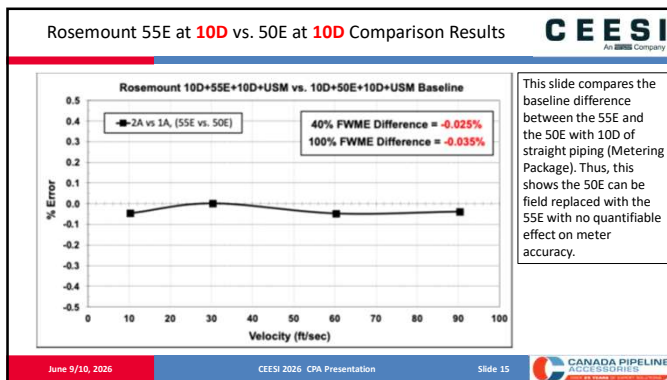
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Discussion on Presentation of Results

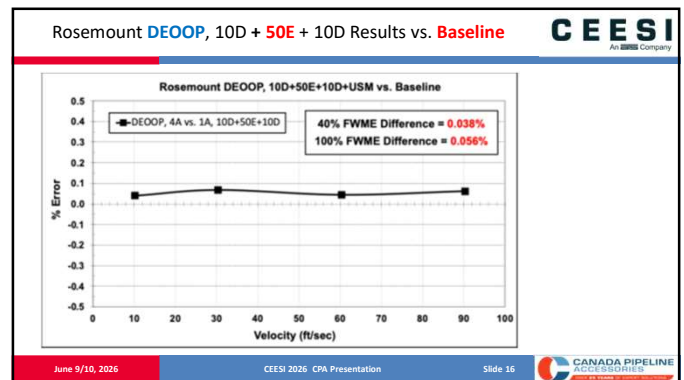
- This presentation focuses on "un-biased" test results for the two most popular USM brands
- To minimize making any immediate comparisons of each meter for each test, results from one manufacturer will be presented first, and then the second meter results will follow
- This is to minimize the desire to do direct comparisons during the presentation
- We at CPA are more than happy to discuss the results in more detail after the presentation
- Each manufacturer has all the data used to develop the graphs include Maintenance Reports for each of the 4 gas velocities
- Remember, most of the data that is being shown is well within the repeatability and reproducibility of the meter and the facility
- Also, the installation effects shown were from just one piping configuration and may not represent your company's design
- The DEOOP package, as labeled in this presentation, implies the Tee is directly attached to the elbows

