PAP-468

CALIBRATION OF FLOWMETERS FOR CALAMUS DAM

STAGE 3 - NORTH LOUP DIVISION

BY

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PAP-468

DFC-11 (12-61)
PRS

INFORMATIONAL ROUTING

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PAP file

PAP-468

Memorandum
Chief, Structural Behavior Branch

Denver, Colorado
December 5, 1984

Chief, Division of Dam Safety JRG 12/11
FOR Chief, Division of Research and Laboratory Services HWA, 12/10

Chief, Hydraulics Branch

Calibration of Flowmeters for Calamus Dam, Stage 3 - North Loup Division - Pick-Sloan Missouri Basin Program, Nebraska

We have completed calibration of two electromagnetic flowmeters as requested in your September 20, 1984 memorandum on the same subject.

The velocity readings of the meters were checked in an open channel as shown in figure 1. The electromagnetic flowmeter readings were compared to an Otte flowmeter used in our laboratory. In the range from 2.5 to 4.5 ft/s, the electromagnetic current meter readings averaged about 4 percent higher than the Otte current meter readings (figs. 2 and 3). This is within an expected accuracy for this type of velocity measurement.

Since the flowmeters will be used to measure discharge in relief wells, the velocity comparisons in an open channel are not directly applicable. A calibration was done in an 8-inch-diameter pipe in the pipe test stand in our laboratory. These relief wells are 8-inch-diameter pipes flowing full. The electromagnetic flowmeters were mounted in the center of the pipe as shown on figure 4.

With this setup, it was possible to test very low flows and compare the meter velocity readings to a volumetric calibration using our laboratory calibration tank. At higher discharges, our Venturi meters were used as the standard, since these meters have been calibrated volumetrically and check within one-half of one percent.

Figures 5 and 6 show calibration curves for centerline velocity versus discharge in the 8-inch-diameter pipe. The curve marked "flowmeter" gives the electromagnetic meter results. The long sample mode on the flowmeters should be used to obtain accurate readings. The curve marked "actual" shows the computed centerline velocity versus discharge in a circular pipe. The centerline velocity was computed with the following equation.[1]

$$\frac{v\ (\text{centerline})}{v\ (\text{average})} = 1.43\ (f)^{0.5} + 1$$

where f is the Darcy-Weisbach friction factor. The friction factor is

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[1] Rouse, H. "Elementary Mechanics of Fluids," Wiley and Sons, Oct. 1984, pp 198.

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computed for each flow using the "Moody diagram," which relates Reynolds number to friction factor.

The calibration equations for the 2 meters over the full range (from figs. 5 and 6) are:

Meter No. 1 - $Q\ (ft^3/s) = 0.2967\ v\ (ft/s) + 0.0208$
Meter No. 2 - $Q\ (ft^3/s) = 0.2940\ v\ (ft/s) + 0.0159$

where v is the meter reading.

Figures 7 and 8 show the same curves plotted in figures 5 and 6 on a log-log scale. These figures demonstrate the differences between a uniform velocity distribution in a circular pipe (actual) versus the electromagnetic flowmeter readings. For example, at $Q = 0.04\ ft^3/s$ (18 gal/min), the centerline velocity in an unobstructed circular pipe would be 0.15 ft/s. With the electromagnetic flowmeter installed, the center of the pipe is obstructed by the meter. The meter reading is 0.078 ft/s. This is about one-half of the velocity that would be expected in an unobstructed pipe.

CONCLUSIONS

1. The electromagnetic flowmeters check within 4 percent of our laboratory Otte flowmeter in an open channel.

2. The flowmeters cause a significant obstruction to the velocity distribution in the pipe, especially at low discharges.

3. The calibration curves or equations given in this memorandum for the electromagnetic flowmeters can be used to obtain dicharges to within ± 5 percent at low flows (around $0.10\ ft^3/s$). The meter calibrations are accurate to within ± 1 percent at high flows (around $2.0\ ft^3/s$).

