B-60

EVALUATION STUDIES
of
A BRODIE BIROTOR METER MODEL B-40 D
(Serial No. 183379)

For

COLD FLOW LABORATORY
THE MARTIN COMPANY
DENVER DIVISION

by

S. S. Karaki

Colorado State University Research Foundation
Civil Engineering Section
November, 1960

CER60SSK67

ERRATA SHEET

Report No. CER60SSK67

Page 8, the first line of the last paragraph, the figure 0.5 should read <u>0.05</u>

APPENDIX I, Equation at bottom of the page should read

$$\frac{\rho'_a}{\rho_s}\ (\text{min}) = \frac{.00100146}{\underline{7.0}} = \underline{.000143}$$

to

$$\frac{\rho'_a}{\rho_s}\ (\text{max}) = \frac{.00101466}{\underline{7.0}} = .000145$$

APPENDIX II, 2nd page of TABLE 4., 5th, 6th, 7th and 8th column headings should read

Acc. Meter Vol. gal.	Diff. gal.	Per Cent Diff.	Acc. Diff. gal.

2nd page of TABLE 5., 7th column heading should read

Per
Cent
<u>Diff.</u>

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SUMMARY

A study of a Brodie BiRotor Meter Model B-40 D was made to determine the operating conditions under which the meter would give accurate and reliable measurements of flow volume. The results of these studies indicate that accuracy is dependent upon use of the meter at the line pressure and flow rate for which the meter was calibrated. Variation to a large degree from either the calibration pressure or flow rate can result in significant errors. The cumulative error in measurement is not linear with total volume.

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INTRODUCTION

General Meter Description

The Brodie BiRotor Model B 40 D Meter is designed to measure total volume of flow at discharge rates up to a maximum of 60 gallons per minute. The meter is positive displacement in principle and will measure flow of non-corrosive fluids in either pump or gravity installations.

The essential components of the meter shown in Fig. 1, consists of the housing assembly, the measuring unit, adjuster and counter. Auxiliary units, such as the strainer, air eliminator, gear change adaptor, electric pulser and quantrol valve are also available for the meter.

The outer housing, or meter body, is of welded steel construction designed to withstand a maximum pressure of 125 psi. The meter should be protected from water hammer or shock pressures in certain installations by providing a relief valve. The measuring unit, located inside the meter body, consists of two rotors intermeshed and so arranged that the flow rotates them in opposite directions. An arrangement of gears controls the drive shaft which connects the rotor to the adjuster and hence to the counter. The adjuster is a mechanical change of gear ratios used to adjust the counter reading to give true values as determined by calibration.

The flowmeter tested in the laboratory was also provided with a combination air eliminator and strainer. This unit bolted to the outer housing at the upstream side. Although not used in the studies, an electric pulser was also included in the total flow meter assembly.

The pulser provides the means for remotely registering meter output. It consists of a pair of contact points and an actuating cam attached to the meter shaft. The cam interrupts an electrical circuit and produces pulses in direct proportion to the meter output.

The gear change unit is used in conjunction with the pulser or remote counter transmitter to change the meter reading to volumetric

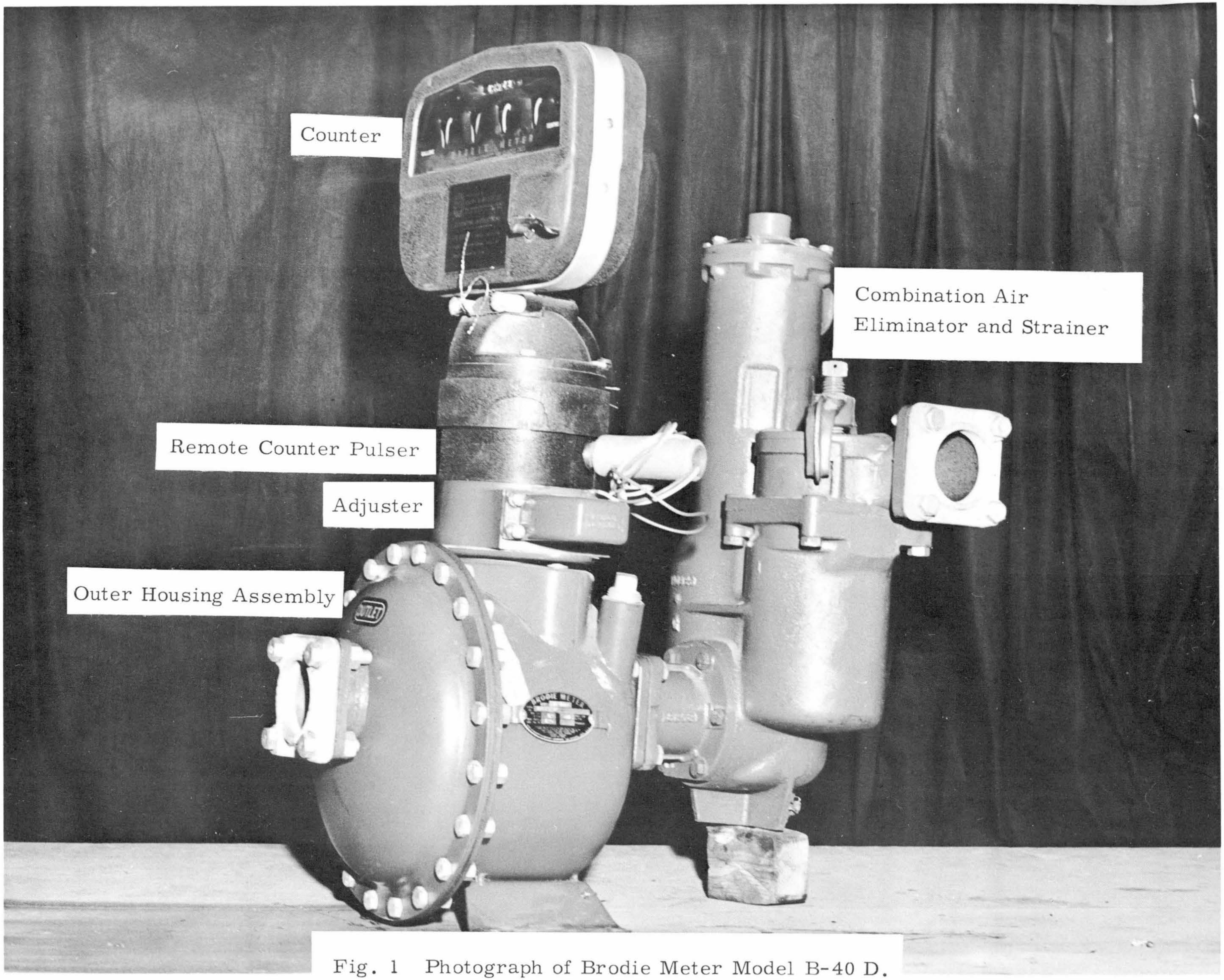


Fig. 1 Photograph of Brodie Meter Model B-40 D.

units other than U.S. gallons. If the remote readout is not used, the gear change is normally accomplished at the base of the counter. The quantrol valve is an automatic device connected to the counter, used to shut off the flow at a preset volume.