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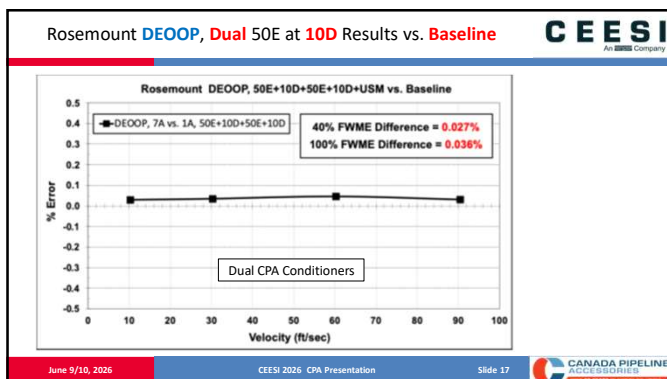
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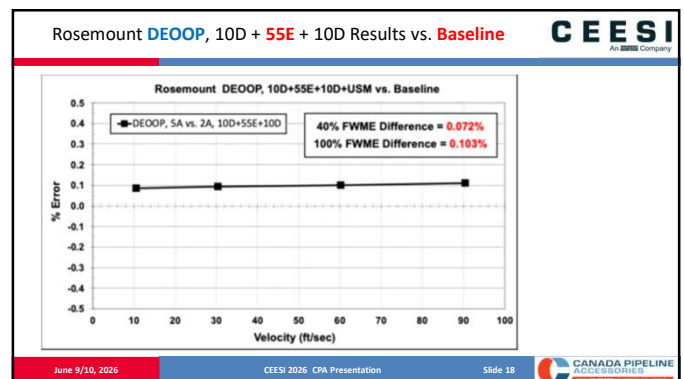
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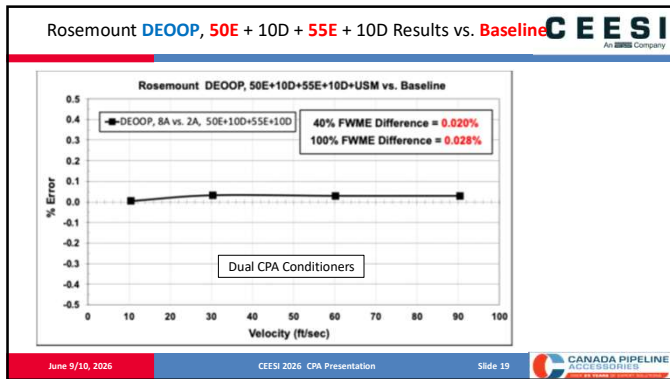
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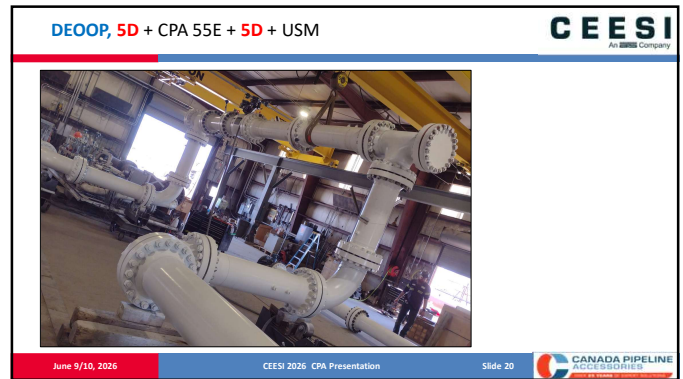
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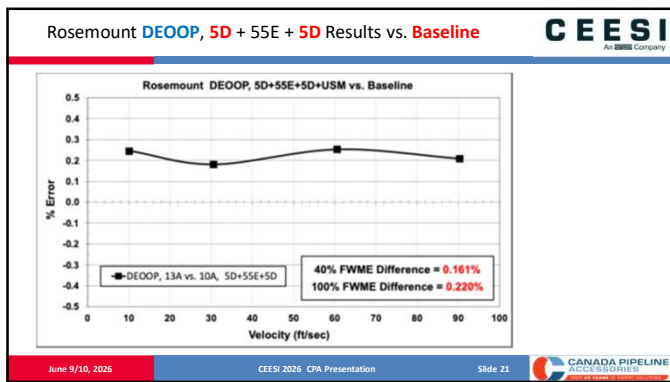