Philip H. Burgi

Attachment

Copy to: D-1500
D-1530
D-1531
D-1531 (PAP file)
D-1532
D-1532 (Fitzwater)
D-3300
(with attachment to each)

7-1654 (7-73)
Bureau of Reclamation

COMPUTATION SHEET

BY	DATE	PROJECT	SHEET ____ OF ____
CHKD BY	DATE	FEATURE	
DETAILS			

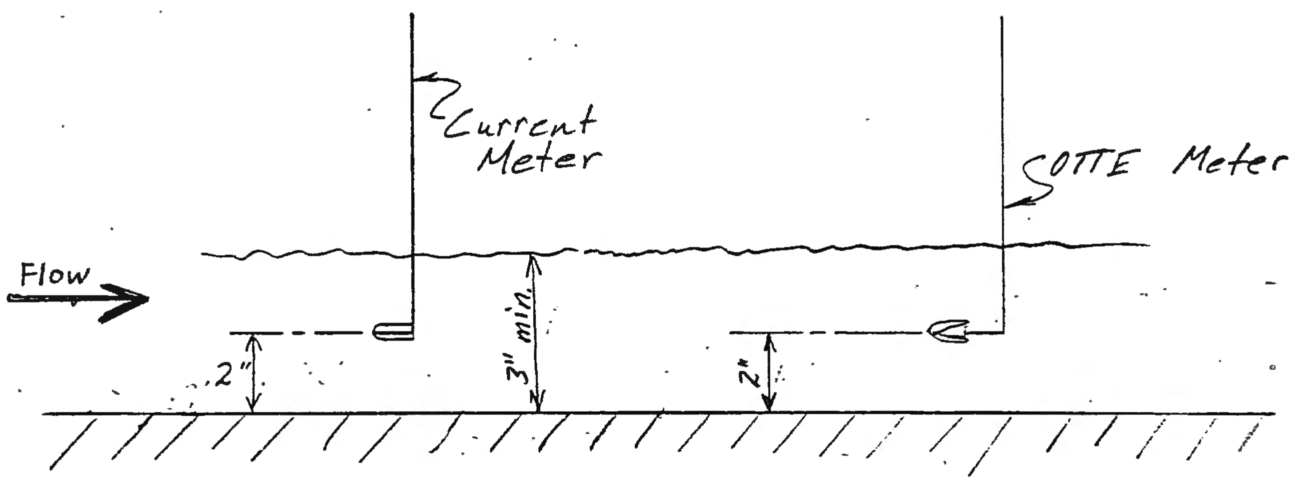

Figure 1. Test set up in open channel to check velocity readings.

