Alden Test Results
On
AMITY Insert Venturi

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A laboratory test was performed on an AMITY designed insert Venturi at the Alden on October 27, 2009 to obtain the coefficient of discharge (C). An Air Products representative witnessed the Test along with personnel from AMITY flow.

The meter being crated is shown in Figure 1.

Figure 1 Air Products AMITY 36 " Venturi

The ALDEN laboratory flow circuit is shown in Figure 2

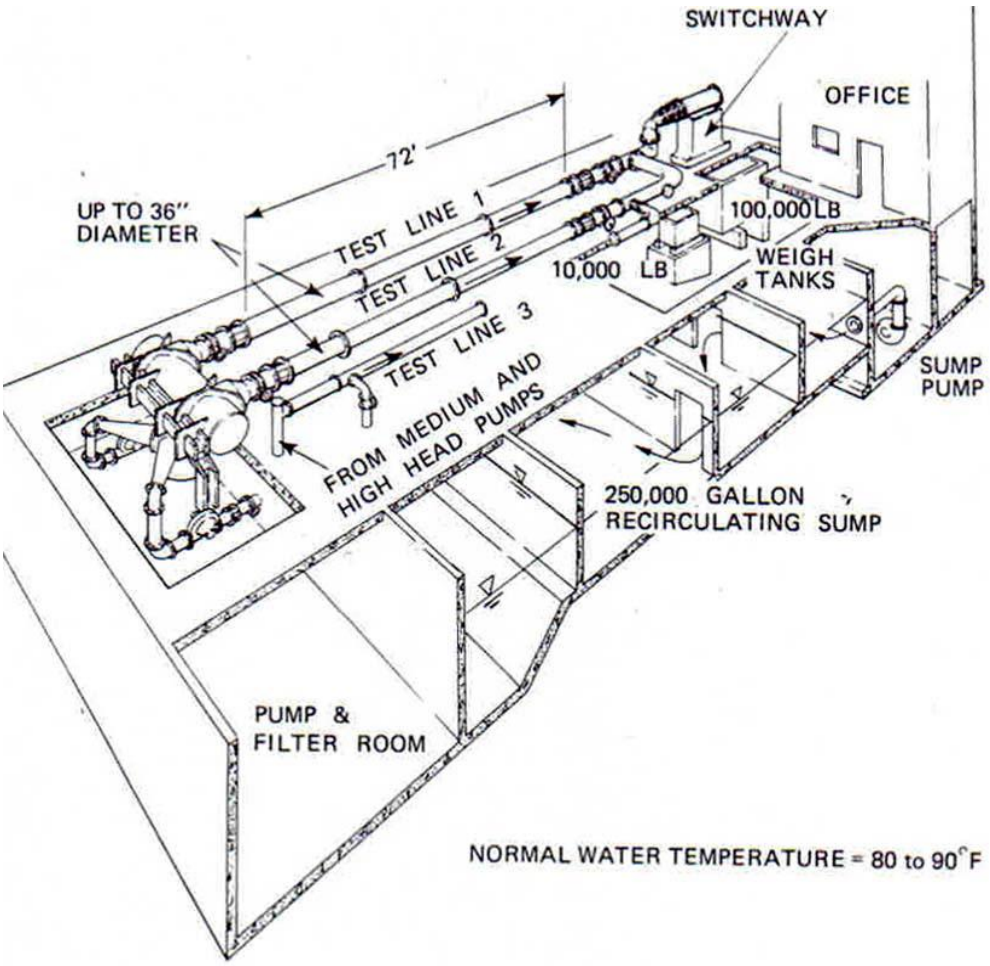

Figure 2 ALDEN Flow Circuit

During installation it was noted

1. The meter's centerline was eccentric with respect to the pipe centerline; a result of the laboratories flange bolt circle not bein the same as the meter.
2. The upstream tap to throat tap distance was not as specified by AMITY or per Air Products specifications. (Approximately 1 pipe diameter).

