PAP-662

LABORATORY TESTING OF AN 8-INCH MONOVAR VALVE

by

K. Warren Frizell

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MEMORANDUM

To: Philip Burgi, D-8560

From: K. Warren Frizell
Hydraulic Engineer

Subject: NM003 Research Progress

Attached is a report on laboratory testing of an 8-inch Monovar valve which was performed during FY94. The results of this testing have brought a closure to our program on Throttling Plates and Valves, which has been the major focus of *Improved Design of Gates and Valves* (NM003) for the past 2 years. The information in this report will be included in a summary report which reviews all of the throttling devices tested under this program and should be published later this year.

K. Warren Frizell

Attachment

cc: D-6700 (Ponce)
D-8420 (Frisz)
D-8560 (file)
D-8560 (Frizell, K.W.)
(w/att to each)

WBR:KWFrizell:flh:11-3-94:236-2000, ext. 456
(c:\wp\d3752\monomen.doc)

PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

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Peer Reviewer Clifford A. Pugh Document Author(s)/Preparer(s) K.Warren Frizell

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REVIEW REQUIREMENT

Part A: Document Does Not Require Peer Review

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Part B: Document requires Peer Review : SCOPE OF PEER REVIEW

Peer Review restricted to the following Items/Section(s): Reviewer:

REVIEW CERTIFICATION

Peer Reviewer - I have reviewed the assigned Items/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: Clifford A. Pugh Review Date: 10-19-94
Signature

Preparer: I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Member: K Warren Frizell Date: 10 - 18 - 94
Signature

Laboratory Testing of an 8-inch Monovar Valve

by K. Warren Frizell

Abstract:

As part of Reclamation's research program *Improved Designs of Gates and Valves* (NM003), the Monovar valve was tested to provide information to compare to two throttle valves developed internally. Testing was performed in the Water Resources Research Laboratory's (WRRL) high-head pump facility. Testing was completed on both in-line and end-of-line applications. The Monovar valve performed well in both applications tested. Comparison with manufacturers data did show some differences in discharge capacity. The energy dissipation characteristics of the Monovar were excellent and the valve would be an excellent choice for applications when both flow control and throttling are required.

Introduction

The Monovar valve was developed by Alsthom Fluides of France and has been widely used in Europe and Japan for over ten years in flow control and pressure reducing applications. It's use in North America and in particular the United States has been very limited. The Monovar is a multi-ported valve using a fixed and sliding plate design. When fully open, the holes of the fixed and sliding plate are aligned, figure 1.

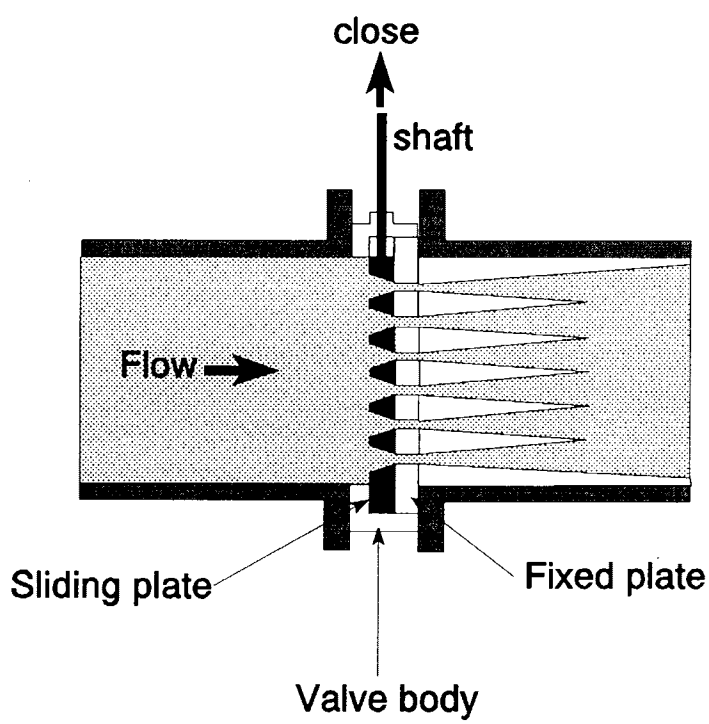

Figure 1: Sectional view of the Monovar valves simple design.

