

PAP-606

HYDRAULICS BRANCH
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TEST REPORT

Shunt-Line Venturi Flowmeter Analysis

WHEN BORROWED RETURN PROMPTLY

by

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Funded by

Research and Laboratory Services Division

WATER Project - WSR06
Water Operations Technology

for

U.S. Bureau of Reclamation
Grand Junction Projects Office

April 1992

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D-3751
PAP file

PAP 606

D-3752

Memorandum

APR 30 1992

To: Projects Manager, Grand Junction CO
Attention: GJ-223

From: ^{Acting} Chief, Research and Laboratory Services Division

Subject: Flowmeter Testing, Government Highline Canal and Laterals, Grand Valley Unit, Colorado (Your Letter Dated August 9, 1991) (Hydraulic Research)

The results of the flowmeter analysis you have requested are enclosed. Please contact James Higgs, (303) 236-6166, if you have specific questions related to test results.

We appreciate the working relationship we have with the Grand Junction Projects Office, and look forward to further technical exchanges.

Danny L. King

Enclosure
(on file in D-3751)

cc: Regional Director, Salt Lake City UT, Attention: UC-200
(w/encl)

bc: D-3752
D-3752 (Higgs)
D-3751 (file)
D-3751
D-3750
D-3700
(w/encl to each)

WBR:JHiggs:flh:4/24/92:236-6166
(c:\wp\d3752\vent.ltr)

Background

The Grand Junction Projects Office has field tested various types of flowmeters on the Grand Valley Salinity Project over the past 8 years. Project water is high in silt and sand content. This has caused excessive wear in flowmeter bearings and plugging of several flow control devices and has resulted in high maintenance and replacement costs.

In an effort to reduce these costs, flowmeters in the Grand Valley are often evaluated in the order of (1) device cost, (2) maintenance cost, and (3) accuracy.

To continue their testing program, the Grand Junction Projects Office requested the Hydraulics Branch evaluate a Miller shunt-line venturi flowmeter. The meter tested for this report is displayed in Figure 1.

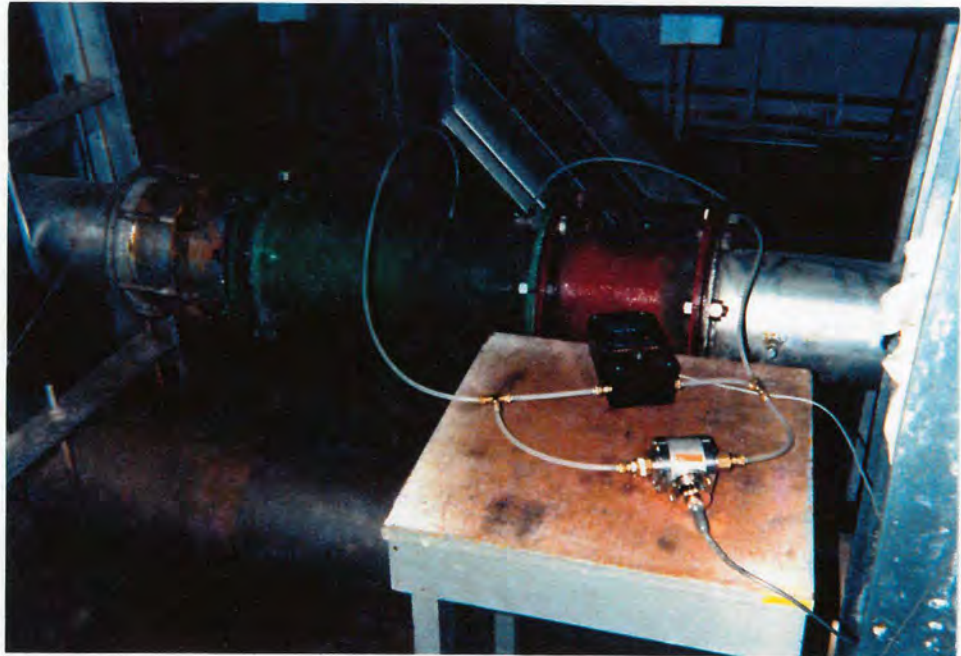


Figure 1. - Miller shunt-line venturi flowmeter. Flow is from right to left. The straightening vane housing (red) is on the right. The meter (green), is on the left. The black box and a pressure transducer are shown in the foreground.

Device Description

The flowmeter consists of an 8-in-nominal-diameter pipe section and a welded V-notch throat. Taps are located upstream and on the tip of the throat. The straightening vanes supplied with the device were installed so they did not align with the taps.

The flowrate/totalizer readout device, or "black box", has an internal pressure transducer and two LCD displays for both flowrate and total flow. As requested by the manufacturer, the black box was never opened.

Air could not be entirely expelled from the internal differential pressure transducer. Many pressure transducers contain bleed ports so air can be expelled from the diaphragm. Air

against the diaphragm or in the line will cause pressure reading errors due to buoyant effects. Unless a way can be found to expel the air, random and unpredictable errors may occur.