Scope of The Study

The objectives of this evaluation study were to determine the conditions under which the flowmeter would be most accurate and reliable. The flowmeter was then to be calibrated to within $\pm$ 0.05 per cent of true volume.

CALIBRATION FIXTURE

General Description

A schematic diagram of the calibration fixture is shown in Fig. 2. An 8-inch high head turbine pump was used to supply water to the flowmeter. The pressure control valve upstream of the flowmeter and the by-pass valve were used to maintain running pressure in the two-inch approach pipe to the meter. The by-pass provided a control to shut off pressures. The regulating valve located downstream of the meter and the shutoff valve, were used to control the flow at various flow rates. The manual shutoff valve was used for positive stop of flow.

The gravimetric system was used in this study for measuring quantity of flow as it provided greater accuracy than the volumetric method. Two scales were used in tandem; the overflow from the first tank spilled into the second tank. The capacities of the two tanks were approximately equal and the total amounted to about 540 gallons.

Both scales were calibrated before the study began to 1/4-pound accuracy in increments of 5 pounds, and was rechecked midway through the study. Standard cast-iron weights were used to calibrate the scales. Water temperatures were measured by direct reading immersion-type thermometers with divisions to 0.2^0 centigrade.

Calibration Fixture Accuracy

The over-all accuracy sought in the calibration fixture was 0.05 per cent. The principle measurements involved were weight and temperature. Time measurement was important only in determining the flow rate and was thus considered independent of the total volume measured through the flowmeter.

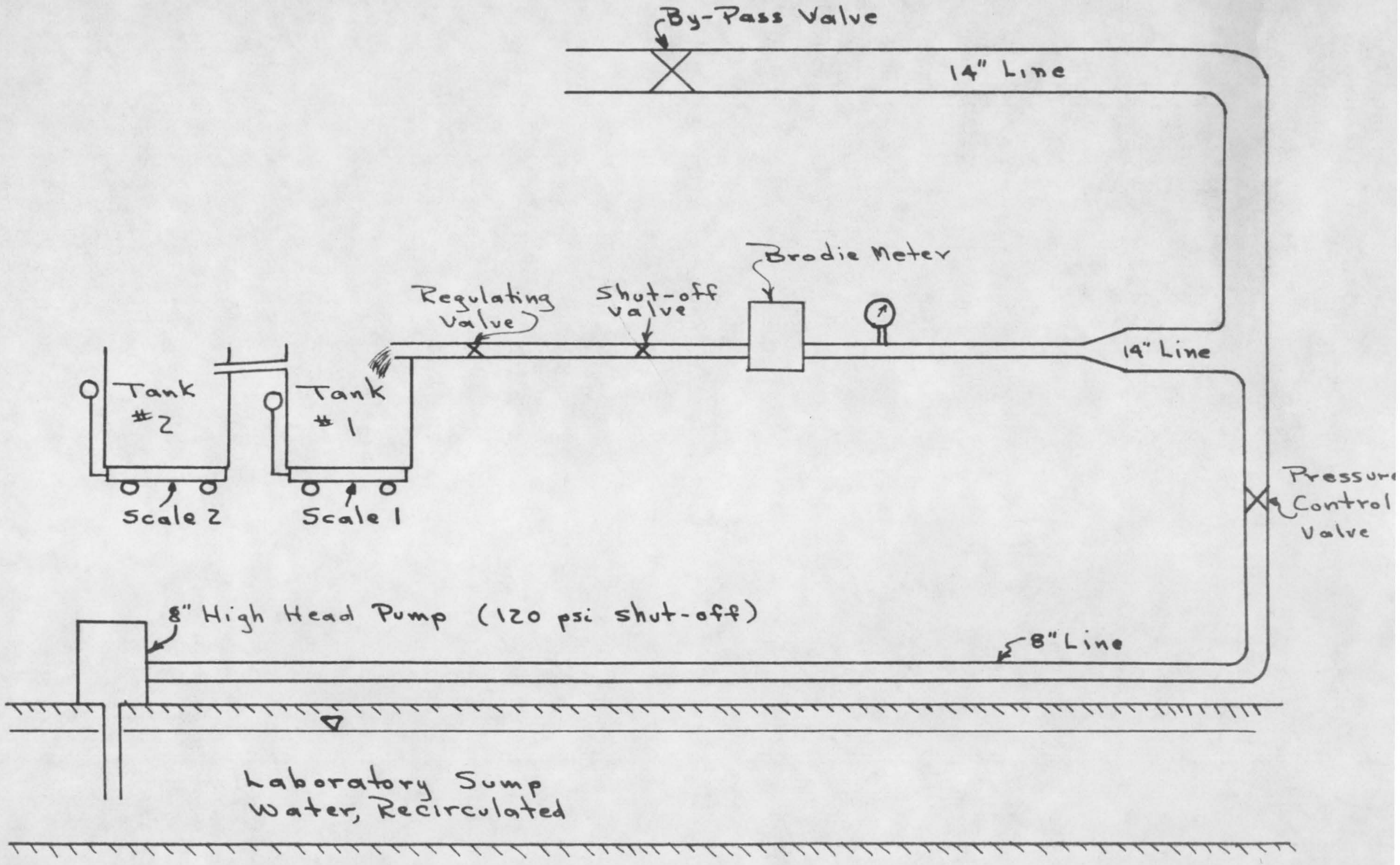


Fig. 2 Schematic Diagram of Test Equipment

The accuracies of the various components of the calibration system are tabulated below:

TABLE OF CALIBRATION FIXTURE ACCURACIES

Item	Scale 1			Scale 2			
	Absolute Unit	Total Capacity	Accuracy Percent	Absolute Unit	Total Capacity	Accuracy Percent	Total Accuracy Percent
Weight	0.25 lbs	2500 lbs	0.01	0.50	2500 lbs	0.02	0.030
Temp.(Sp.wt.)	$0.1^{o}C$	---	0.002	$0.1^{o}C$	---	0.002	0.004
Total			0.012			0.022	0.034

The accuracy for determining the flow rate through the meter was based on stop-watch measurements to the nearest 0.1 sec. If 5 minutes is used as the minimum base for determining flow rate, the accuracy for time measurements would be 0.03 per cent. As indicated previously, the accuracy of time measurements is not involved in determining the flow meter accuracy and hence, is not additive to the total accuracy of the table shown above.