The sliding plate is on the upstream side and has 57 tapered orifices, the fixed plate has 57 straight orifices which when aligned with the sliding plate form multiple venturi-type flow passages. The individual jets emanating from these orifices are effective in dissipating energy and are spaced to minimize cavitation damage and maximize pressure recovery. The valve body is a wafer style, which is sandwiched between ANSI flanges. The valve can be mounted from horizontal to vertical, however, the flow direction is one-way. The Monovar is available in sizes of 4-inch through 60-inch, each size being geometrically similar.

Reclamation has long had an interest in adjustable throttling valves which could be used on pipeline and penstock filling and drain lines to dissipate energy without damaging the system. In-house development and testing has included different adjustable throttle valves. Testing of the commercially available Monovar valve allows us to make a more informed and economical decision as to which type of throttling device should be specified for a given situation.

Experiments

We performed both in-line and end-of-line testing on an 8-inch Monovar. The in-line testing used the high-head pump (600 ft shut-off head) in Reclamation's hydraulic laboratory. A schematic of the test setup is shown in figure 2.The basic test plan consisted of varying the Monovar opening in 10-

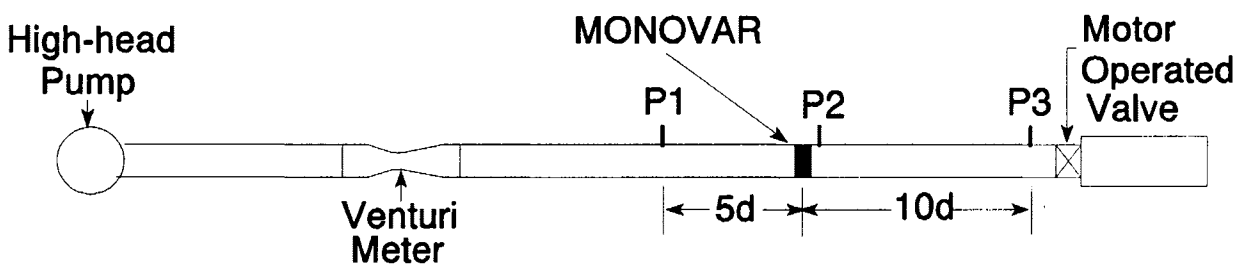

Figure 2: Schematic of laboratory setup for in-line testing of the 8-inch Monovar valve.

percent increments over a range of heads up to about 300 ft for three different downstream pressure conditions. At each test point, the discharge, and three pressures P1-P2, P1-P3, and P1 were measured. In addition, observations of the valve's operation and any audible cavitation noise were noted.

The end-of-line testing was also carried out on the high-head test facility. The test arrangement was slightly altered, figure 3.