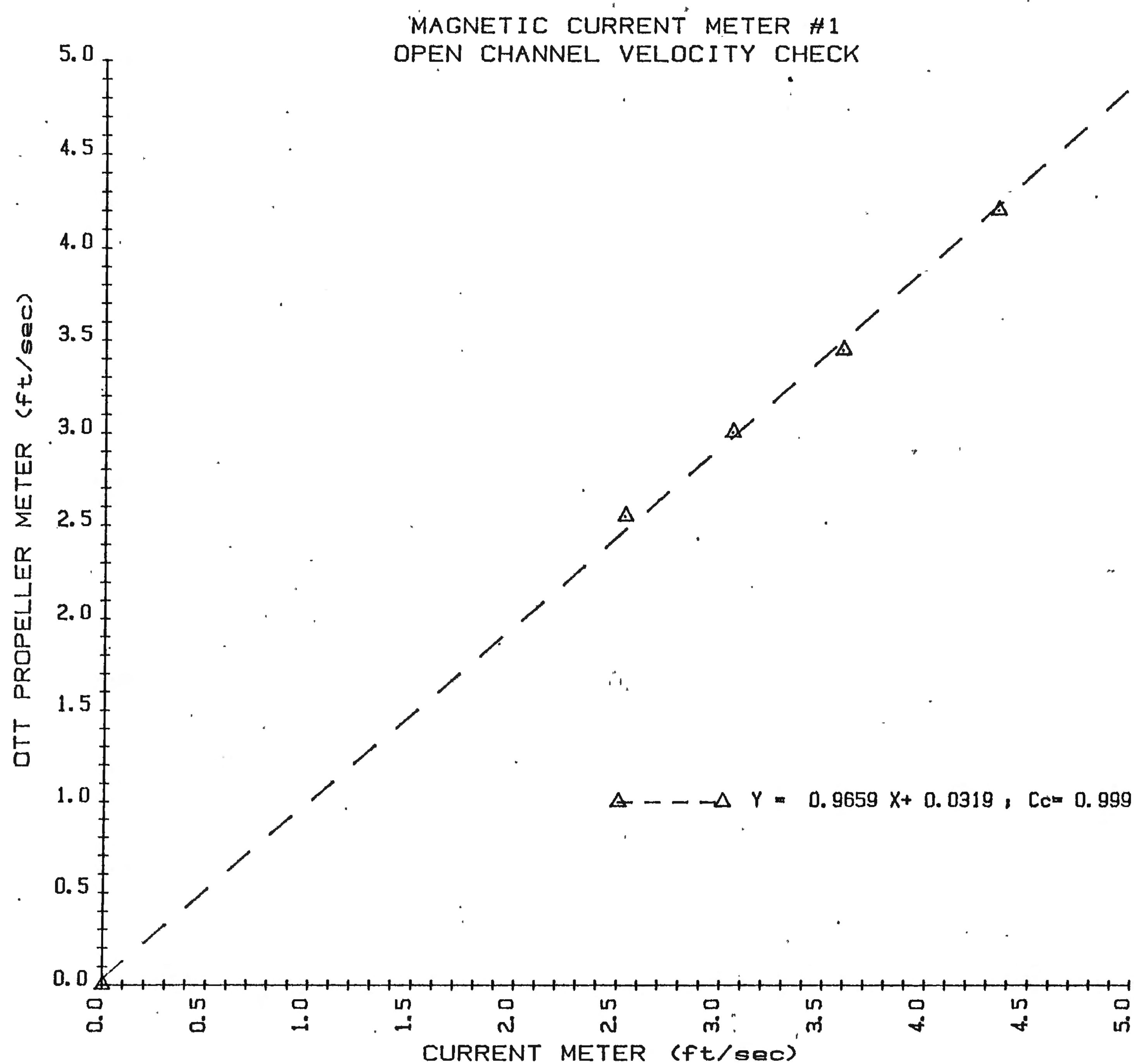
MAGNETIC CURRENT METER #1
OPEN CHANNEL VELOCITY CHECK
OTT PROPELLER METER (ft/sec)
CURRENT METER (ft/sec)
Y = 0.9659 X+ 0.0319 ; Cc= 0.999
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