Correction Factor

There are certain conversion and correction factors necessary to change weight of the fluid measured to volume. When a particularly high degree of accuracy is required, as it was for this study, a correction for air buoyancy of the scaled weight is necessary to obtain the true weight. This correction to be applied depends upon ρ_a, the density of the air at the pressure, temperature, and humidity of the room. It also depends upon ρ_w, the density of the metered fluid, water in this case, and ρ_s, density of the standard weights used to calibrate the scale. The total correction is embodied in the following equation:

$$\frac{W}{W_s} = 1 + \frac{\rho_a}{\rho_w} - \frac{\rho'_a}{\rho_s}$$

where

W = true weight

W_s = scaled weight

ρ'_a = density of the air at the time of scale calibration.

The variation of ρ'_a in the hydraulic laboratory during scale calibration was small and a single value of $\frac{\rho'_a}{\rho_s}$ was used. The changes in ρ_a were taken into account for individual test runs.

The conversion from weight to volume is made by using the specific weight of water. A table of specific weights of water in pounds per gallon is included in the appendix.

EXPERIMENTAL PROCEDURE

The Brodie BiRotor Model B 40 D was tested with water at prevailing laboratory sump-water temperatures.

The meter was tested over a range of operating line pressures at a constant flow rate of 50 gallons per minute. Because the measuring chamber of the meter is isolated by a capillary seal, it was thought that the slip would be dependent upon the operating line pressures.

With the operating pressure established, the meter was tested over a range of flow rates, from 30 to 60 gallons per minute at the established pressure. The meter was then calibrated accurately at the established flow rate and line pressure.

The limitation of the adjusting unit of the meter was 0.5 per cent. Thus, it is not always possible to adjust the meter in such a way that the errors would be random about zero error. In order to determine what cumulative errors could occur, two tests of approximately 20,000 gallons each were made.

EXPERIMENTAL RESULTS

Effect of Line Pressure Variation

A series of test runs were made with line pressure varying from 15 to 57.5 psi in approximately 10 psi increments. The discharge was maintained constant throughout the test series at about 50 gpm. Figure 3 shows the results in terms of per cent error between measured and metered volume. Some adjustments in the gear ratios were made during the tests and they are taken into account in plotting Fig. 3 so that the test results have the same base for comparison. The difference or percent error of meter readout from true volume apparently depends upon the operating line pressure. For any set counter gear ratio, the meter reading decreases with increase in line pressure, at approximately a linear relationship. At the low and high line pressures the fluctuation between maximum and minimum difference becomes greater than at 27 or 36.5 psi. With the exception of run 19, the variation between individual tests at line pressures of 27 and 36.5 psi is about 0.05 per cent.

Effect of Flow Rate

Differences in meter readout at flow rates of 30, 40, 50, and 60 gpm are shown in Fig. 4. This test shows that if the meter is calibrated at a particular flow rate and line pressure, variation from the calibrated flow rate at the same pressure will result in considerable error of measurement. At 30 gpm, the variation of error is considerably more than at flow rates of 40, 50 or 60 gpm. It is therefore, advisable that the flowmeter be used at a flow rate of either 40, 50 or 60 gpm.