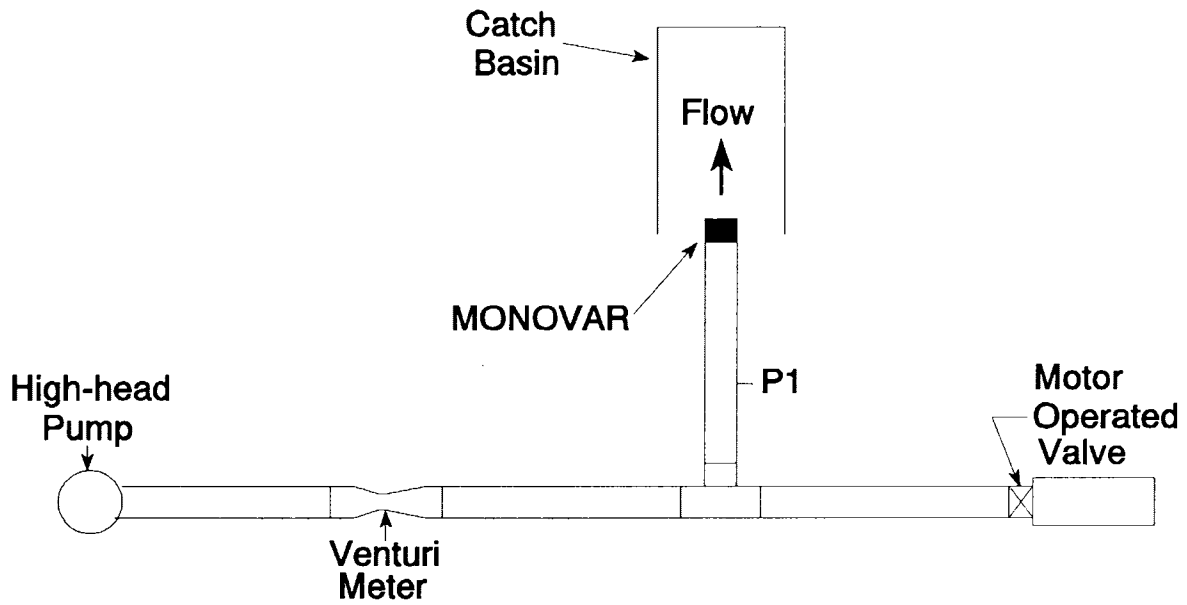

Figure 3: Schematic of end-of-line test setup in Reclamation's hydraulic lab.

The major purpose of the end-of-line or free discharge testing of the Monovar was to verify the discharge capacity and observe the valve's operation. The data collected included, the discharge and pressure P1 for 10-percent increments in the Monovar opening for a range of heads up to about 300 ft.

Results

In-line Tests: Data were collected for the three downstream pressure conditions throughout the range of head drops and valve openings to the extent possible using our test facility. With high back pressures, an increase in flow for a given test condition was noted, especially at the larger valve openings. The base discharge curve, figure 4, was taken with no additional back pressure on the valve. Our test facility was limited on the lower end based on the idling speed of the pump's motor and at the high end based on reaching the motor's maximum r.p.m.

Additionally, the flow coefficient, C_v, as described by Monovar in their literature was also computed, figure 5. C_v is defined as the discharge in gallons per minute at a differential of 1 lb/in^2.

$$C_v = \frac{Q}{\sqrt{(\Delta P)}}$$

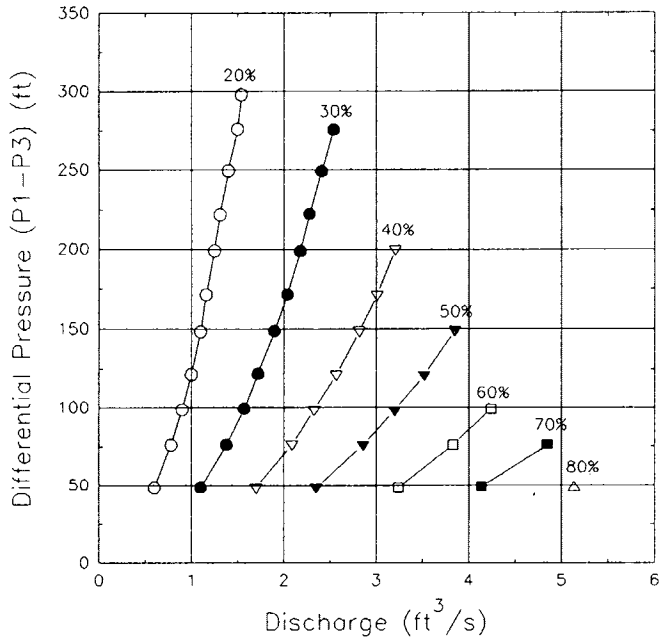

Figure 4: Discharge curve for 8-inch Monovar valve, no added backpressure.