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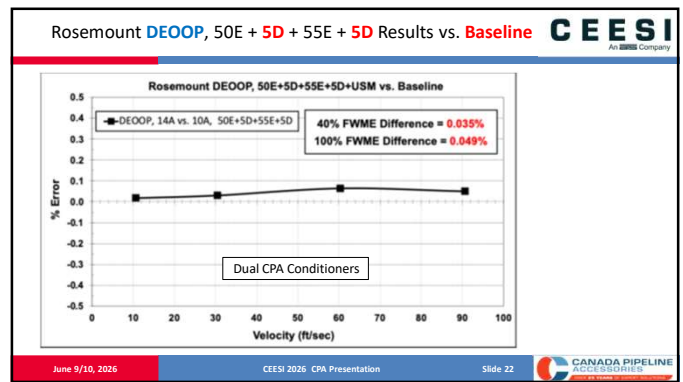
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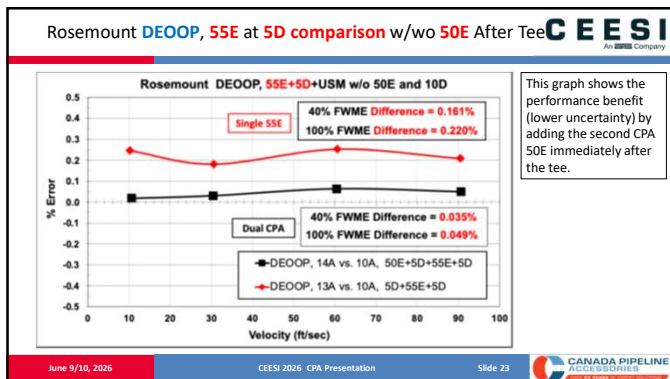
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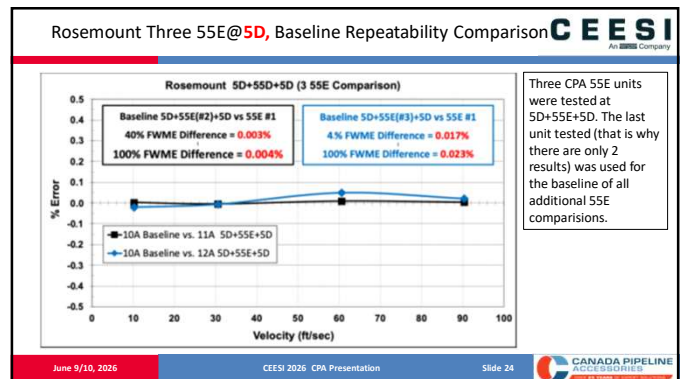
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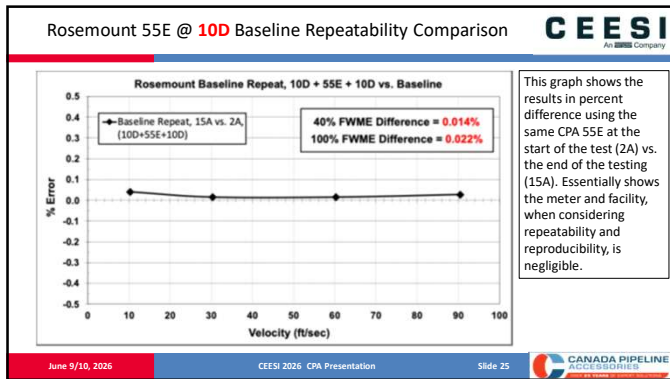
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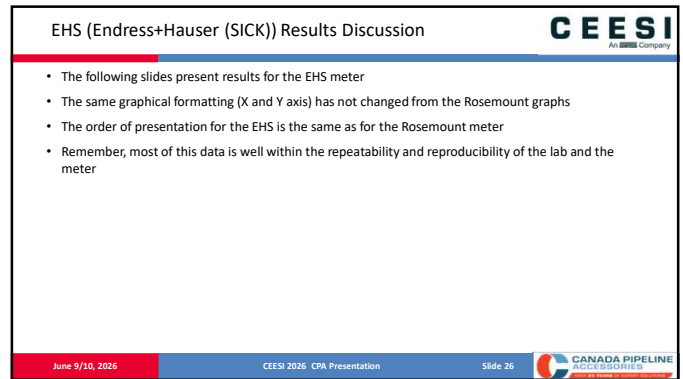
