



LABORATORY/OFFICE:
 54043 County Rd. 37
 Nunn, Colo. 80648
 Phone: 970-897-2711
 FAX: 970-897-2710

**COLORADO ENGINEERING
 EXPERIMENT STATION INC.**

...the primary source for flow measurement solutions...



IOWA HIGH FLOW FACILITY
 2365 240th St.
 Garner, IA 50438
 Phone: 641-923-3664
 FAX: 641-923-3693

CERTIFICATE OF CALIBRATION
Traceable to the
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Customer: **Item Calibrated:** Ultrasonic Flowmeter

Address: **Model:**

CEESI Data File(s): **Serial Number:**

Test Date: **Job Number:** **Order:**

The uncertainty in flowrate indicated by CEESI standards is estimated to be +/- 0.23% of reading to 95% confidence.

The calibration identified by the above CEESI DATA FILE was performed in accordance with the American Gas Association Transmission Committee Report Number 9 using calibration standards that are traceable to the National Institute of Standards and Technology. All natural gas properties were calculated in compliance with American Gas Association Report Number 8.

Calibration Performed at: CEESI Iowa High Flow Natural Gas Facility
 2365 240th Street
 Garner, IA 50438

Calibration Performed by: Allan Luppen

 Bryan Trostel
 Measurement Assurance

 Bill Johansen
 On behalf of Colorado Engineering
 Experiment Station, Inc.

NOTE: *This Certificate and accompanying documentation shall not be reproduced, except in full, without the written consent of Colorado Engineering Experiment Station Inc.*

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Uni-Directional Calibration Configuration Details

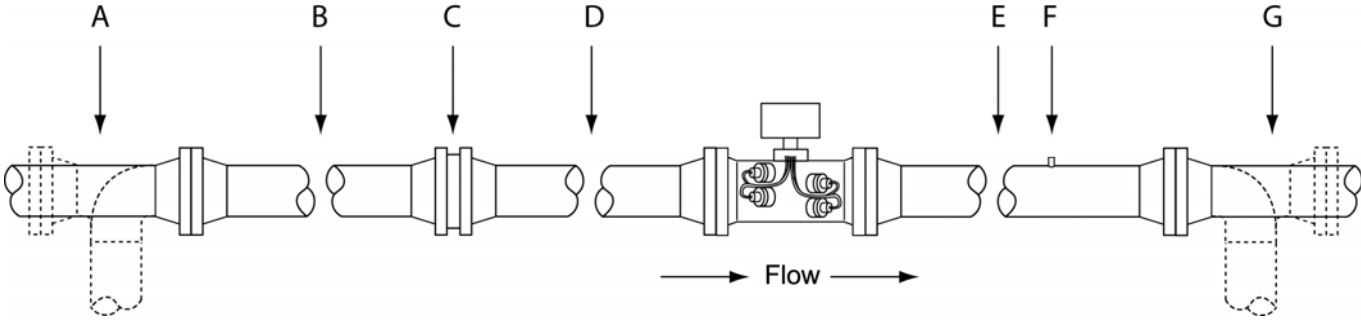


Figure 1: Piping Configuration

Meter Tube Identification:

Identifier	Length	Serial Number
B - Upstream Tube	40.0 Inches	
D - Inlet Tube	80.0 Inches	
E - Exit Tube	40.0 Inches	

Meter Flow Conditioner Identification:

Identifier	Installed	Manufacturer	Serial Number	Flow Arrow	Top Dead Center
C - Upstream Flow Conditioner	No	NA	NA	NA	NA

Meter Thermowell Identification:

Identifier	Distance to Closest Meter Flange Face	Quantity
F - Exit Thermowell	24.0 Inches	2

Fitting Identification:

Identifier	Type
A - Entrance Fitting	Straight Pipe
G - Exit Fitting	Straight Pipe

Meter installed with CEESI flow tubes and manually aligned.



