Caterpillar Oil Aeration Test (COAT) Group Visit

August 15, 2017

Questions and Answers

1. What does Emerson recommend to assure universality of MM setup across labs?

   – Although there are several options to unify all of the density measurements for COAT, all options can provide equivalent accuracy. Suggested options that should provide equivalent results are:

     a) Hold the meter ambient temperature at the same temperature as the process fluid (iso-thermal). This may be done by heating the test chamber to the process temperature or by using heating jackets on the sensors to heat them to the process fluid temperature. This iso-thermal setup eliminates the heat transfer effects that can result in the sensor RTD reading a different temperature from the measured process fluid temperature.

     b) Use an accurate external temperature measurement of the process fluid for the density calculation

        1. Model 2700 and 5700 transmitters may be configured to use the temperature value written to them via Modbus or HART for the density calculation. The 5700 can also accept a 4-20 mA signal for this.
        2. The density may be calculated externally to the sensor/transmitter. The tube frequency may be polled via Modbus, or back-calculated from the transmitter density value using the transmitter RTD temperature. Density may then be calculated using the period/frequency in combination with the external process fluid temperature value.

     c) Hold each meter at a fixed process fluid and ambient temperatures (50° for instance). Use custom DTC coefficients developed from Micro Motion enhanced density calibrations or known density test results at different temperatures. Consult Micro Motion for assistance with this.

2. Can Emerson provide us a detailed schematic of the flow meter and measured parameters for future reference?

   – Covered by discussion, demo unit and video: https://www.youtube.com/watch?v=31jYXlnu-hU&index=10&list=PLTI6uY3auTkZNUoe7HpcN47EtAt06dd4c

   – Measured parameters are delta T between the pickoff sine waves, resistance of the platinum RTD and the tube period from one of the pickoff sine waves

3. What are the differences in the meters?

   – *Include model numbers of transmitters, sensors, meters (model numbers),* puck *(include all info including serial IDs)*

   – Firmware version: what are the differences and can they affect the results

     • SMV is available on newer models

4. What are the differences in the transmitters and puck?

     • The ‘puck’, also known as the core processor, derives the parameters for measuring flow, temperature and density. The core processor may be mounted on the sensor, remotely with/in the 2700 or 5700, or located between the sensor and the transmitter in a configuration known as a ‘double hop’.

   – Is there a difference in the density, flow, or temperature calculation?

     • No, except for old RFT9739s that allowed temperature reading adjustment by the user, which affected the density calculation

   – Will any difference cause potential differences in observed parameters?

     • Old 9739s will cause differences if the temperature in the transmitter is adjusted (affects density calculation). Otherwise no.

5. How do our systems calculate density?
   - How is temperature used in the calculation?

     See attachment ‘Density Equations’
   - What temperature is used?
     - Temperature from the RTD located in the inlet tube manifold on CMF025s produced since 2006 (7digit serial numbers). Temperature from the RTD mounted on an inlet tube for 6 digit serial numbers prior to 2006
   - Can that temperature be manipulated via software by the labs?
     - Indicated temp can be adjusted, this does not affect temp used for density calculation in device. As mentioned, 2700 and 5700 transmitters may be configured to use an external temperature input for the density calculation.
   - Should calibration correct for any temperature discrepancies?
     - Differences in RTD and fluids (inner tubes, measured by thermocouples)
       a) Calibration under a constant set of conditions can correct for discrepancies. See question 1.
   - Is mathematically correcting density for temperature a valid option?
     - Yes. Given the heat transfer considerations in the COAT, using a more accurate process temperature for the density calculation is a valid approach. This is discussed in question 1.
6. How do our systems calculate temperature?
   - Using a Pt100 Class A RTD using Pt100 Class A RTD resistance equations
   - What is that temperature representative of (tubes or fluid)?
     - It is most representative of the tubes, however temperature differences and low heat transfer rates can affect this and lead to differences between the RTD reading and the process fluid.
7. How do our systems calculate flow? See the video link in question 2.
8. What is Emerson’s calibration process? Standard or others.
   - For this application we recommend the enhanced 0.0002 g/cc calibration when purchasing new unit. One can approximate this calibration using known density test results from various temperatures.

9. Can the calibration be done closer to the test conditions?

   – For density?

   – For Temperature?

      • 55C with the enhanced density calibration option

   o What is the accuracy of the RTD? Pt100 Class A:

ELECTRICAL SPECIFICATIONS:	
RESISTANCE:	100 OHMS ±.060 OHMS AT 0°C.
MEAN TEMPERATURE COEFFICIENT:	38.5Ω/100Ω/100°C IN ACCORDANCE WITH DIN IEC 751
PERMISSIBLE DEVIATION:	-60°C TO +200°C ±(0.060Ω + .001Ω/°C) IN ACCORDANCE WITH CLASS A, DIN EN60751
	-200°C TO -60°C ±(0.120Ω + .002Ω/°C) IN ACCORDANCE WITH CLASS B, DIN EN60751
OPERATING TEMPERATURE RANGE:	-200°C TO +200°C BELOW -50°C THE ASSEMBLY MUST BE PROTECTED FROM ROUGH HANDLING OR IMPACT LOADING.

   o Is the RTD calibrated? How accurate is the indicated temperature?

      ▪ The supplier trims the RTDs to specification.

   – For Flow?

      • Meters may be ordered with custom flow rate calibrations

10. What is “Adjusted Density Calibration Factor” referenced in last year’s question and answer document?

    See attachment ‘Questions for Emerson regarding Micromotion sensors 11July2016’

   – What would it do?