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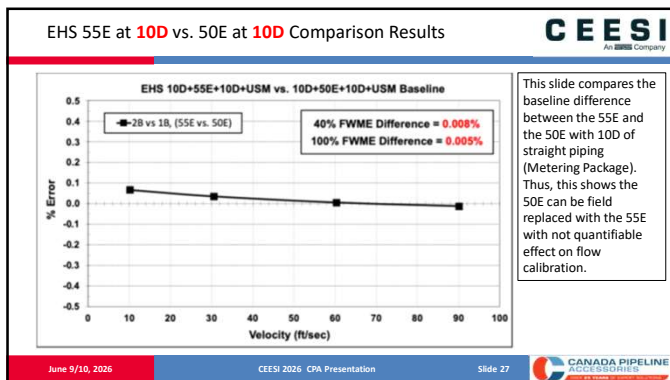
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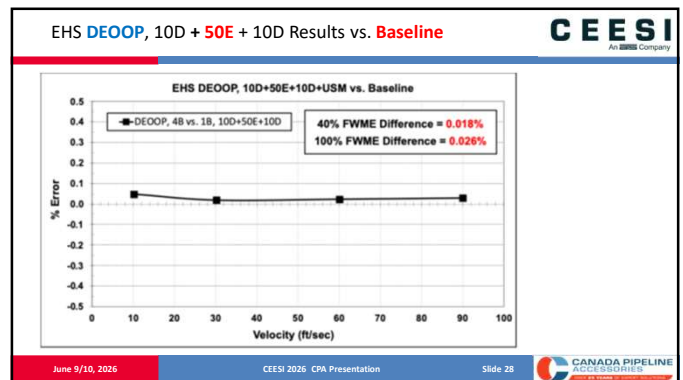
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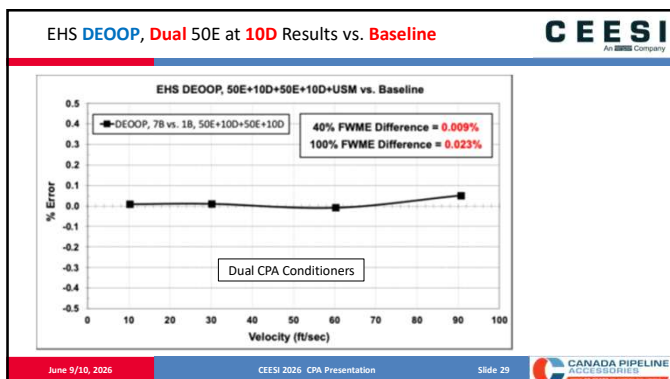
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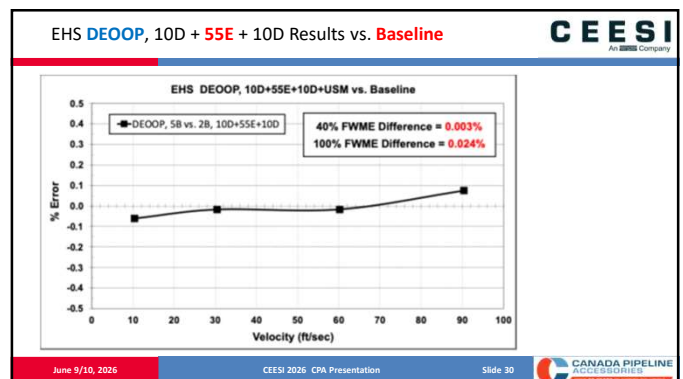
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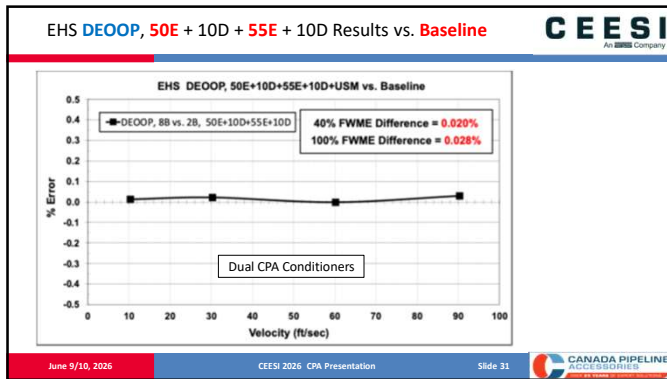
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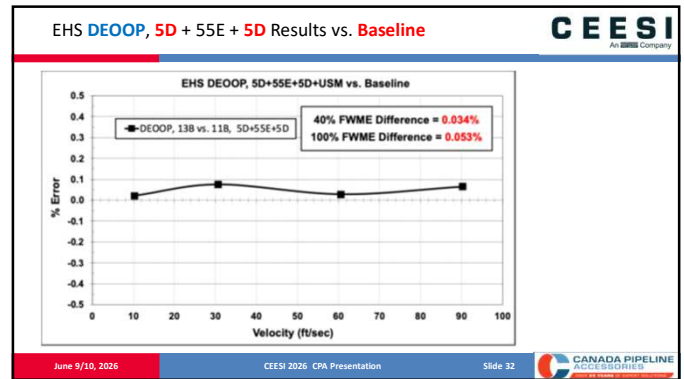
