

COALITION EXHIBIT 'E'

Background Information for Flow Meters

1. Primer on magnetic flowmeters and how they measure flow of conductive (salty) liquids:

Basics of flow meters (turbine and magnetic):

<http://www.youtube.com/watch?v=DqsUQIVjn4Y&feature=related>

Spitzer and Boyes Consumer Guide to Flowmeters (\$250) mentioned in credits:

<http://www.cafepress.com/spitzerandboyes.255167017>

Magnetic flowmeter basics (pretty easy to understand):

<http://www.youtube.com/watch?v=f949gpKdCl4&feature=related>

2. Comparisons of field calibration methods and the value of using "smart meter varification":

Field calibration methods and value of a "smart meter verification"

<http://www.emersonprocessxperts.com/2011/09/magnetic-flowmeter-calibration-verification-and-diagnostics/>

Five minute video demonstrating the "smart meter verification"

<http://www.youtube.com/watch?v=qAYf8pghKRU>

Article referred to in video:

<http://www.eddl.org/SiteCollectionDocuments/Articles/pg42-47-1-MAG3.pdf>

3. Valley Air Solutions flow meters for Dairy

Website:

<http://www.valleyairsolutions.com/products.htm#manure%20flowmeter>

Factsheet:

<http://www.valleyairsolutions.com/VAS%20VDP%20Flowmeter%20Datashet.pdf>

Worksheet used to order a flow meter for a dairy:

<http://www.valleyairsolutions.com/SiteSurveyValleyAirSolutions.pdf>

4. MagMaster products

Spec sheet for magmaster flow meters:

[http://www05.abb.com/global/scot/scot203.nsf/veritydisplay/5c3a8f527f58bd7dc12575ad002b2f20/\\$file/ss_mag_ww_20.pdf](http://www05.abb.com/global/scot/scot203.nsf/veritydisplay/5c3a8f527f58bd7dc12575ad002b2f20/$file/ss_mag_ww_20.pdf)

5. Global Water

Brochure:

<http://www.globalw.com/downloads/SMPProduct/wmx101B.pdf>

Manual (page 8 shows where to install flow meter with respect to potential cavitation) <http://www.globalw.com/downloads/SMPProduct/wmx101.pdf>

Brief description of all their flowmeters (including open channel and pipe) <http://www.globalw.com/downloads/Catalog/FlowMetering.pdf>

Rest of the resources book:

<http://www.globalw.com/ResourceBook.html>

Magnetic flow meter price list:

<http://www.globalw.com/products/wmx101.html#Options>

Prices for other options, such as alarms and remote sensing:

http://www.globalw.com/catalog_remote.html

6. Shenitech DigitalMag888 Magnetic Flowmeter

Website with specs:

<http://www.shenitech.com/DigitalMag888.htm>

7. Discussion of calibrating

As a percentage of rate versus percentage full-scale and which is more accurate:

<http://www.flowcontrolnetwork.com/measurement/flowmeters/article/flowmeter-calibration>

Archives of many brief articles about flow measurement:

<http://www.flowcontrolnetwork.com/measurement/flowmeters/issue-archives/recent>

Series on flow measurement problems:

Part 1 <http://www.flowcontrolnetwork.com/measurement/flowmeters/article/part-i-flow-measurement-problems>

Part 2 <http://www.flowcontrolnetwork.com/measurement/flowmeters/article/part-ii-open-channel-flowmeter-problems>

Part 3 <http://www.flowcontrolnetwork.com/measurement/flowmeters/article/part-iii-open-channel-flowmeter-problems>

Upstream requirements:

<http://www.flowcontrolnetwork.com/measurement/flowmeters/article/which-piping-configuration-requires-the-longest-upstream-straight-run>

8. Introduction to pressure differential flow meters orifice plates, venturi meters:
<http://www.youtube.com/watch?v=QV2V8Dazpz0&feature=related>

Another back to basics video:

<http://www.youtube.com/watch?v=R9MJEjgrUqo&feature=related>

Endress+hauser video:

<http://www.youtube.com/watch?v=oUd4WxjoHKY&feature=related>

9. Fundamentals of orifice plate flow meters

<http://www2.emersonprocess.com/siteadmincenter/PM%20Daniel%20Documents/Fundamentals-of-Orifice-Measurement-techWpaper.pdf>

10. White paper on theoretical uncertainty of orifice plates - areas of concern relate to physical properties of the fluid measured, eccentricities of orifice plate installation, effects of sloppy seals and gaskets, and proper placement within the flow pipe system.