figure 2

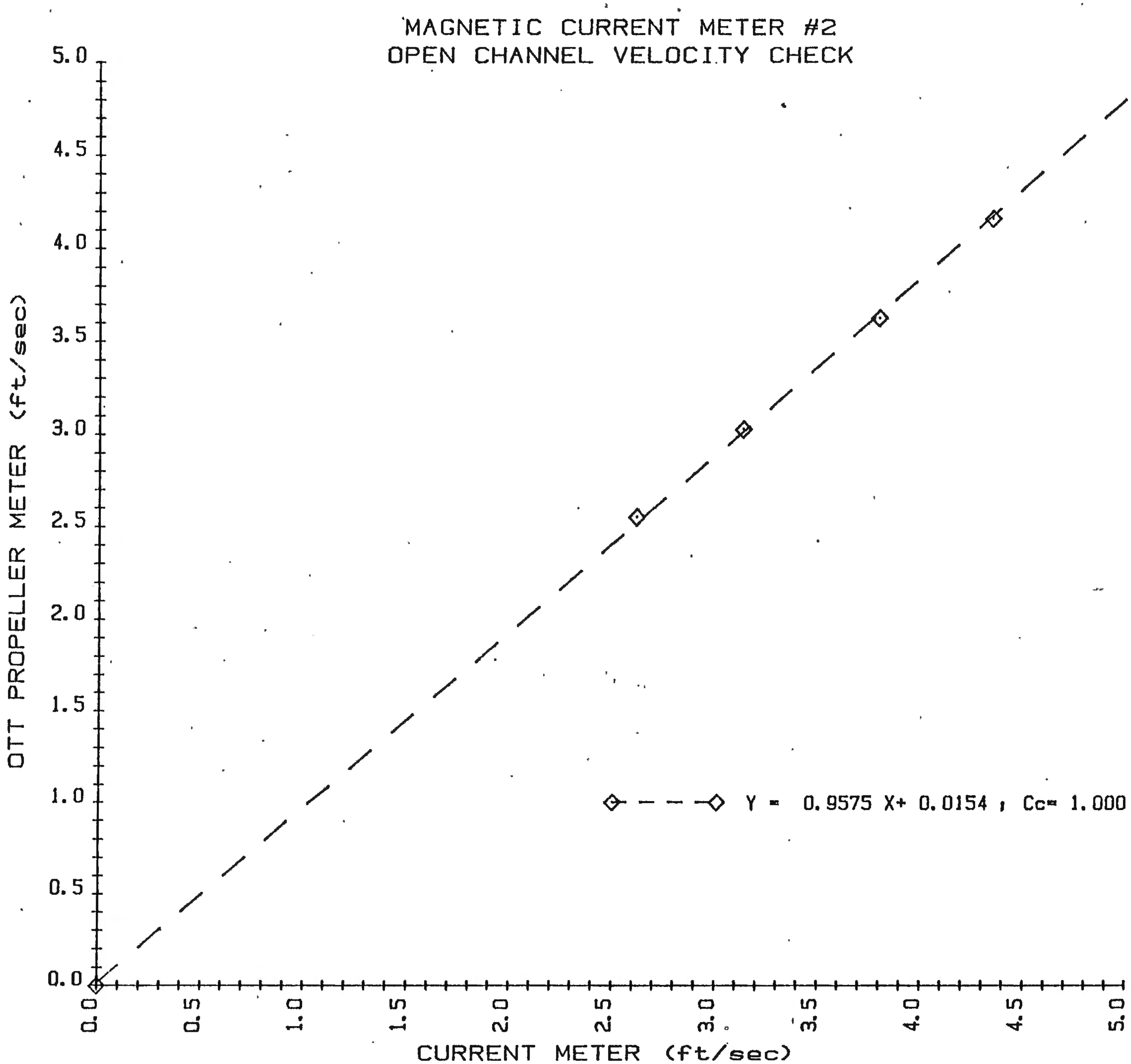
MAGNETIC CURRENT METER #2
OPEN CHANNEL VELOCITY CHECK
OTT PROPELLER METER (ft/sec)
CURRENT METER (ft/sec)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Y = 0.9575 X+ 0.0154 ; Cc= 1.000