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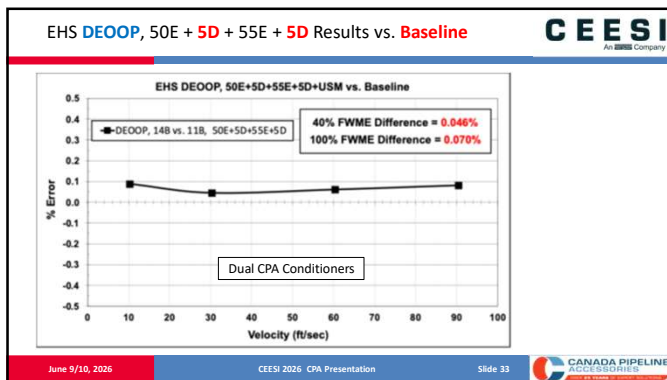
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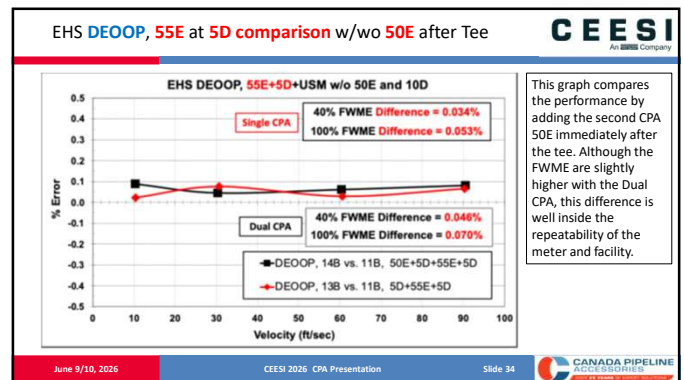
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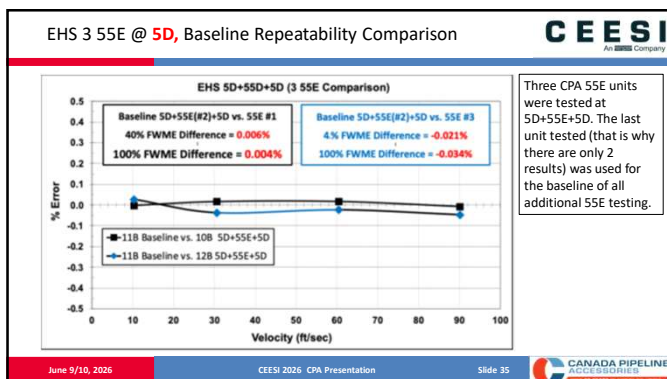
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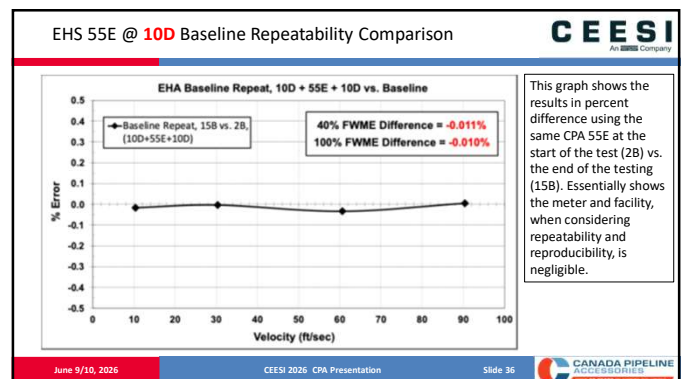
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Pressure Drop Discussion