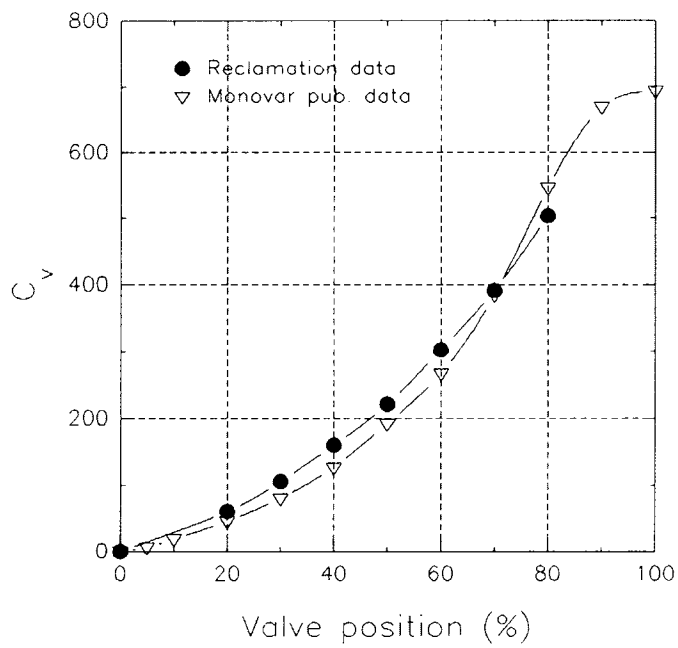

Figure 5: C_v values from Reclamation in-line tests compared to Monovar's published data.

In addition to the discharge information, we computed the cavitation parameter σ for the test conditions we ran. Sigma, or the cavitation index, is defined as:

$$\sigma = \frac{P3\,(ABS)}{P1 - P3}$$

where: P3 (ABS) is the downstream pressure, absolute, less vapor pressure
P1 is the upstream gage pressure (5d upstream of the valve)
P3 is the downstream gage pressure (10d downstream of the valve).

This data is shown on figure 6, along with recommended operating ranges from Monovar where the valve can perform as a flowmeter, operate (but not as a flowmeter), and where they recommend no operation. It was interesting to note

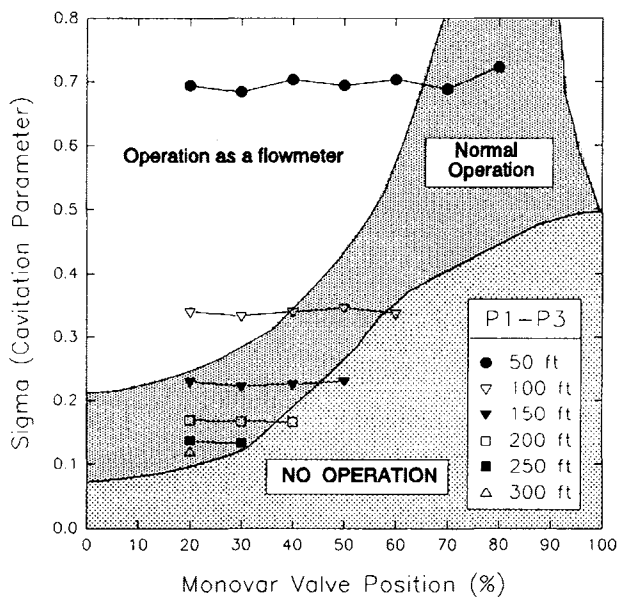

Figure 6: Cavitation index with recommended operational guidelines from Monovar for Reclamations test conditions.

that the line corresponding to operation not recommended roughly follows where we stopped taking data due to excessive noise and vibration in the pipeline.

End-of-line Tests: The end-of-line tests we performed determined the discharge capacity and included observations of the free discharge flow conditions. The discharge capacity is shown in figure 7. Once again, the flow coefficient, C_v was computed and compared to Monovar's published data, figure 8. The operation of the valve was very smooth and free from vibration. The individual jets emanating from the valve were highly aerated, figure 9a & 9b. As the pressure head was increased, the basic flow pattern remained the same, however a finer mist was generated due to higher shear intensity, figure 10a & 10b.