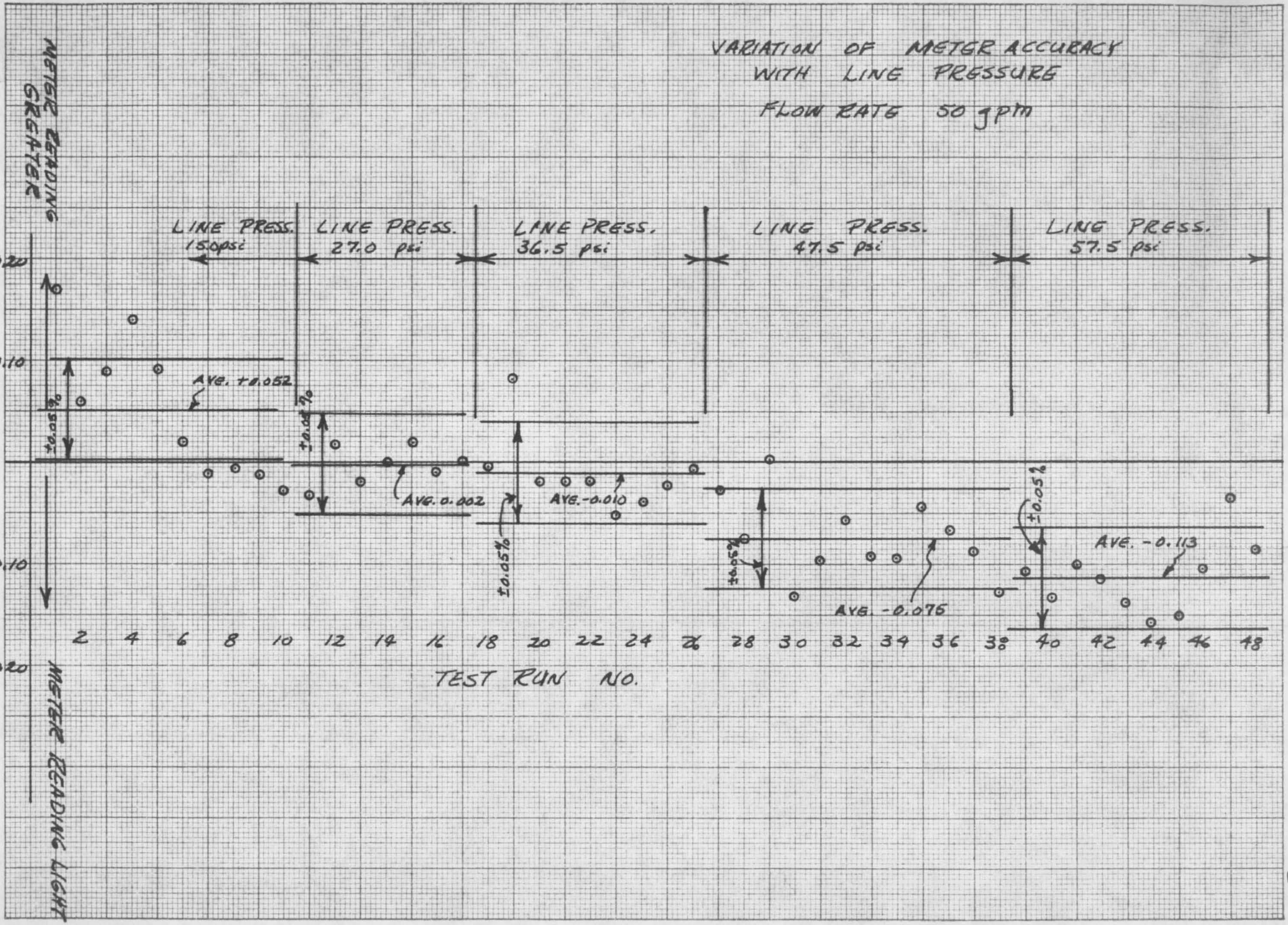

VARIATION OF METER ACCURACY
WITH LINE PRESSURE
FLOW RATE 50 gpm
METER READING GREATER
METER READING LIGHT
PERCENT
PERCENT
0.20
0.10
0
0.10
0.20
LINE PRESS. 15.0 psi
LINE PRESS. 27.0 psi
LINE PRESS. 36.5 psi
LINE PRESS. 47.5 psi
LINE PRESS. 57.5 psi
AVE. +0.052
AVE. 0.002
AVE. -0.010
AVE. -0.076
AVE. -0.113
±0.05%
±0.05%
±0.05%
±0.05%
±0.05%
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
TEST RUN NO.

FIG. 3

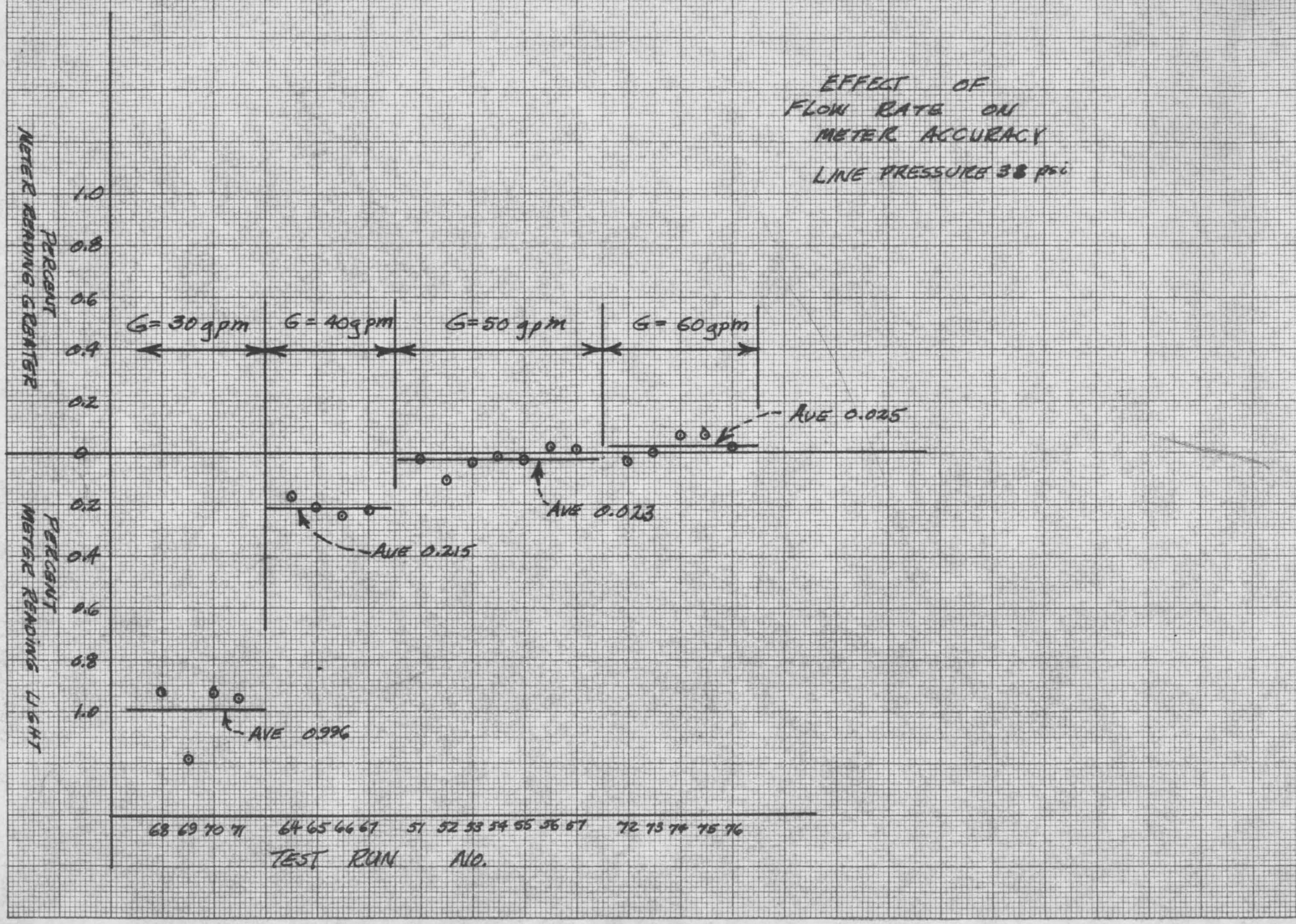

EFFECT OF
FLOW RATE ON
METER ACCURACY
LINE PRESSURE 38 psi
PERCENT
METER READING GREATER
PERCENT
METER READING LIGHT
1.0
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1.0
G= 30 gpm
G = 40 gpm
G= 50 gpm
G = 60 gpm
AVE 0.025
AVE 0.023
AVE 0.215
AVE 0.996
68 69 70 71
64 65 66 67
51 52 53 54 55 56 57
72 73 74 75 76
TEST RUN NO.