Customarily ALDEN runs high, mid range and low flow-rate data points to establish any calibration or meter problems before a full test. It was noted that the low flow rate point was lower than expected by approximately 0.35%. A subsequent repeat indicates an increase in coefficient (at the same Reynolds number) of 0.31 %.

These results are most probably caused by

1. The bore of the meter and meter orientation within the pipe had not reached full thermal equilibrium. (Laboratory water temperature= 103 ^{0} F)
2. Increased white noise at the upstream pressure tap resulting from meter eccentricity.
3. The leads to the differential pressure transmitters acts like a zero offset due to different temperature within the leads.

Sufficient upstream piping provided a fully developed flow at the Venturi entrance. Preliminary ALDEN results are presented in Figure 3.

The initial three data may have a dimensional, orientation, or lead line temperature bias; however, test results are in excellent agreement with boundary layer theory, suggesting a minimal effect (estimated <0.05 %)

AMITY FLOW
Purchase Order Number: 1002-02
36" AVM INSERT STYLE METER
Serial Number: 1002-01

CALIBRATION
DATE: October 27, 2009
PIPE DIAMETER = 35.2500
THROAT DIAMETER = 18.3110

Run #	Line Temp Deg F	Air Temp Deg F	Net Weight lb.	Run Duration secs.	Output [see note]	Flow GPM	H Line FT H20	Pipe Rey. # x 10^6	Coef
1	103	86	99943	35.196	5.552~	20594.88	9.326	2.7650	0.9858
2	103	85	97281	49.414	3.706~	14277.13	4.483	1.9089	0.9857
3	103	86	95118	101.151	2.391~	6819.51	1.032	0.9118	0.9812
4	102	87	99446	37.247	5.136~	19361.86	8.234	2.5860	0.9864
5	103	87	98986	39.542	4.758~	18154.14	7.243	2.4272	0.9861
6	102	87	98475	42.294	4.389~	16885.02	6.275	2.2552	0.9854
7	102	86	97975	45.334	4.059~	15672.67	5.409	2.0933	0.9852
8	103	84	96939	53.696	3.433~	13092.43	3.767	1.7505	0.9861
9	103	84	96530	58.982	3.176~	11868.83	3.094	1.5869	0.9864
10	102	84	95883	65.816	2.934~	10564.98	2.457	1.4111	0.9853
11	103	84	95504	74.536	2.721~	9292.27	1.898	1.2424	0.9859
12	102	84	95237	86.047	2.539~	8026.41	1.421	1.0720	0.9843
13	102	84	95082	101.006	2.390~	6826.56	1.029	0.9118	0.9836