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- The question about pressure drop is always mentioned when adding a second flow conditioner
- There is an infinite number of meter station designs, so a single answer is not practical
- Pressure drop is also a function of flow rate and all the associated piping
- A typical meter station design might include two parallel runs with an underground header
- The following CFD graphic shows what might be considered a typical design using dual-tees upstream and downstream of the meter run
- Pressure drop was computed via CFD with two assumptions: 806 PSIG inlet and 60 FPS flow rate

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Typical 12" Dual-Run Station with Headers and Dual-Tees

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- Assume in Outlet Pressure is 800 PSIG
- Assume a flow velocity of 60 FPS
- Let's look at the total pressure loss from the upstream inlet (green dot) to downstream outlet (red dot).

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6" Dual-Tee Package Installation Effects at CEESI Calibration

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- The use of dual-tee packages upstream and downstream have been used by many over the past 20 years
- Many believe this package will produce the same flow profile regardless of upstream field piping conditions
- The previous slides help summarize potential pressure losses with this design
- In April 2016, a client sent their 6" dual-tee package to CEESI for flow calibration (Tees+10D+50E+10D+USM)
- This photo is from the downstream end, but is the same design as the inlet to the meter run
- CEESI notified the client that the flow profile was **abnormal** and suggested adding a 2nd CPA
- The following graphs show the profile before the second CPA 50E was added, and afterwards
- This was part of a joint paper published by Randy Miller and John Lansing at the May 2017 AGA Operations Conference in Kissimmee, Florida

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6" Meter Diagnostics with Tees and one CPA 50E, 1st Meter

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Two CPA 50E Units

Before the 2nd CPA 50E was Installed

After the 2nd CPA 50E was Installed

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Second 6" Dual-Tee Installation Effects

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- A few weeks later a second 6" meter run arrived at the calibration facility
- It had the same design with only one CPA 50E installed at 10D from the meter (10D+50E+10D)
- This picture shows the entire meter run with the upstream side on the left
- Once again, the meter diagnostics indicated there was a problem
- CEESI contacted the client and explained the issue with the flow profile
- The client then agree to have CEESI add a second 50E immediately after the upstream tee package
- The following slide shows the diagnostics for this second meter

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6" Meter Diagnostics with Tees and one CPA 50E, 2nd Meter

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Two CPA 50E Units

Before the 2nd CPA 50E was Installed

After the 2nd CPA 50E was Installed

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Dual-Tee Installation Effects Summary

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- The intent of the dual-tee package is to provide a fully developed, non-swirling symmetrical flow profile regardless of the upstream flow profile
- Although these meters utilized the same dual-tee design, the flow profile for both was **abnormal** (exhibited swirl), and the swirl was in the **opposite direction** on the second meter
- Upstream field piping may have caused a completely different flow profile compared to the lab since the lab used 50+D of straight piping, and thus **there were no lab-incurred flow profile distortions**
- The addition of the second 50E at the outlet of the upstream dual-tee package (at 20D from the meter) eliminated the distorted profile (swirl) issues for both meters
- One question that is often asked is: "Does the orientation of the **upstream** 50E have any effect on the **downstream** 50E?" In other words, does rotating the upstream 50E affect the meter's accuracy?
- In this same AGA paper that question was answered when the upstream 50E was rotated 30 degrees
- Test results showed the orientation of the upstream flow conditioner **had no effect** on the downstream flow conditioner's performance (meter accuracy)

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Conclusions

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- The intent of this testing was to validate using a second flow conditioner further reduces uncertainty
- A typical piping installation effect (DEOP with a tee) was used for all installation-effects testing
- This installation effect is certainly not the most difficult that has been seen in the field
- The dual 50E testing was performed to show the benefits for clients using 10D+50E+10D+USM
- The 55E testing was performed using 10D to confirm replacing a 50E (at 10D) with a 55E does not affect the original calibration
- Installation effects with the 55E at 10D were included for clients to understand the benefits over the 50E
- Dual flow conditioner testing was done with both 10D of piping and 5D of piping (55E only at 5D)
- The results of the dual flow conditioner (50E+5D+55E+5D) certainly suggests shorter metering packages are very practical and don't add significant measurement uncertainty compared to 10D piping
- Shorter piping (5D) not only saves ~\$1700 for each 12" spool (~\$3400 for both), but allows for a shorter skid package, and therefore significantly reduces the cost of a single or multiple meter-run design

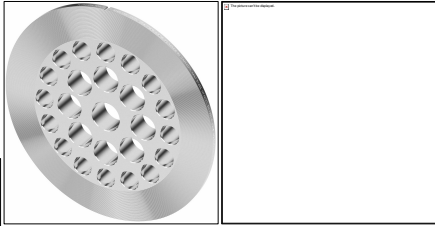
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Thank You – Questions?