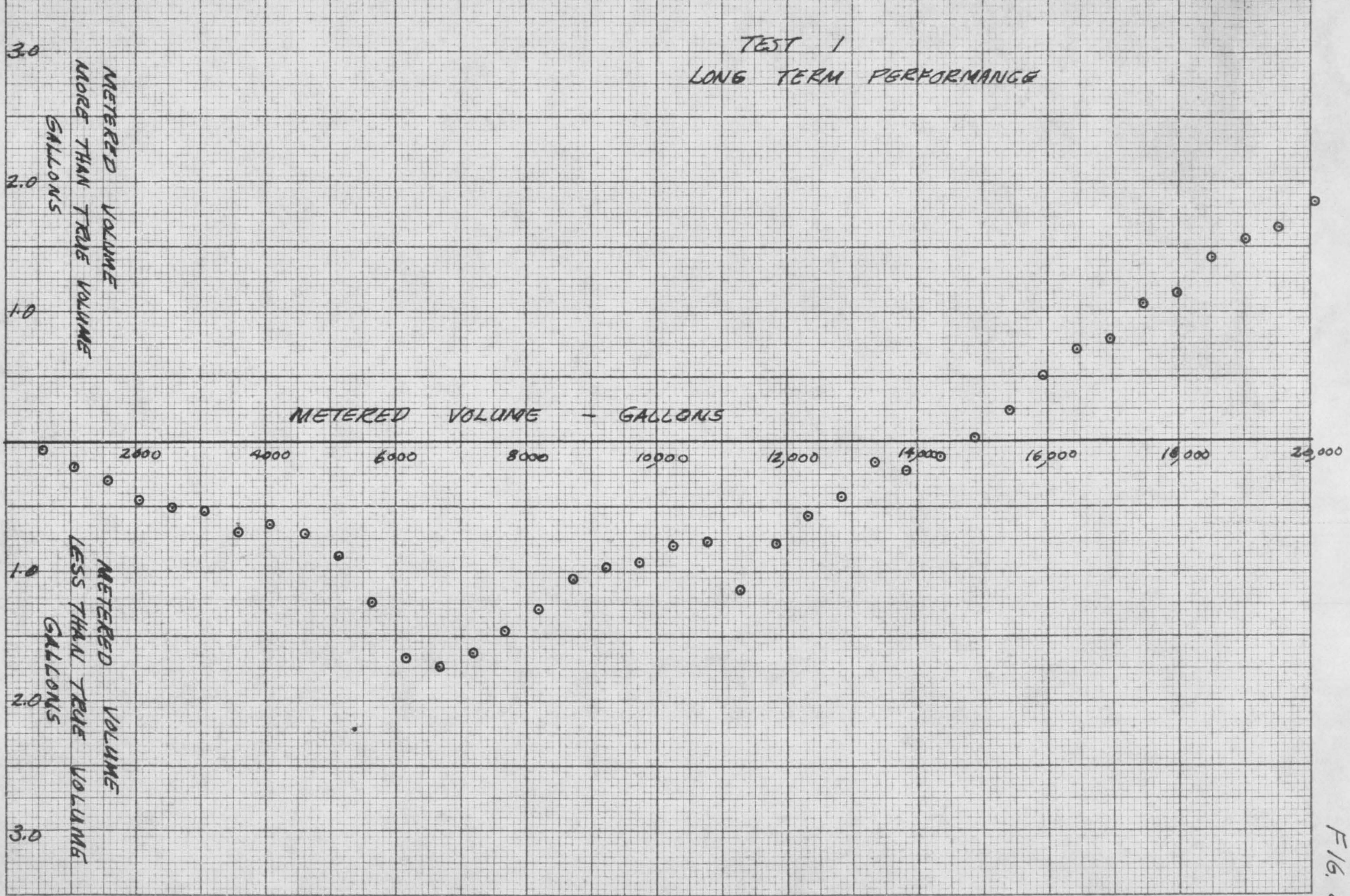
Fig. 4

Effect of Prolonged Use at 50 gpm and 35 psi

Two prolonged tests were made for a total quantity of about 20,000 gallons each, to observe the variations in flowmeter output at a set discharge rate and line pressure. The purpose of these tests were to determine the over-all accuracy of the meter for use in calibrating large volume tanks and to determine a proper operating period before recalibration became necessary.

The results of the two tests are shown in Figs. 5 and 6. The average accuracy exhibited by the meter for the first series of tests for 39 test runs is + .004 per cent. However, as Fig. 5 indicates, the meter accuracy changed from a minus error (meter under register) to a plus error (over register) at about 6,500 gallons. This resulted in an over-all error of about 1.8 gallons in 20,000 gallons, or .009 per cent accuracy. The data indicated also a minus 1.8 gallon at 6,500 gallons for an accuracy of 0.028 per cent at that point. In terms of absolute values, the error in this test was never greater than ± 1.8 gallons. It is important to note as shown in the table in the appendix, that the meter register varied from - 0.082 to + 0.070 per cent of true volume in the total 20,000 gallons, but the variation was systematic with discharge so that the meter register did not vary by more than ± 0.05 per cent in any short series of consecutive runs.

The results of the second test of 20,000 gallons also supports the first test. The actual magnitude of error in this test was slightly greater at 3.6 gallons at 18,500 gallons.



TEST 1
LONG TERM PERFORMANCE
METERED VOLUME - GALLONS
METERED VOLUME MORE THAN TRUE VOLUME GALLONS
METERED VOLUME LESS THAN TRUE VOLUME GALLONS
3.0
2.0
1.0
1.0
2.0
3.0
2000
4000
6000
8000
10000
12,000
14,000
16,000
18,000
20,000