Figure 3 ALDEN data

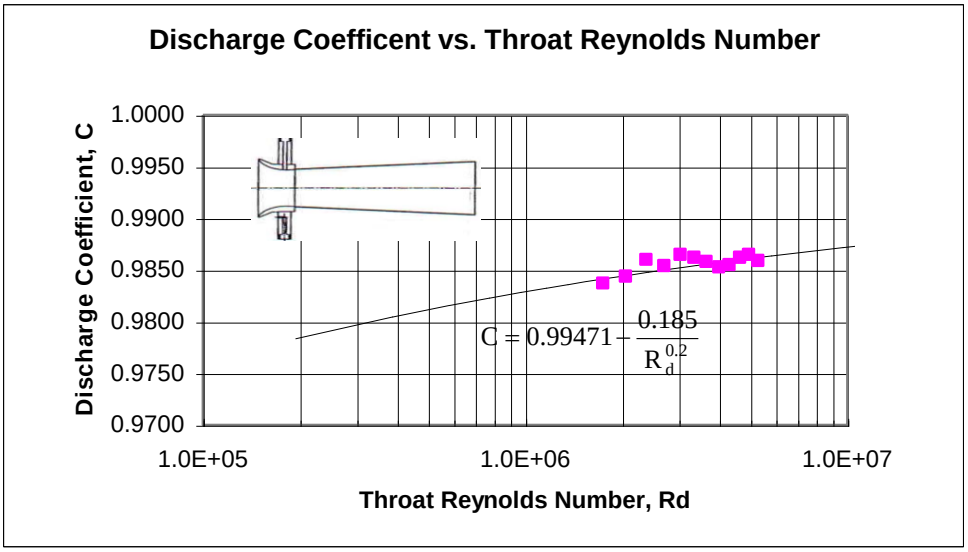

Figure 4 Plot of ALDEN data

Data Analysis: The AMITY meters are designed such that the throat area is in accordance with the exacting requirement for the ASME PTC-6 nozzle. This throat is the controlling area that defines meter performance. The literature clearly indicates that a throat area and properly manufactured pressure tap will replicate and be predicable to the boundary layer theory presented in numerous papers. This design objective has been verified by test results at ALDEN for all of the AMITY meters.

The AMITY sizing Program incorporated this theory (see References) in the design of the meter for Reynolds number pressure and temperature effects.

1. Tap geometry and fabrication
2. Throat entrance streamline
3. Throat surface finish
4. Required circularity

Excluding data point 3 following extrapolation equation is derived from the ALDEN data using the recommended PTC-6 method.

$$C_d = 0.99471 - \frac{0.185}{R_d^{0.2}}$$

The constant 0.99471 is the discharge coefficient at “infinite” Reynolds number and its values depends on the inlet geometry design. A Computational Fluid Dynamic (CFD) study of the fabricated meter is shown in Figure 5.

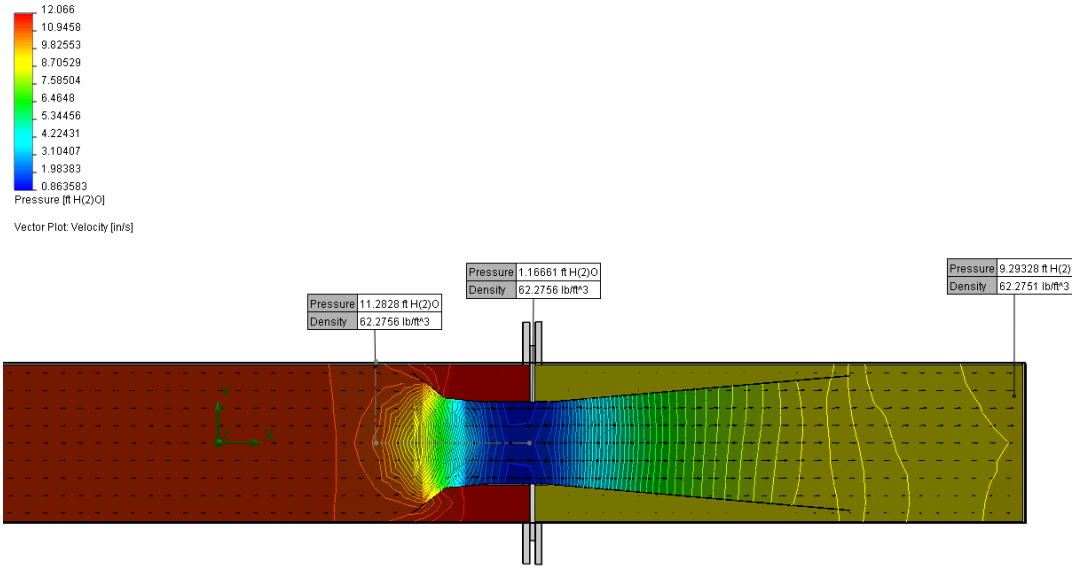

Figure 5 CFD Study

For the normal operating Bore Reynolds number the extrapolated Coefficient is

$$Cd := 0.99471 - \frac{0.185}{\left(\frac{6472868}{.51919}\right)^{.2}}$$

$$Cd = 0.98766278$$

The extrapolated discharge coefficient is expected to be within $2\sigma = \pm 0.1\% \pm$

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