      • See question 1, option C

11. Where exactly is the tube RTD along the flow path? In the middle, at one end?

   – In the manifold at the inlet side for 7 digit serial numbers (post 2006). Mounted on the tube for 6 digit serial numbers (pre-2006)

12. Where exactly is the RTD measuring temperature of the tube?

   – The desired measurement is the tube skin temperature. How well the RTD can measure this is impacted by heat transfer from the fluid through the tube wall to the RTD and on to the atmosphere surrounding the RTD. Heat transfer from the fluid correlates to the flow rate through the tubes. COAT’s rates are less than optimal for this, though this can be addressed via option C in question 1..

13. What is the tube wall thickness in a CMF025?

– 0.020”

14. What is the magnitude of the temperature effect on the modulus of elasticity between 85C and 90C? 0.21% (4.2%/100C)

    – Does this factor in the temperature gradient across the tube between an indicated fluid temp of 90C and an indicated tube temp of 85C?

        • Yes.

15. What is the pressure drop through a CMF025 at 1.5 L/min of oil at 90C?

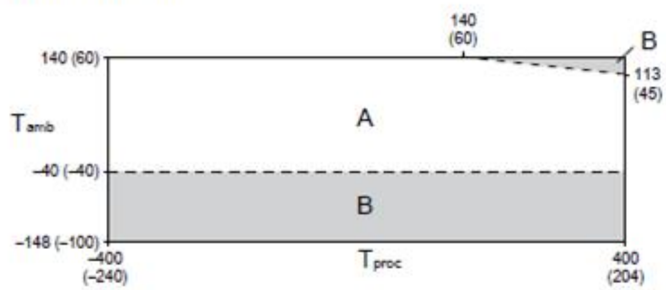
    – ~ <1 psi. Need viscosity and density for more precise answer. Your salesperson or the Factory (800-522-6277) can answer this with this additional information.

16. Can we really operate the sensor in a high temperature ambient of 212F (100C) for long periods of time since the guidance in the manual says 140F (60C) is the upper limit for the sensor?

    – See additional notes from the Product Data Sheet on the next slide. CMF025 sensor max. is 204C, ambient limits relate to the electronics, including the core processor.

July 2017 **ELITE Series Coriolis Flow and Density Meters**

Ambient and process temperature limits for ELITE CMF*M/L/H/P (excludes special order cryogenic modifications) and CMFS010-015 meters**



T_{amb} – Ambient temperature °F (°C)

T_{proc} – Process temperature °F (°C)

A – All available electronic options

B– Remote mount electronics only

Temperature limits

Sensors can be used in the process and ambient temperature ranges shown in the temperature limit graphs. For the purposes of selecting electronics options, temperature limit graphs should be used only as a general guide. If your process conditions are close to the gray area, consult with your Micro Motion representative.

Notes

- In all cases, the electronics cannot be operated where the ambient temperature is below –40 °F (–40 °C) or above +140 °F (+60 °C). If a sensor is to be used where the ambient temperature is outside of the range permissible for the electronics, the electronics must be remotely located where the ambient temperature is within the permissible range, as indicated by the shaded areas of the temperature limit graphs.
- Temperature limits may be further restricted by hazardous area approvals. Refer to the hazardous area approvals documentation shipped with the sensor or available from the Micro Motion web site (*www.micromotion.com*).
- The extended-mount electronics option allows the sensor case to be insulated without covering the transmitter, core processor, or junction box, but does not affect temperature ratings. When insulating the sensor case at elevated process temperatures (above 140 °F), please ensure electronics are not enclosed in insulation as this may lead to electronics failure.
- For the CMFS007 sensor, the difference between the process fluid temperature and the average temperature of the case must be less than 210°F (99°C)

17. According to the graph, the sensor is rated to 400F (204C) specification and the electronics are rated to the 140F (60C) ambient. So, when the ambient electronics temperature is above the 140F (60C) it has the "B" notation where the electronics must be remote mounted. All the electronics are only rated to a temperature at or below the 140F (60C) so they must be remote at or above that temperature. I believe you run your process at 80 to 100C and if you build a heat box that will maintain the ambient to that same temperature as the process fluid, the electronics will need to be remote (outside of the heated box).

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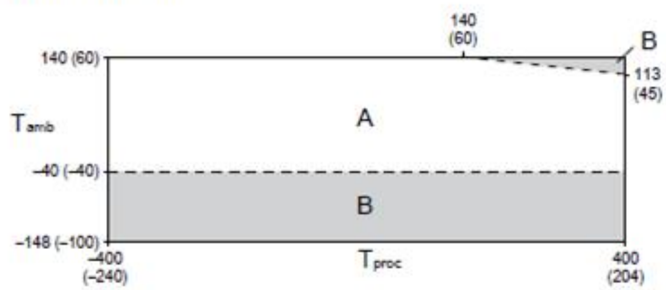

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18. How are other units handled that are in service with a delta of ~40C between ambient and process temperatures?

    a. Many customers insulate and heat trace the meter body to keep the meter at operating process conditions (meter body is kept at process fluid temperatures). These meters typically have a 9-wire junction box on the sensor and a remotely mounted electronics.

19. How is the output and calibration affected by operating with a process fluid below atmospheric at 84 kPaA?

    b. The only concern would be pressure drop as there is very little pressure in the system so minimal pressure drop would be a requirement to keep the system flowing properly. There would be no effect on the output or calibration. With the small meters you use (CMF025) there is no pressure effect.

20. What is the flow accuracy at 1.5L/min of oil with a density of 0.82 g/cc?

    c. For a CMF025 meter, 0.10%