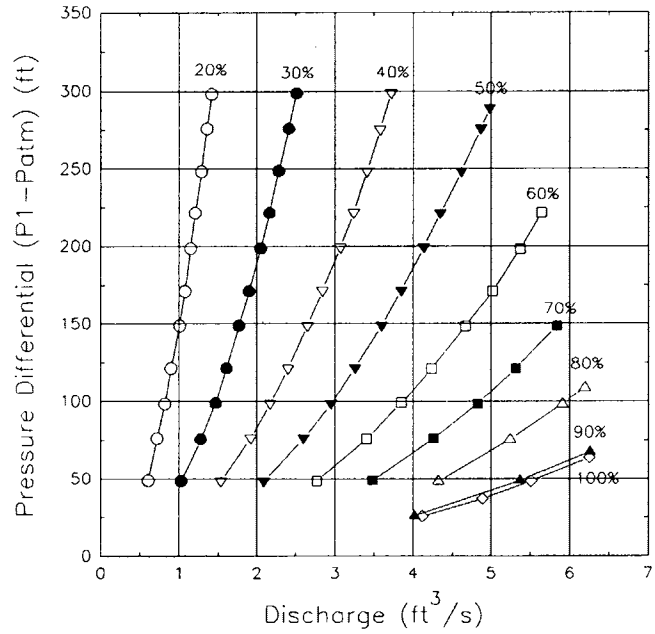

Figure 7: Discharge capacity for end-of-line arrangement.

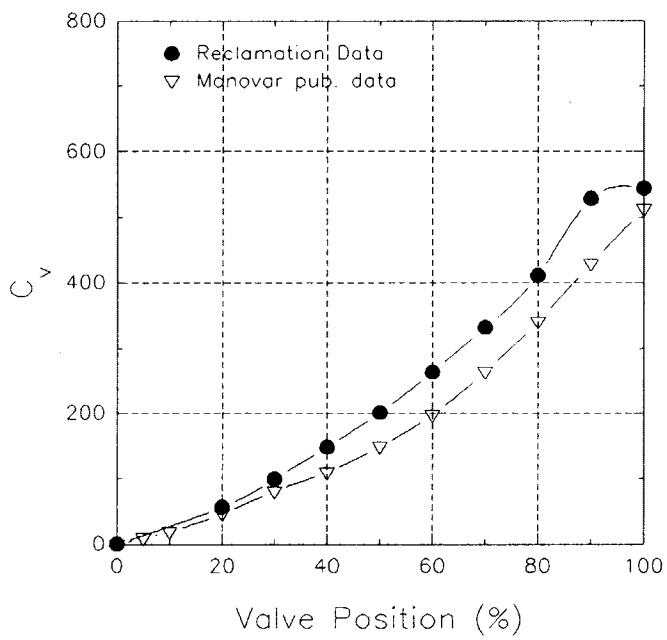

Figure 8: Flow coefficient for end-of-line discharge. Reclamation data compared to Monovar's published data.

Figure 9a: 8-inch Monovar, end-of-line discharge, 20-percent open, H=50 ft.

Figure 9b: 8-inch Monovar, end-of-line discharge, 100-percent open, H=50 ft.

Figure 10a: 8-inch Monovar, end-of-line discharge, 20-percent open, H=250 ft, note downward trajectory of the combined jets.

Figure 10b: 8-inch Monovar, end-of-line discharge, 100-percent open, H=250 ft, note that you can still see individual jets near the valve face.