Accuracy Test

Flowrate accuracy tests were performed in the hydraulic laboratory, using the 8-in pipe in the calibration test stand. The meter was mounted 10 ft from the riser in this stand. Flow was routed through the 8-in pipe and meter then to the volumetric/weight tank. The actual flowrate was determined using weight and time. Comparisons of the meter readings and actual flow are shown on figure 2 and in table 1.

The flowrate readout on the black box fluctuated rapidly. In order to obtain a representative reading, 10 flowrates were recorded and averaged (see appendix A). In the field, this may be overcome by physical dampening equipment. However, such equipment may be clogged due to the waters high silt content. Electronic dampening inside the black box may be the only viable solution to the problem.

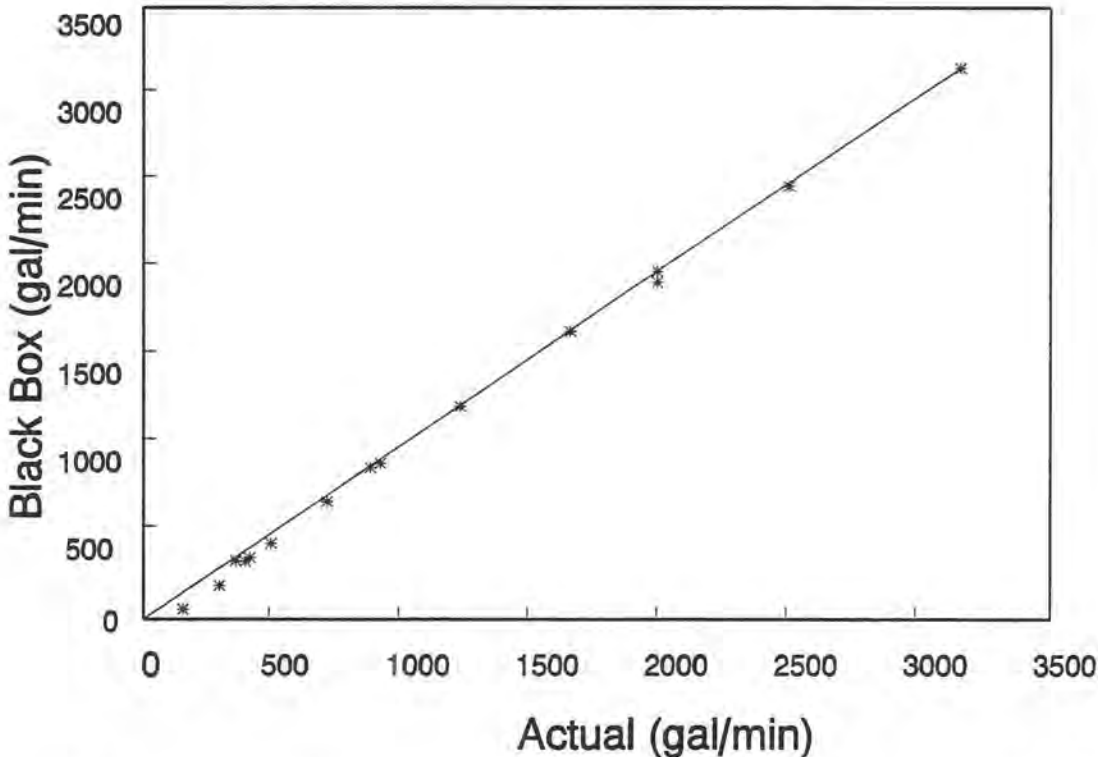


Figure 2. - Venturi meter accuracy test. Measurement accuracy is erratic while flowrate is less than 900 gal/min.

Table 1. - Laboratory test summary. Flows less than 1,000 gal/min generally have accuracy errors greater than 2 percent.

Test No.	Black box flow (gal/min)	Actual flow (gal/min)	Percent error (black box to actual)
7	53.6	152.7	64.9
8	188.4	290.9	35.2
6	333.1	354.4	6.0
9	328.8	392.0	16.1
1	350.0	406.6	13.9
10	427.8	488.3	12.4
11	667.5	705.3	5.4
2	860.4	874.2	1.6
12	886.9	913.1	2.9
3	1213.6	1221.6	0.7
4	1640.4	1647.3	0.4
13	1919.0	1984.9	3.3
5	1980.5	1984.9	0.2
14	2470.8	2492.9	0.9
15	3152.1	3152.1	0.0

Recommendations

The shape of the V notch, the roughness of the welds, and the location and quality of the taps will cause each flowmeter to have different calibrations. These may also cause differences in the acceptability range of flow from meter to meter.

It is recommended that each meter have its own calibration and the acceptable accuracy range be checked before installation.

Appendix A

Ten readings from the black box were recorded and averaged. Actual readings are listed to display typical fluctuations of the read out.