figure 3

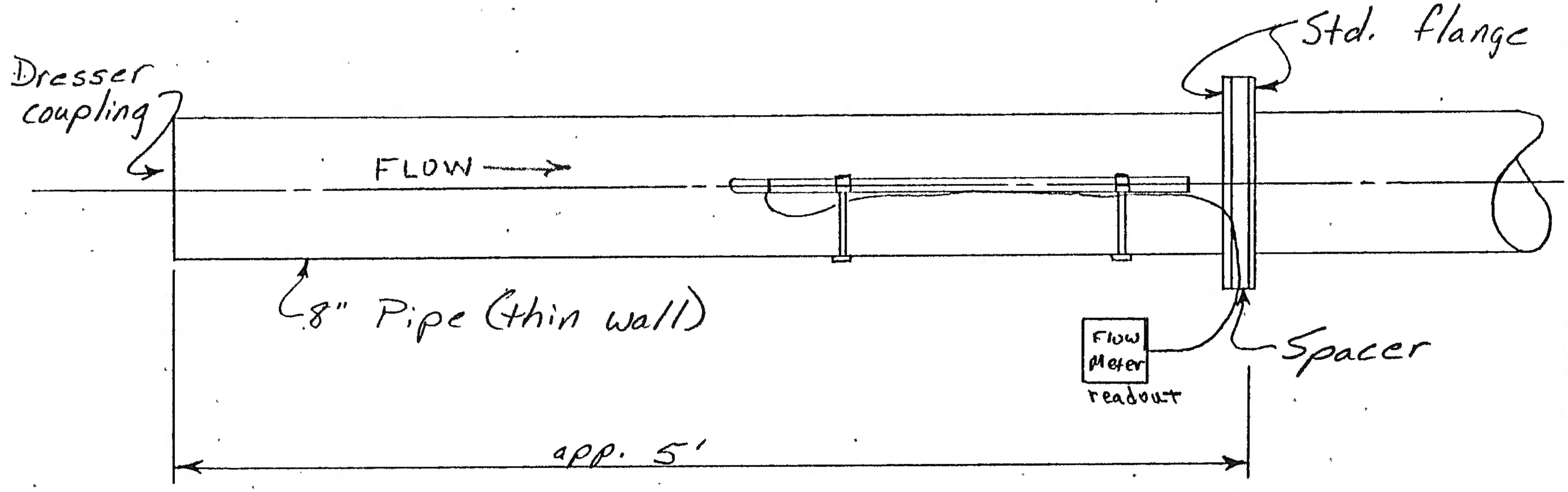

Figure 4. Magnetic flowmeter installation in 8-in-diameter pipe

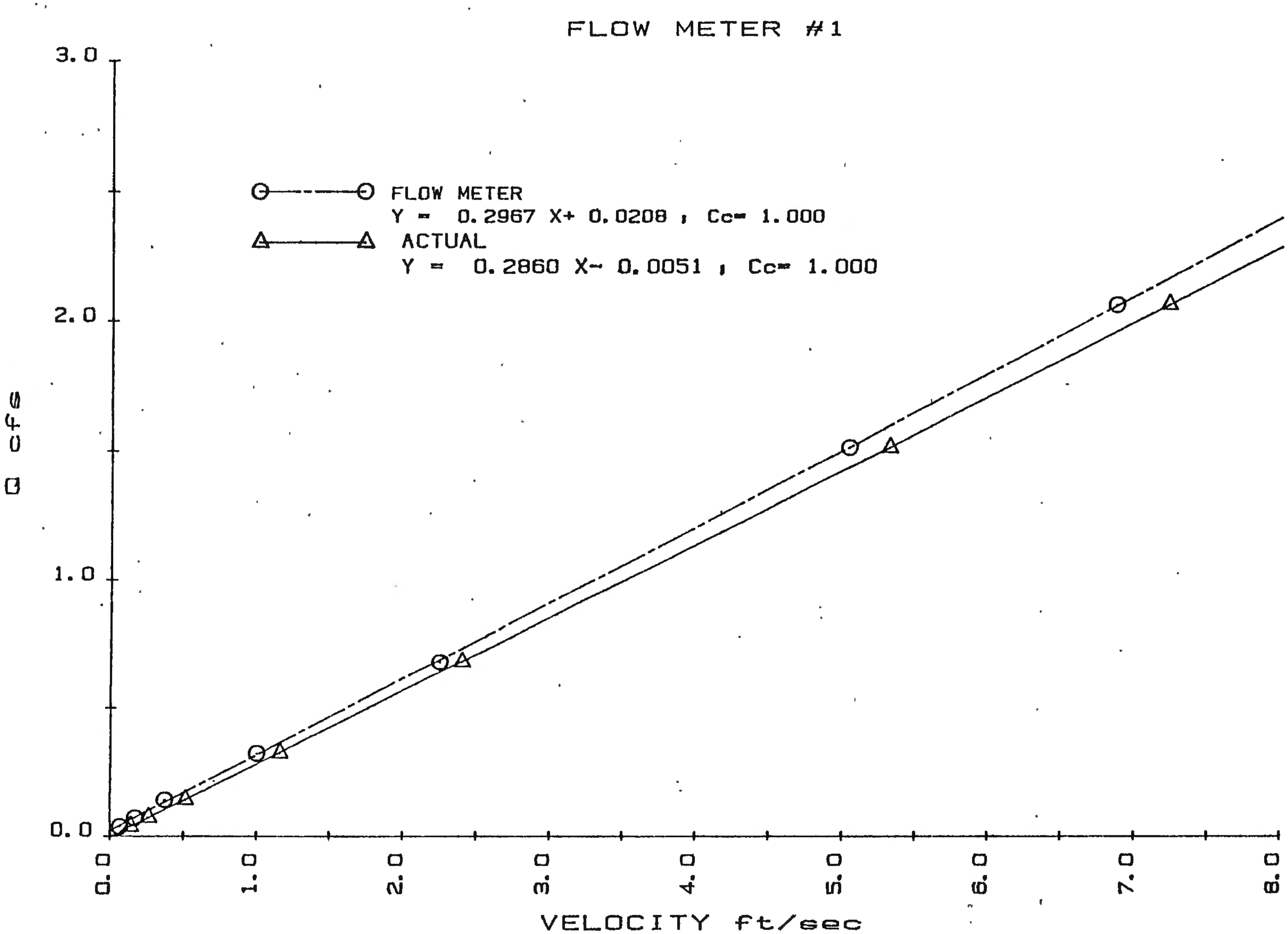