-13-

FIG. 5

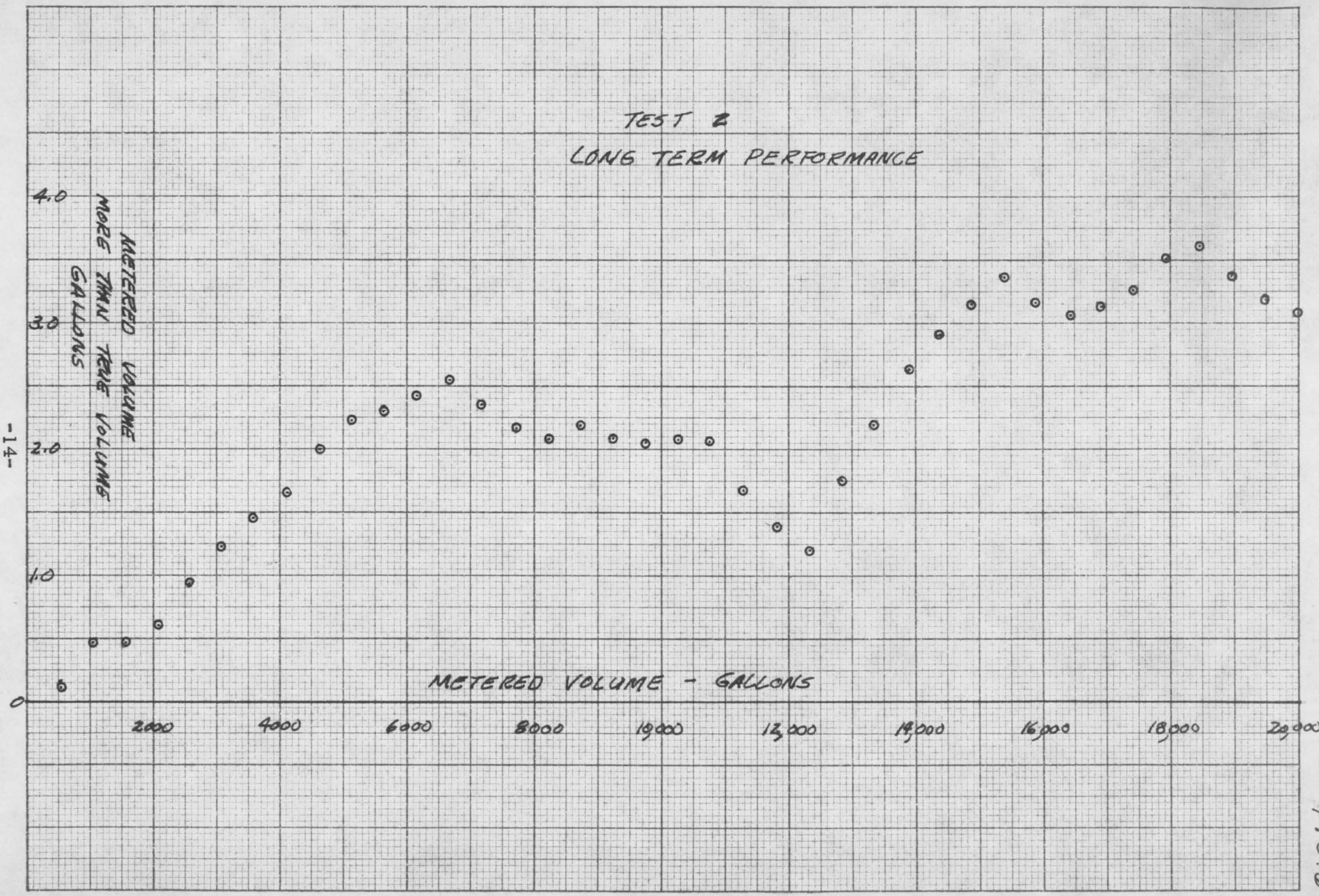

TEST 2
LONG TERM PERFORMANCE
METERED VOLUME MORE THAN TRUE VOLUME GALLONS
4.0
3.0
2.0
1.0
0
METERED VOLUME - GALLONS
2000
4000
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000

FIG. 6

CONCLUSIONS

The evaluation program of the particular Brodie BiRotor meter under study was expanded considerably from that originally requested in the Specifications. The change in the study program was initiated and undertaken by mutual consent to provide valuable additional data which was considered essential for accurate and reliable use by the Martin Company, Cold Flow Laboratory.

The results from this study lead to the following conclusions:

1. If a particular flowmeter is calibrated at a given operating line pressure, the meter should be used with the same operating pressure in order to produce accurate and reliable results. For this meter, best results were obtained at a line pressure of about 38 psi.

2. Variation of flow rate through the Brodie meter testes resulted in differences between metered volume and actual volume. A particular meter should therefore be used at the same flow rate at which it was calibrated if excessive errors are to be avoided. A flow rate of 50 gpm is recommended and was used for the final calibration.

3. In prolonged use, the flowmeter accuracy will vary by more than $\pm$ 0.05 per cent from a preset adjustment. The errors however, are systematic rather than random, and if the meter is operated at the calibrated flow rate and line pressure, the actual magnitude of error should be about $\pm$ 3.5 gallons in say 20,000 gallons.

4. The prolonged tests did not indicate a certain volume after which calibration was necessary. However, in the interest of accurate and reliable meter output, it would be wise to recalibrate the meter after some period of use convenient to the user.

APPENDIX

I. CORRECTION FOR AIR BUOYANCY

It can be shown that the buoyancy correction factor can be expressed as:

$$\beta = 1 + \frac{\rho_a}{\rho_w} - \frac{\rho'_a}{\rho_s}$$

where

ρ_a = air density at the time of volume measurement

ρ_w = water density at the temperature measured

ρ_s = standard weight density

ρ'_a = air density at the time of scale calibration

The air density ρ'_a varied slightly during calibration of the scales and its effect will be calculated below:

Temp. ^{0}C.	Barometric Pressure mm Hg	Dew Point ^{0}C.	Air Density gms/ml.	Remarks
20.4	633.45	- 9.4	.00100146	Min. density
16.7	633.61	-10.6	.00101466	Max. density

The factor $\frac{\rho'_a}{\rho}$ would vary from:

$$\frac{\rho'_a}{\rho_s} \text{(min)} = \frac{.00100146}{7^0} = .00143$$

to

$$\frac{\rho'_a}{\rho_s} \text{(Max)} = \frac{.00101466}{7^0} = .000145$$

The difference in value between the two factors is two units in the sixth decimal place which can be considered insignificant. The average value for $\frac{\rho'_a}{\rho_s}$ = .000144 was used to calculate the buoyancy correction factor β.

TABLE 1.

ABSOLUTE DENSITY

Density in pounds per U.S. Gallon. Computed from Tables, Handbook of Chemistry and Physics 33rd Edition, page 1790. Based on Relative values by Thiesen, Scheel and Disselhorst (1900) and absolute value at 3.98^0C by the International Bureau of Weights and Measures (1910).

Degrees Centigrade	0	1	2	3	4	5	6	7	8	9
10	8.34294	286	279	271	264	255	248	239	231	223
11	214	206	198	188	180	171	162	153	143	134
12	125	115	106	096	086	076	066	056	045	035
13	024	013	003	*992	*981	*970	*959	*947	*936	*925
14	8.33913	901	890	878	866	854	843	830	817	805
15	8.33792	780	767	755	741	729	715	702	689	675
16	662	678	634	620	607	593	578	564	550	536
17	521	507	492	477	462	447	432	417	402	386

<u>Conversion Factors</u>

1 gm = .002204622 lb. av.

1 litre = 0.264178 U.S. gallon

1 litre = 1.000027 c.c.

1 c.c. = 0.00264171 U.S. gallon

1 gm/cc = 8.34544 lb/gal.

II. TABLES OF EXPERIMENTAL DATA

TABLE 2.

EFFECT OF LINE PRESSURE ON METER ACCURACY

Note: Per cent differences adjusted to give common base for comparison. Adjusted values are based on mechanical gear ratio changes.