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Meter and Calibration Parameters:

Calibration of a Ultrasonic Flowmeter

Model: Serial Number:

Bore Diameter: Electronics Serial Number:

Meter Output: Modbus SPU Revision Number:

Test Medium: Natural Gas Test Date:

CEESI Data File(s):

Gas Composition During Test:

<u>Component</u>	<u>Calibration Beginning Normalized Mole Percent</u>	<u>Calibration Ending Normalized Mole Percent</u>
Methane	95.676	95.8158
Nitrogen	1.5638	1.5876
Carbon Dioxide	0.6251	0.6399
Ethane	1.6287	1.4926
Propane	0.1327	0.1131
Hydrogen	0.3245	0.3046
Iso-Butane	0.0048	0.0043
Normal-Butane	0.0068	0.0058
Iso-Pentane	0.0006	0.0005
Normal-Pentane	0.0003	0.0003
C6+	0.0012	0.0012
Helium	0.0355	0.0342
Heating Value (BTU/ft ³)	1004.36	1002.741
Total Un-Normalized	99.9238	100.1202

<u>Verification Beginning Normalized Mole Percent</u>	<u>Verification Ending Normalized Mole Percent</u>
95.6138	95.5036
1.6357	1.6199
0.6442	0.6621
1.657	1.7563
0.1131	0.1131
0.2877	0.295
0.0042	0.0045
0.0057	0.0059
0.0008	0.0007
0.0005	0.0004
0.0015	0.0015
0.0356	0.0372
1003.594	1004.271
100.2631	100.1471

Table 1: Gas Composition



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Calibration Results

Data File:

The calibration results are summarized in the table below. The column labeled 'Calibration Factor' is the value by which the volume flowrate is multiplied to achieve the corrected value.

CEESI Flowrate [acfh]	Meter Flowrate [acfh]	Velocity [ft/sec]	Calibration Factor	Percent Error[%]
124934	125363	100.3	0.9966	0.343
93800	94171	75.3	0.9961	0.395
62865	63115	50.5	0.9960	0.397
31485	31616	25.3	0.9959	0.414
3201	3205	2.6	0.9986	0.137
12786	12831	10.3	0.9965	0.347
6499	6517	5.2	0.9973	0.272

Table 2: Calibration Results

The uncertainty due to systematic effects present in the calibration facility is estimated to be $\pm 0.23\%$ at a 95% level of confidence.

Upon Completion of the calibration the coefficients listed below were input into the meter and then the meter was put into a "Read Only" mode.

Register	Name	Value	Register	Name	Value
328	FwdFlwRt1	125363	340	FwdMtrFctr1	0.9966
329	FwdFlwRt2	94171	341	FwdMtrFctr2	0.9961
330	FwdFlwRt3	63115	342	FwdMtrFctr3	0.996
331	FwdFlwRt4	31616	343	FwdMtrFctr4	0.9959
332	FwdFlwRt5	12831	344	FwdMtrFctr5	0.9965
333	FwdFlwRt6	6517	345	FwdMtrFctr6	0.9973
334	FwdFlwRt7	3205	346	FwdMtrFctr7	0.9986
335	FwdFlwRt8	0	347	FwdMtrFctr8	1
336	FwdFlwRt9	0	348	FwdMtrFctr9	1
337	FwdFlwRt10	0	349	FwdMtrFctr10	1
338	FwdFlwRt11	0	350	FwdMtrFctr11	1
339	FwdFlwRt12	0	351	FwdMtrFctr12	1

Table 3: Coefficient Inputs



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Calibration Results

Data File:

**Ultrasonic Flowmeter
 Data File:
 S/N:
 CEESI Iowa Calibration Curve**

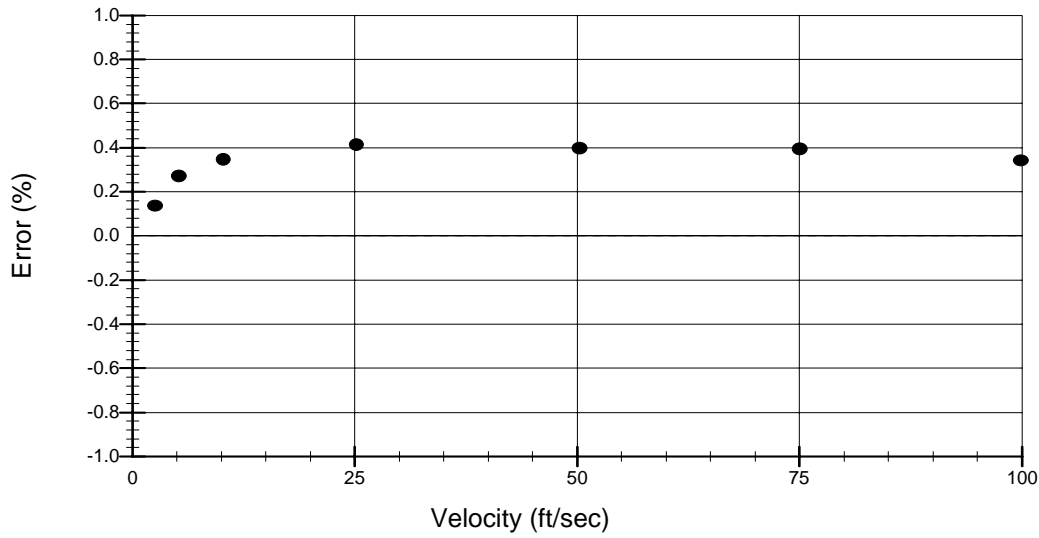


Figure 2: Calibration Results



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Calibration Results

Data File:

Table of Calibration Data:

Press. (psia)	Temp. (°R)	Density [lbm/ft ³]	Lab. Qavg [acfh]	Meter Qavg [acfh]	Qavg Error [%]	Calc. VOS [ft/sec]	Meter VOS [ft/sec]	VOS Error [%]
1102.22	528.1	3.7228	124657	125057	0.32	1391.1	1391.6	0.04
1102.12	528.1	3.7233	125224	125661	0.35	1390.9	1391.6	0.05
1102.06	528.1	3.7231	124921	125369	0.36	1390.9	1391.5	0.05
1103.56	528.3	3.7277	93654.1	94009.8	0.38	1391.1	1391.8	0.05
1103.44	528.3	3.7273	93769.8	94163.0	0.42	1391.1	1391.9	0.06
1103.37	528.3	3.7274	93893.9	94257.7	0.39	1391.0	1392.0	0.07
1103.28	528.3	3.7272	93884.2	94252.8	0.39	1391.0	1392.0	0.07
1106.85	528.5	3.7373	63158.8	63415.1	0.41	1391.7	1392.8	0.08
1106.83	528.5	3.7368	62734.3	62977.3	0.39	1391.7	1392.8	0.08
1106.68	528.5	3.7364	62702.7	62952.9	0.40	1391.7	1392.8	0.08
1107.51	528.5	3.7372	31529.2	31654.5	0.40	1392.2	1393.2	0.07
1107.22	528.5	3.7363	31488.9	31622.6	0.42	1392.2	1393.2	0.07
1106.86	528.5	3.7350	31438.4	31570.8	0.42	1392.1	1393.2	0.08
1102.46	528.4	3.7124	3200.71	3207.19	0.20	1393.3	1394.1	0.06
1102.06	528.4	3.7107	3200.97	3205.93	0.15	1393.3	1394.1	0.05
1101.71	528.3	3.7094	3200.95	3202.72	0.06	1393.3	1394.1	0.05
1106.61	528.5	3.7328	12772.3	12816.9	0.35	1392.4	1393.2	0.06
1106.31	528.5	3.7319	12785.6	12829.9	0.35	1392.4	1393.2	0.06
1106.08	528.5	3.7312	12790.1	12836.3	0.36	1392.3	1393.2	0.06
1105.81	528.5	3.7299	12797.2	12839.4	0.33	1392.4	1393.2	0.06
1104.96	528.5	3.7274	6512.95	6531.60	0.29	1392.3	1393.3	0.08
1104.76	528.5	3.7267	6496.98	6513.52	0.25	1392.3	1393.5	0.09
1104.47	528.4	3.7217	6496.84	6517.07	0.31	1393.0	1393.7	0.05
1104.13	528.4	3.7206	6489.34	6504.69	0.24	1393.0	1393.9	0.07

Table 4: Calibration Results



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Verification Results

Data File:

The Verification results are summarized in the table below. The column labeled 'Calibration Factor' is the value by which the volume flowrate is multiplied to achieve the corrected value.