figure 5 - Velocity vs. discharge in an 8-in-diameter pipe

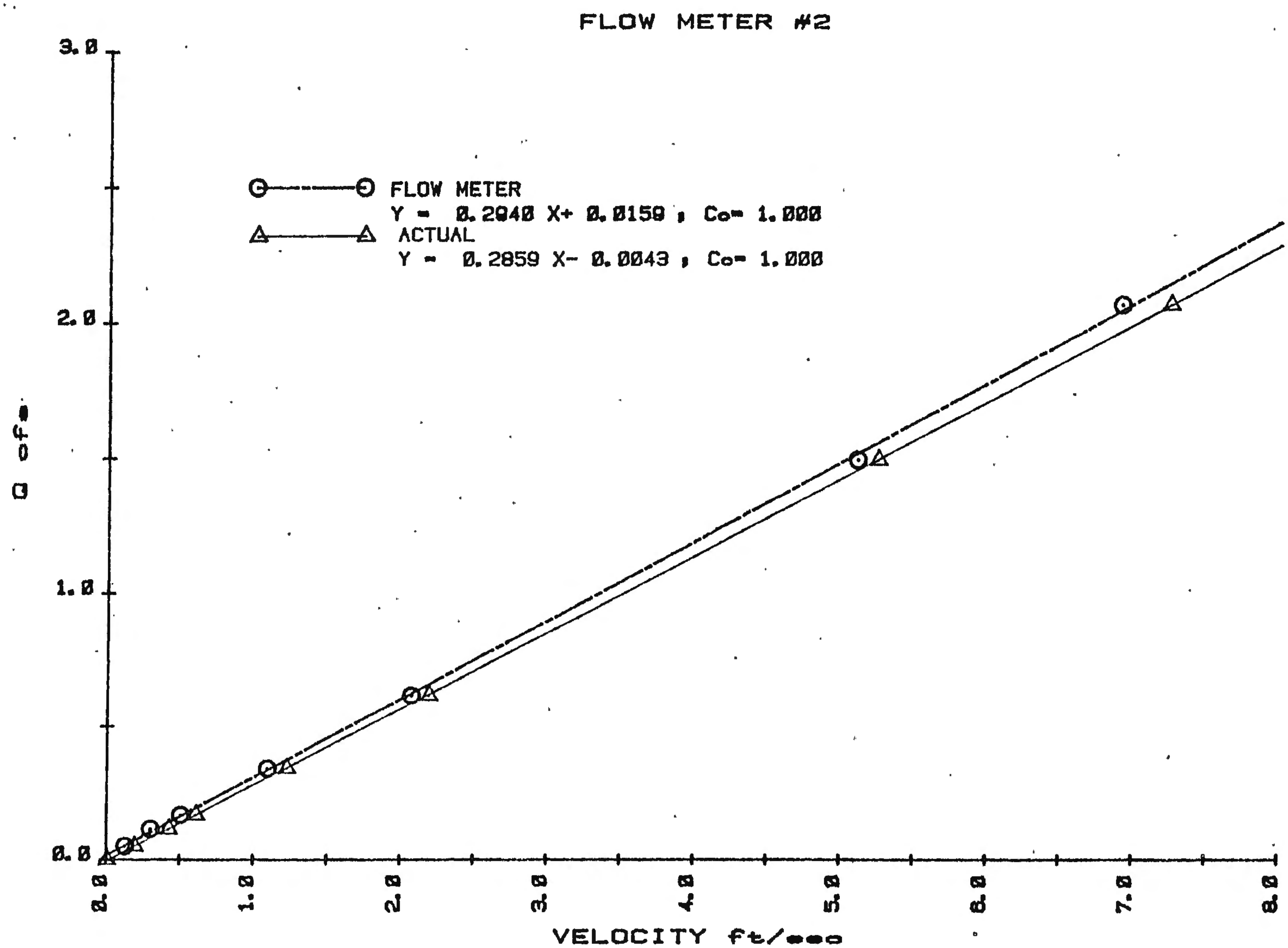

figure 6 - Centerline