Run No.	Water Temp. °C.	Meas. Vol. gal.	Flow Rate gpm.	Meter Vol. gal.	Per cent diff.	Line Pressure psi.
1	14.1	502.97	49.65	502.30	+.170	15.0
2	14.1	502.70	50.78	501.49	+.060	15.0
3	14.05	505.29	50.23	504.73	+.090	15.0
4	14.0	501.01	49.90	501.22	+.140	15.0
5	14.1	501.57	50.06	501.50	+.090	15.0
6	14.3	500.71	49.97	500.32	+.020	15.0
7	14.8	502.20	50.17	501.91	-.010	15.0
8	13.95	501.30	50.03	501.02	-.005	15.0
9	13.9	502.94	50.00	502.88	-.011	15.0
10	13.85	501.72	50.00	501.58	-.027	15.0
11	14.2	500.64	50.01	500.48	-.031	27.0
12	14.5	500.06	50.01	500.16	+.019	27.0
13	14.5	524.79	50.41	524.69	-.019	27.0
14	14.55	500.79	50.08	500.79	+.001	27.0
15	14.55	511.11	50.10	511.22	+.021	27.0
16	14.6	502.72	50.22	502.67	-.009	27.0
17	14.1	514.49	49.95	514.51	+.003	27.0
18	14.1	507.94	50.15	507.93	-.001	36.5
19	14.2	512.55	50.00	512.98	+.083	36.5
20	14.6	514.31	50.10	514.22	-.017	36.5
21	14.85	501.92	50.04	501.82	-.019	36.5
22	14.95	506.60	50.00	506.50	-.019	36.5
23	12.85	504.74	50.0	504.48	-.051	36.5
24	12.85	512.84	49.91	512.65	-.037	36.5
25	12.90	509.27	49.71	509.15	-.023	36.5
26	12.95	510.44	50.0	510.40	-.007	36.5

TABLE 2. - Continued.

Run No.	Water Temp. °C.	Meas. Vol. gal.	Flow Rate gpm.	Meter Vol. gal.	Per cent diff.	Line Pressure psi
27	13.05	513.86	49.71	513.71	-.029	47.5
28	13.15	512.82	50.0	512.43	-.076	47.5
29	12.9	511.67	50.0	511.69	+.003	47.5
30	12.6	505.13	50.0	504.47	-.130	47.5
31	12.6	515.69	50.29	575.19	-.096	47.5
32	12.55	514.44	51.62	514.15	-.056	47.5
33	12.5	505.71	49.64	505.24	-.092	47.5
34	12.7	509.50	49.57	509.53	-.095	47.5
35	12.7	517.41	50.12	517.70	-.044	47.5
36	12.75	510.67	49.86	510.24	-.067	47.5
37	12.9	524.44	50.0	524.50	-.089	47.5
38	12.95	508.02	50.0	507.88	-.127	47.5
39	13.2	510.34	50.17	510.30	-.107	57.5
40	13.3	508.67	49.53	508.50	-.133	57.5
41	13.4	519.11	50.09	519.10	-.101	57.5
42	13.25	513.16	49.32	513.09	-.113	57.5
43	13.5	507.93	49.67	507.74	-.137	57.5
44	13.35	507.38	50.39	507.09	-.157	57.5
45	13.25	513.37	49.15	513.10	-.152	57.5
46	13.2	508.06	50.00	508.04	-.103	57.5
47	13.1	512.85	50.07	513.19	-.034	57.5
48	13.35	513.17	49.98	513.24	-.087	57.5

TABLE 3.

EFFECT OF FLOW RATE ON METER ACCURACY
Line Pressure 38 psi

Run No.	Water Temp. ^{0}C.	Meas. Vol. gal.	Flow Rate gpm	Meter Vol. gal.	Per cent Diff.	Remarks
51	13.6	502.93	50.0	503.08	-.021	Per cent
52	13.8	508.31	50.0	508.03	-.105	diff. corr.
53	13.8	513.14	48.45	513.20	-.039	for counter
54	13.9	514.04	50.0	514.21	-.017	adjust. 0.05
55	13.65	513.16	49.12	513.31	-.021	per cent at
56	13.80	513.41	50.50	513.80	+.025	Run 61.
57	13.9	513.06	50.50	513.41	+.018	
64	14.55	526.74	40.0	525.82	-.174	
65	14.6	506.12	40.61	505.02	-.217	
66	14.65	505.50	39.85	504.27	-.243	
67	14.8	506.95	41.31	505.80	-.226	
68	14.8	516.66	30.0	511.89	-.923	
69	15.0	510.20	30.0	504.17	-1.181	
70	15.1	509.94	30.0	505.19	-0.931	
71	15.2	506.83	30.0	502.02	-.949	
72	15.3	505.60	59.58	505.40	-.039	
73	15.3	504.68	60.04	504.71	+.005	
74	15.3	503.90	59.99	504.24	+.067	
75	15.3	504.95	60.28	505.31	+.071	
76	15.3	503.60	60.08	503.70	+.019	

TABLE 4.

TEST 1 - LONG-TERM PERFORMANCE
Line Pressure 35.0 psi

Run No.	Water Temp. ^{0}C.	Meas. Vol. gal.	Meter Vol. gal.	Acc. Meter Vol. gal.	Diff. gal.	Per Cent Diff.	Acc. Diff. gal.	Flow Rate gpm
201	14.95	512.62	512.56	512.56	-.06	-.011	-.06	50.19
202	15.00	512.47	512.34	1,024.90	-.13	-.025	-.19	50.24
203	15.0	512.32	512.20	1,537.10	-.12	-.023	-.31	50.29
204	15.1	511.79	511.65	2,048.75	-.14	-.027	-.45	50.54
205	15.1	512.27	512.20	2,560.95	-.07	-.013	-.52	50.50
206	15.25	514.07	514.05	3,075.00	-.02	-.004	-.54	50.52
207	15.35	512.47	512.30	3,587.30	-.17	-.033	-.71	50.54
208	15.5	512.09	512.16	4,099.46	+.07	+.013	-.64	50.67
209	15.6	512.20	512.12	4,611.58	-.08	-.015	-.72	50.45
210	15.7	512.31	512.15	5,123.73	-.16	-.031	-.88	50.58
211	15.7	513.07	512.71	5,636.44	-.36	-.070	-1.24	50.24
212	15.8	512.77	512.35	6,148.79	-.42	-.082	-1.66	50.27
213	15.0	513.32	513.24	6,662.03	-.08	-.016	-1.74	50.09
214	14.75	512.40	512.50	7,174.53	+.10	+.020	-1.64	50.30
215	14.4	512.28	512.45	7,686.98	+.17	+.033	-1.47	50.30
216	13.8	512.18	512.36	8,199.34	+.18	+.035	-1.29	50.12
217	13.4	512.81	513.03	8,712.37	+.22	+.043	-1.07	49.65
218	13.2	511.41	511.50	9,223.87	+.09	+.017	-0.98	49.37
219	12.95	512.21	512.26	9,736.13	+.05	+.010	-.93	49.65
220	11.65	524.97	525.09	10,261.22	+.12	+.023	-0.81	50.00
221	11.30	516.45	516.42	10,777.67	+.03	+.005	-0.78	50.00
222	12.45	516.05	515.68	11,293.35	-0.37	-.071	-1.15	49.02
223	12.7	512.46	512.83	11,806.18	+.37	+.071	-0.78	50.59
224	12.8	511.95	512.15	12,318.33	+.20	+.039	-0.58	50.74
225	13.2	511.95	512.10	12,830.43	+.15	+.029	-0.43	51.15
226	13.15	512.18	512.45	13,342.88	+.27	+.052	-0.16	50.38
227	13.1	512.15	512.09	13,854.97	-.06	-.011	-.22	50.44
228	13.25	512.22	512.32	14,367.29	+.10	+.019	-.12	50.29
229	13.25	518.53	518.68	14,885.97	+.15	+.029	+.03	50.22
230	13.35	522.47	522.68	15,408.65	+.21	+.040	+.24	50.14
231	13.40	517.13	517.39	15,925.78	+.26	+.050	+.50	50.22
232	13.60	515.81	516.02	16,441.80	+.21	+.041	+.71	50.42