Test no. 2

Black box reading
(GPM)

871
855
846
852
867
875
862
849
865
862

	gpm	ft ³ /s
Average=	860.4	1.917112
std dev=	9.124	0.020329
Min	846	1.885027
max	875	1.949643
%error	4.242	@95.4 % confidence

actual flow = 1.9478 ft³/s
error= 1.58 %

Test no. 3

Black box reading
(GPM)

1214
1200
1215
1209
1213
1198
1231
1216
1222
1218

	gpm	ft ³ /s
Average=	1213.6	2.7041
std dev=	9.222	0.020547
Min	1198	2.66934
max	1231	2.74287
%error	3.039	@95.4 % confidence

actual flow =2.721953 ft³/s
error= 0.66 %

Test no. 4

Black box reading

(GPM)

1637

1639

1644

1658

1639

1647

1612

1636

1641

1651

	gpm	ft ³ /s
Average=	1640.4	3.65508
std dev=	11.491	0.025604
Min	1612	3.5918
max	1658	3.694296
%error	2.802	@95.4 % confidence

actual flow =3.670488 ft³/s
error= 0.42 %

Test no. 5

Black box reading

(GPM)

1995

1988

1968

1989

1974

1976

1990

1995

1973

1957

	gpm	ft ³ /s
Average=	1980.5	4.412879
std dev=	12.110	0.026983
Min	1957	4.360517
max	1995	4.445187
%error	2.446	@95.4 % confidence

actual flow =4.422724 ft³/s
error= 0.22 %

Test no. 6

Black box reading

(GPM)

343

347

359

353

356

322

309

327

310

305

	gpm	ft ³ /s
Average=	333.1	0.742201
std dev=	19.867	0.044267
Min	305	0.67959
max	359	0.799911
%error	23.857	@95.4 % confidence

actual flow = 0.789562 ft³/s
error= 6.00 %

Test no. 7

Black box reading

(GPM)

45

52

54

56

57

53

58

52

54

55

	gpm	ft ³ /s
Average=	53.6	0.11943
std dev=	3.441	0.007667
Min	45	0.100267
max	58	0.129234
%error	25.679	@95.4 % confidence

actual flow = 0.34029 ft³/s
error= 64.90 %

Test no. 8

Black box reading
(GPM)

165
171
176
170
226
172
174
171
224
235

	gpm	ft ³ /s
Average=	188.4	0.419786
std dev=	26.409	0.058844
Min	165	0.367647
max	235	0.523619
%error	56.070	@95.4 % confidence

actual flow =0.648174 ft³/s
error= 35.24 %

Test no. 9

Black box reading
(GPM)

306
313
344
341
345
312
312
339
342
334

	gpm	ft ³ /s
Average=	328.8	0.73262
std dev=	15.105	0.033656
Min	306	0.681818
max	345	0.768717
%error	18.376	@95.4 % confidence

actual flow =0.873341 ft³/s
error= 16.11 %

Test no. 10

Black box reading
(GPM)

413
416
420
449
444
418
414
417
445
442

	gpm	ft ³ /s
Average=	427.8	0.953209
std dev=	14.253	0.031759
Min	413	0.920232
max	449	1.000446
%error	13.327	@95.4 % confidence

actual flow =1.088022 ft³/s
error= 12.39 %

Test no. 11

Black box reading
(GPM)

674
664
651
667
682
673
654
659
671
680

	gpm	ft ³ /s
Average=	667.5	1.487299
std dev=	9.952	0.022176
Min	651	1.450535
max	682	1.519608
%error	5.964	@95.4 % confidence

actual flow =1.571441 ft³/s
error= 5.35 %

Test no. 12

Black box reading

(GPM)

888
885
884
896
887
879
876
891
895
888

	gpm	ft ³ /s
Average=	886.9	1.976159
std dev=	6.007	0.013386
Min	876	1.951872
max	896	1.996435
%error	2.709	@95.4 % confidence

actual flow =2.034561 ft³/s
error= 2.87 %

Test no. 13

Black box reading

(GPM)

1935
1910
1918
1912
1911
1921
1929
1929
1899
1926

	gpm	ft ³ /s
Average=	1919	4.275847
std dev=	10.507	0.023412
Min	1899	4.231283
max	1935	4.311497
%error	2.190	@95.4 % confidence

actual flow =4.422724 ft³/s
error= 3.32 %

Test no. 14

Black box reading

(GPM)

2488

2478

2444

2467

2481

2472

2475

2477

2463

2463

	gpm	ft ³ /s
Average=	2470.8	5.505348
std dev=	11.677	0.026019
Min	2444	5.445633
max	2488	5.543672
%error	1.890	@95.4 % confidence

actual flow = 5.554596 ft³/s

error= 0.89 %

Test no. 15

Black box reading

(GPM)

3153

3119

3141

3176

3146

3163

3171

3169

3142

3141

	gpm	ft ³ /s
Average=	3152.1	7.023396
std dev=	16.778	0.037383
Min	3119	6.949643
max	3176	7.076649
%error	2.129	@95.4 % confidence

actual flow = 7.0234 ft³/s

error= 0.00006 %