Velocity vs. discharge in an 8-in-diameter pipe

FLOW METER #1

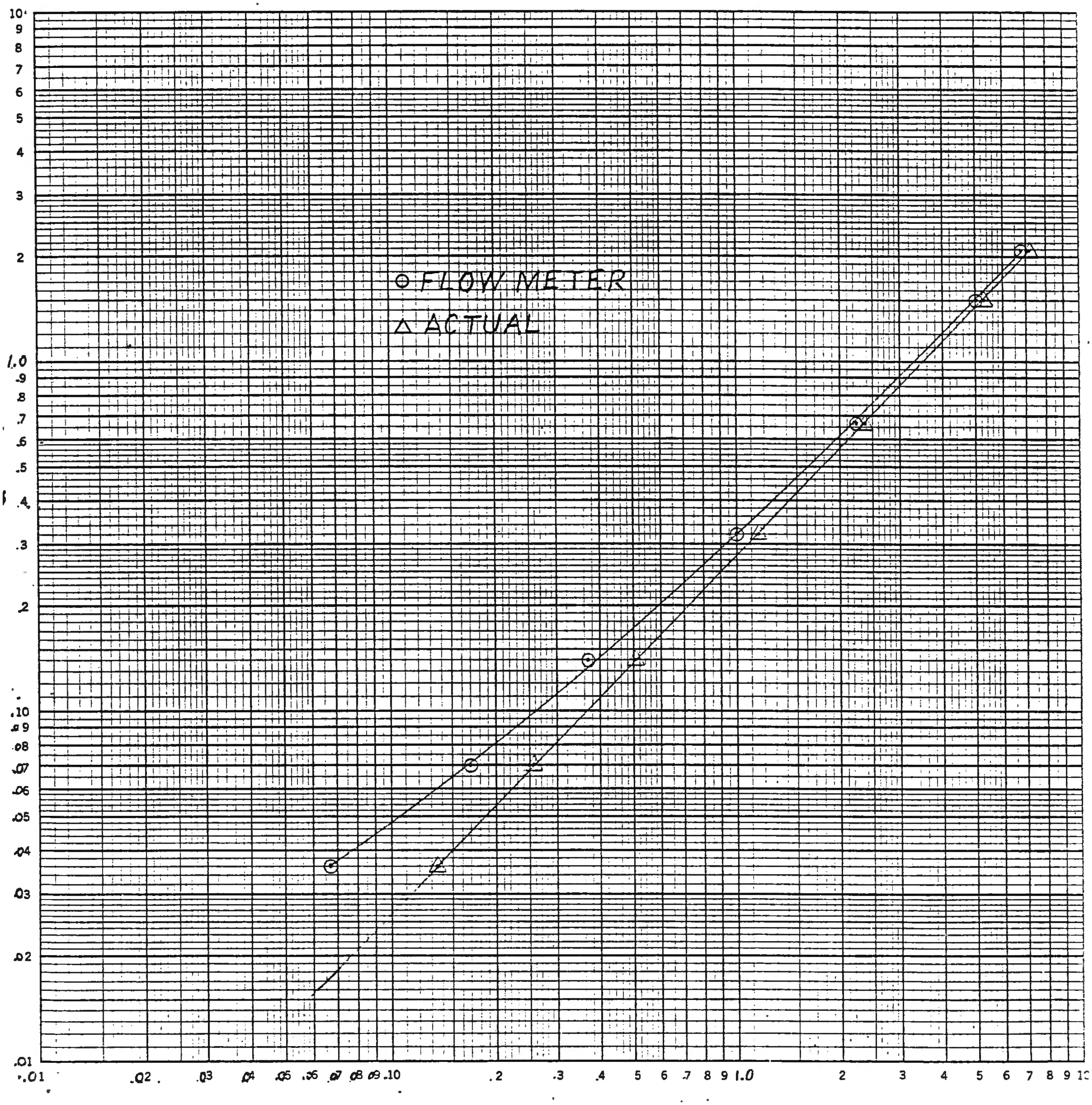

figure 7 - centerline velocity vs. discharge