TABLE 4 - Continued.

Run No.	Water Temp. °C.	Meas. Vol. gal.	Meter Vol. gal.	Meter Acc. Meter Vol. gal.	Per Cent Diff. gal.	Line Per Cent Diff.	Flow Acc. Diff. gal.	Flow Rate gpm
233	13.60	516.42	516.50	16,958.30	+.08	+.015	+.79	50.23
234	13.75	515.49	515.77	17,474.07	+.28	+.054	+1.07	50.15
235	13.65	515.42	515.50	17,989.57	+.08	+.016	+1.15	50.18
236	13.70	515.05	515.32	18,504.89	+.27	+.052	+1.42	50.22
237	13.80	515.96	516.10	19,020.99	+.14	+.027	+1.56	50.25
238	13.80	514.89	514.98	19,535.97	+.09	+.017	+1.65	50.25
239	13.50	516.00	516.19	20,052.16	+.19	+.037	+1.84	50.35

TABLE 5.

TEST 2 - LONG-TERM PERFORMANCE
Line Pressure 35 psi

Run No.	Water Temp. °C.	Meas. Vol. gal.	Meter Vol. gal.	Acc. Meter Vol. gal.	Diff. gal.	Per Cent Diff.	Acc. Diff. gal.	Flow Rate gpm
240	13.7	515.92	516.03	516.03	+.11	+.021	+.11	50.42
241	13.8	514.82	515.18	1,031.21	+.36	+.070	+.47	50.44
242	13.8	515.19	515.19	1,546.40	.00	.00	+.47	50.50
243	13.85	514.85	514.99	2,061.39	+.14	+.027	+.61	50.40
244	13.55	512.00	512.33	2,573.72	+.33	+.064	+.94	50.92
245	13.80	512.79	513.08	3,086.80	+.29	+.056	+1.23	50.27
246	13.95	512.12	512.35	3,599.15	+.23	+.044	+1.46	50.23
247	14.0	512.41	512.61	4,111.76	+.20	+.039	+1.66	50.16
248	14.3	512.06	512.40	4,624.16	+.34	+.066	+2.00	50.74
249	14.4	511.91	512.14	5,136.30	+.23	+.044	+2.23	50.93
250	14.4	514.37	514.44	5,650.74	+.07	+.013	+2.30	51.07
251	14.5	512.29	512.41	6,163.15	+.12	+.023	+2.42	51.19
252	14.7	512.22	512.35	6,675.50	+.13	+.025	+2.55	49.41
253	14.25	514.00	513.80	7,189.30	-.20	-.038	+2.35	48.86
254	14.25	512.47	512.29	7,701.59	-.18	-.035	+2.17	50.14
255	13.65	512.34	512.25	8,213.84	-.09	-.017	+2.08	49.88
256	13.15	512.41	512.51	8,726.35	+.10	+.020	+2.18	50.11
257	13.5	512.34	512.25	9,238.60	-.09	-.018	+2.09	49.55
258	13.75	512.69	512.64	9,751.24	-.05	-.010	+2.04	49.50
259	13.80	512.56	512.60	10,263.84	+.04	+.008	+2.08	49.59
260	14.00	512.52	512.50	10,776.34	-.02	-.004	+2.06	49.65
261	13.80	512.60	512.21	11,288.55	-.39	-.076	+1.67	49.78
262	14.4	512.00	511.73	11,800.28	-.27	-.053	+1.40	49.70
263	14.4	511.76	511.66	12,311.94	-.10	-.020	+1.30	49.18
264	14.50	511.92	512.38	12,824.32	+.46	+.090	+1.76	49.57
265	14.60	511.75	512.19	13,336.51	+.44	+.086	+2.20	49.52
266	14.70	512.10	512.54	13,849.05	+.44	+.086	+2.64	49.54
267	14.9	512.01	512.29	14,361.34	+.28	+.055	+2.92	49.28
268	14.9	512.00	512.24	14,873.58	+.24	+.047	+3.16	49.45
269	14.95	512.42	512.64	15,386.22	+.20	+.039	+3.36	49.70
270	15.45	512.68	512.48	15,898.70	-.20	-.039	+3.16	49.70
271	15.00	511.74	511.65	16,410.35	-.09	-.018	+3.07	49.60

TABLE 5 - Continued.

Run No.	Water Temp. °C.	Meas. Vol. gal.	Meter Vol. gal.	Acc. Meter Vol. gal.	Diff. gal.	Per Cent	Acc. Diff. gal.	Flow Rate gpm
272	15.00	512.19	512.25	16,922.60	+.06	+.012	+3.13	49.75
273	15.10	512.11	512.24	17,434.84	+.13	+.025	+3.26	49.60
274	15.15	512.15	512.40	17,947.24	+.25	+.049	+3.51	49.57
275	15.20	511.25	511.34	18,458.58	+.09	+.018	+3.61	49.59
276	15.20	515.26	515.05	18,973.63	-.21	-.041	+3.39	49.52
277	15.35	512.82	512.61	19,486.24	-.21	-.041	+3.18	49.55
278	15.30	512.40	512.30	19,998.50	-.10	-.020	+3.08	49.60