CEESI Flowrate [acfh]	Meter Flowrate [acfh]	Velocity [ft/sec]	Calibration Factor	Percent Error[%]
63210	63214	50.6	0.9999	0.007
12854	12844	10.3	1.0008	-0.076

Table 5: Verification Results

The uncertainty due to systematic effects present in the calibration facility is estimated to be $\pm 0.23\%$ at a 95% level of confidence.

Ultrasonic Flowmeter Data File S/N: CEESI Iowa Calibration Curve

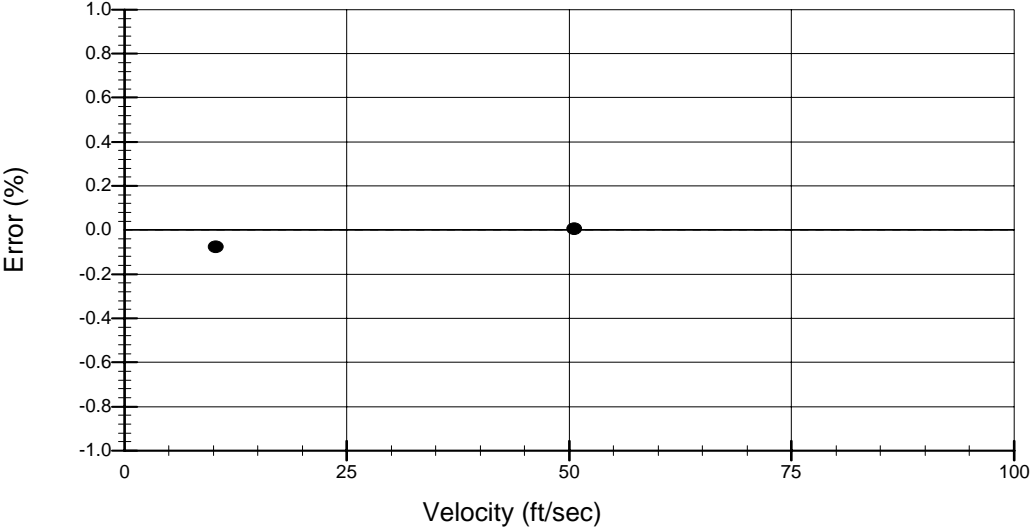


Figure 3: Verification Results



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Verification Results

Data File:

Table of Verification Data:

Press. (Psia)	Temp. (°R)	Density [lbm/ft ³]	Lab. Qavg [acfh]	Meter Qavg [acfh]	Qavg Error [%]	Calc. VOS [ft/sec]	Meter VOS [ft/sec]	VOS Error [%]
1090.15	528.1	3.6803	63209.9	63214.1	0.01	1390.2	1391.0	0.06
1098.26	528.4	3.7135	12853.6	12843.9	-0.08	1389.8	1390.8	0.08

Table 6: Verification Results



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Uncertainty Analysis

The uncertainty analysis for the Iowa facility is performed using methods documented in the ISO GUM and NIST Tech. Note 1297. Each component of uncertainty is classified as Type A or Type B and assigned a statistical distribution (normal or rectangular). Numerical values for standard uncertainty, degrees of freedom and correlation coefficients are estimated. Standard uncertainty values are propagated by addition in quadrature as described in the ISO GUM. The effective degrees of freedom are estimated using the Welch-Satterthwaite approximation. A detailed copy of the uncertainty analysis is available from CEESI

Traceability

Traceability of pressure, temperature and gas composition measurements is maintained based on traditional instrument calibration. Traceability of flowrate measurement is based on periodic engineering analysis of data from three sources:

- 1) control charts
- 2) turbine substitution test
- 3) direct turbine meter calibrations