<http://www2.emersonprocess.com/siteadmincenter/PM%20Daniel%20Documents/Theoretical-Uncertainty-of-Orifice-Flow-Measurement-techWpaper.pdf>

11. Short video on parshall flume measurement of discharge from wastewater lagoon <http://www.youtube.com/watch?v=vh9ifzZuZ1k>

12. Short video history of Parshall flume (designed by a civil and irrigation engineer in early 1900's) <http://www.youtube.com/watch?v=CAUtp0sUxhw&feature=related>

13. Good EPA video on Parshall flumes at POTWs and inspection to verify accuracy - most common problems are location, installation, and sizing of the flume. should be located in a place of little to no turbulent flow. inspect construction materials to be sure they have not degraded over time. downstream discharge from the flume must be able to allow continuous discharge without resistance (meaning, the fluid flowing through the flume should not face a blockage or other means of putting force on the discharge thus slowing it down). Need to inspect for accumulation of debris or scaling at the divergence side of the plume (9:40 min of video)

<http://www.youtube.com/watch?v=y6hiOLgTo6g&feature=related>

14. Water turbulence disrupts accuracy of some flow meters. Analysis of various in-flow flow meters (turbine and paddle wheel) and how turbulence affects accuracy compared to same system with straightening vanes.

http://cdf.org/wp-content/uploads/2012/01/7_14_Schwankl_CalAgArt.pdf

15. Flow meters tested on dairy lagoon water. Field test of electromagnetic flow meters and a Doppler flow meter determined that both were accurate, dependable, and appropriate for measuring manure water flow rates. Discusses problems with using just

pump rate to determine flow rate as the depth of the lagoon drops over the course of the pumping period. This is **Coalition Exhibit 'G'**.

http://cdrf.org/wp-content/uploads/2012/01/7_13_Schwankl_Flow_Meters.pdf

16. Flow Meters for Measuring Dairy Liquid Manure Applications. Each of the other common methods of measuring the amount of lagoon water applied can result in large errors. The flow rate over time method can be inaccurate for both pumped and gravity systems because the depth of water in the pond and the pumping distance will influence the pond discharge flow rate, and the lagoon pump output can be reduced by half when lagoon water is very thick. The pond drop method is rarely accurate because of many difficulties and is especially unreliable if other unmeasured pond outputs and inputs are occurring at the same time as irrigation. This is **Coalition Exhibit 'F'**.

<http://manure.ucdavis.edu/files/52489.pdf>

17. Terminology may be a key to finding compromise:

http://www.emersonprocessxperts.com/2009/10/flow_meter_veri/

Calibration is performed at the factory. It establishes the relationship between flow and signal produced by the sensor. Validation confirms flow performance by comparing a primary flow standard to the sensor. Verification establishes confidence in performance by analysis of the secondary variables associated with flow. Many times these terms are used interchangeably. Also, frequently calibration or validation is done when only verification is needed.

During factory calibration, baseline measurements are performed in which the smart device can self-check against once operating in the field. For example, Micro Motion Coriolis meters check tube stiffness and Rosemount E-Series Magnetic Flowmeters check against a magnetic field signature to perform ongoing verification.

Micro Motion Coriolis meters:

<http://www2.emersonprocess.com/en-us/brands/micromotion/Pages/coriolis-flow-density-measurement.aspx>

Rosemount E-series Magnetic Flowmeters:

<http://www2.emersonprocess.com/en-US/brands/rosemount/Flow/Magnetic-Flowmeters/E-Series-Advanced-Diagnostics/Pages/index.aspx>

Smart meter verification is verification on demand, whenever you want on demand or on a schedule. It provides diagnosis of the whole system including the sensor, drive, and signal processing. This verification process provides absolute confidence in measurement performance.

18. An example of infield verification device for a magflow meter:

Designed for use with the M2000 and M5000 mag meters, this handheld device allows you to perform a series of field verification and analytical performance tests on site, in less than 20 minutes.

Verify the meter is within one percent of its original factory calibration

Check all input/output functions

Measure electrode resistance and integrity; coil insulation resistance; and current and frequency at previously selected flow rate

Evaluate signal processing

Verify noise immunity

<http://www.badgermeter.com/getdoc/93568a57-2590-420f-9171-58fbdce41f3/M-Series-Handheld-Verification-Device.aspx>

Device verifies the electronics (flow meter secondary):

<http://www.badgermeter.com/Water/Water-Meters/Electromagnetic-Flow-Meters/M-5000-Mag-Meter/ITB-194-01--12-10--M-Series-Field-Verification-Dev.aspx>

Brochure on both mag meter and field verification:

<http://dpwsd.waterworld.com/index/display/elp-article-tool-template.articles.waterworld.volume-27.issue-1.products.product-focus.new-mag-meters-offer-field-verification-option.html>