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- For Further information
www.flowconditioner.com
John Lansing
Technical Consultant
John@cpacli.ca
CPA Office: 403.236.4480
John's Cell: 713.203.9979



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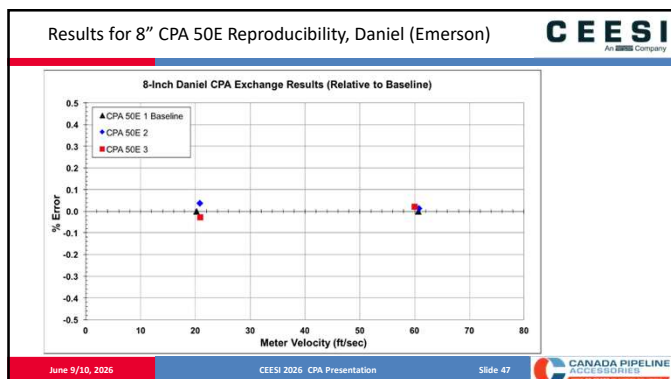
Discussion on Reproducibility of the CPA 50E

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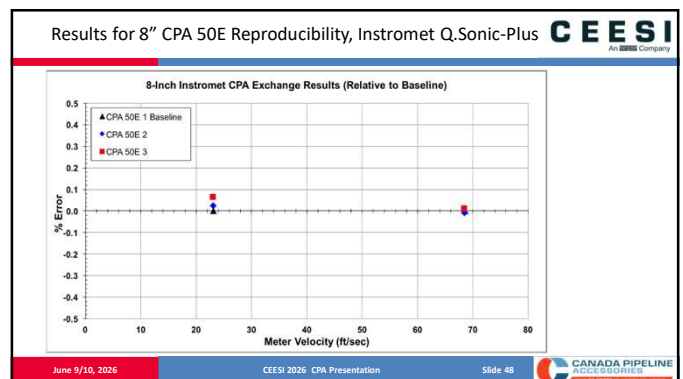
- One might ask if the flow conditioner's performance is reproducible from one conditioner to the next
- That is, if a flow conditioner is replaced, will the results be within the repeatability of the meter & lab?
- Around 2016 a week-long gas USM testing was performed at CEESI Iowa, and a variety of data was collected based on the suggestions of the NAFFMC
- Several representatives comprised the NAFFMC over 15+ years including Randy Miller, Reese Platzer, Jonathan Mustafa, Ed Hanks, Bill Frasier, Gary McCargar, Bob Wurm, Dan Rebman & Eduardo Jasso Rico
- In 2017, an AGA paper was published by Randy Miller and John Lansing titled "Resolving Gas USM Installation Effects Caused by Tees," summarizing a variety of previous years of test results
- One of these tests was to answer the question: "If I replace a CPA 50E in the field, will there be any effect on the meter's calibration?"
- To answer that question, 3 brands of 8", Schedule 40 meters were baseline tested, each with 3 different CPA 50E flow conditioners – Emerson (Daniel), Instromet Q.Sonic-Plus (Honeywell) and SICK
- The following slides show the results for each manufacturer's meter