in an 8-in-diameter pipe

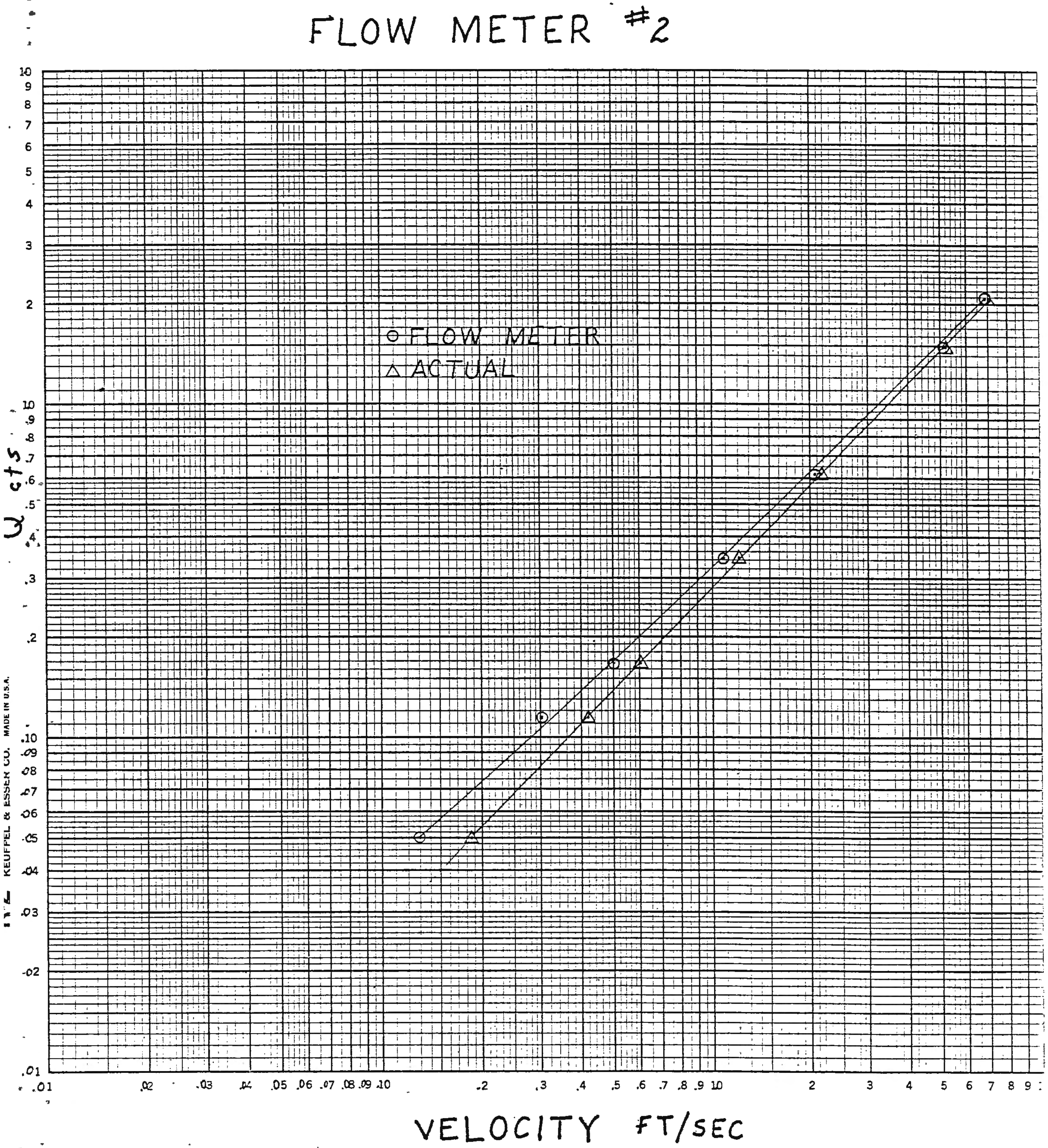

figure 8 - Centerline velocity vs. discharge in an 8 inch diameter pipe