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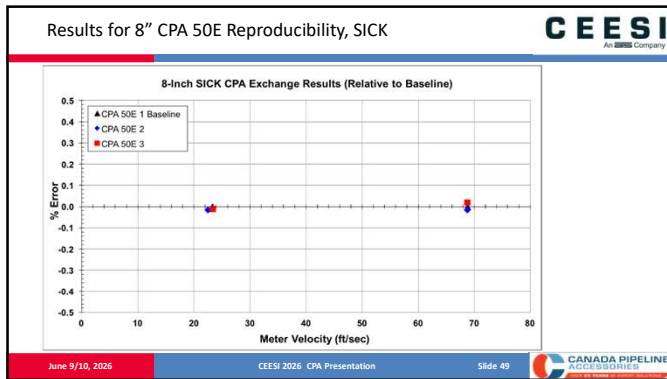
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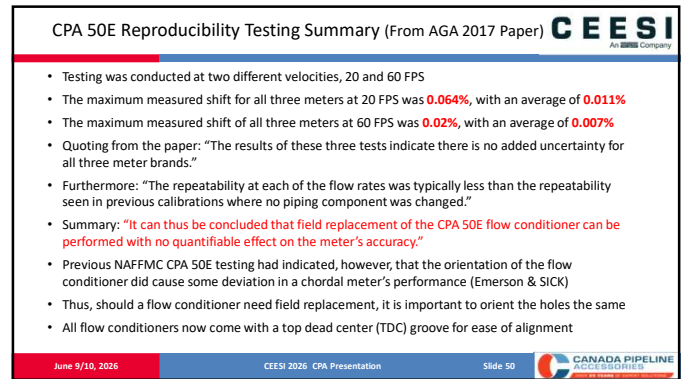
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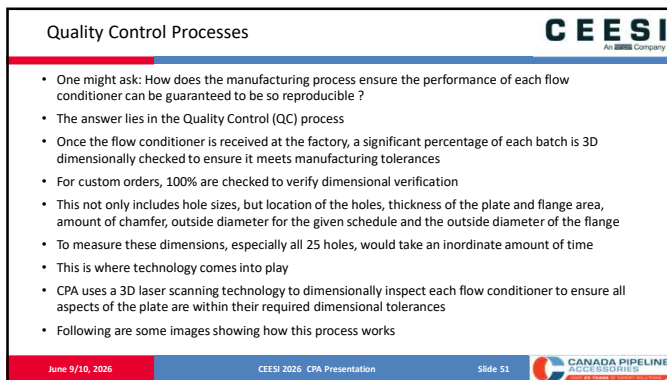
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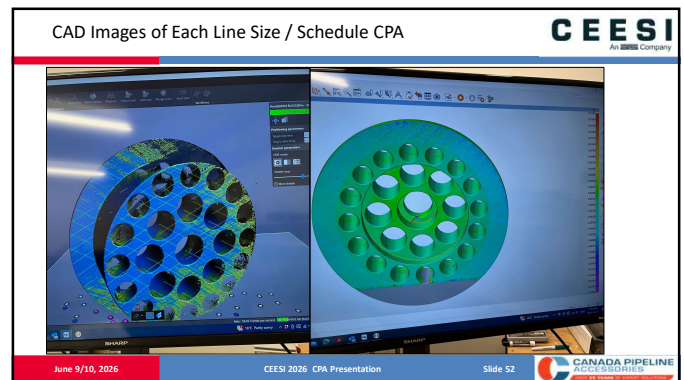
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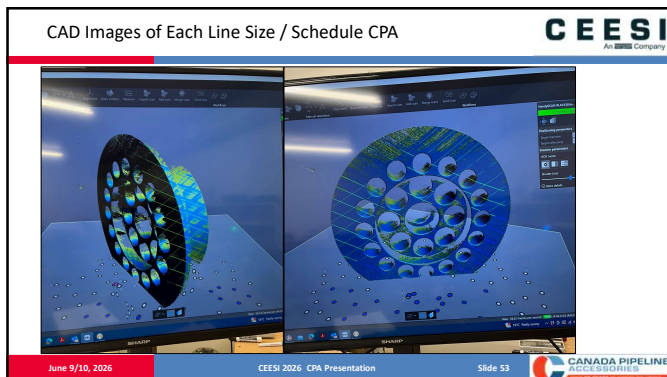
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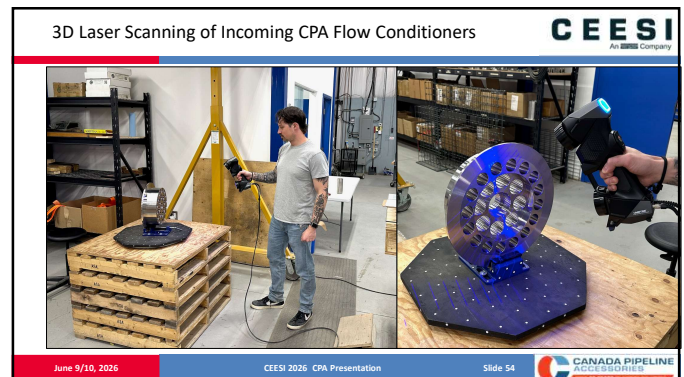
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