Discussion

The Monovar performed well under both in-line and end-of-line discharge arrangements. The operation in both cases was smooth and vibration was minimal, even under known cavitation conditions. The valve we tested had a manual operator which performed well, allowing easy operation, even at shut-off heads of 600 ft. In general, the Monovar literature is accurate in describing the valve and its performance. Our tests showed some deviation in the C_v values for both in-line and end-of-line applications. The in-line test comparison is shown in figure 11. Some of these differences may be due to

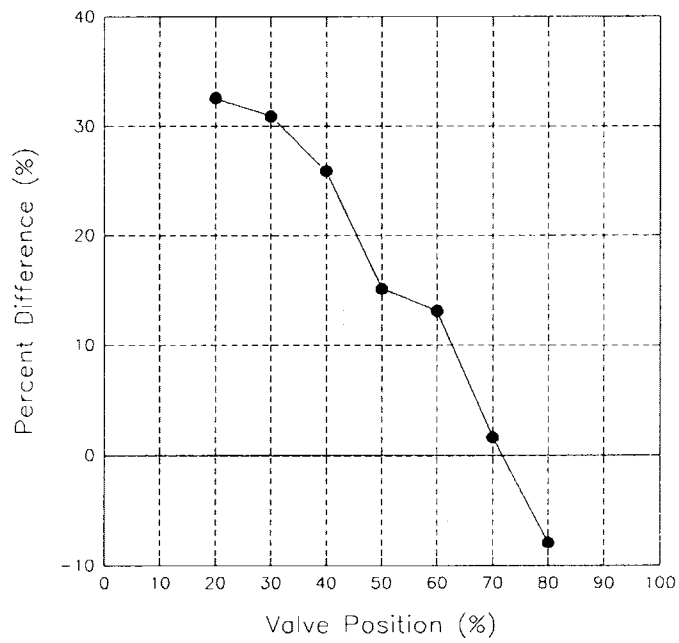

Figure 11: Comparison of in-line flow coefficients. (USBR-Monovar)/Monovar X 100.

measurement of the differential pressure across the valve. Our tests used standard taps located 5 diameters upstream of the valve and 10 diameters downstream. The only reference to pressure taps in Monovar's literature uses 1 diameter upstream and 2 diameters downstream.

In the end-of-line tests, the differences were more consistent throughout the entire range. Reclamation's flow coefficient values were higher (more flow measured for the same ΔP) than Monovar's published values, figure 12. The free discharge operation was very smooth, providing a compact jet (no need for a hood). As expected, at small openings, the jet deflected downward from the horizontal, even at high heads (up to 300 ft). Although no formal measurements were taken of the energy dissipation characteristics of the free discharge, observations indicate that there is increased energy dissipation over a solid jet of similar size.

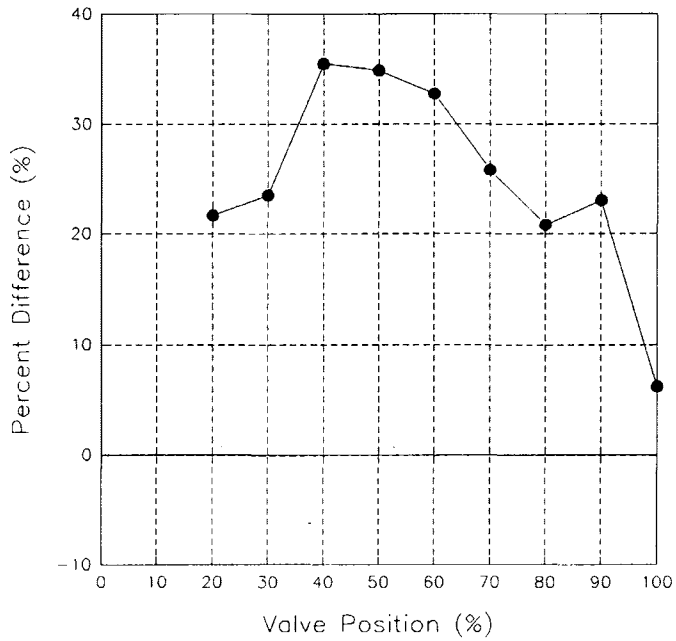

Figure 12: Comparison of end-of-line flow coefficients. (USBR-Monovar)/Monovar X 100.

Acknowledgement

I would like to thank GEC Alsthom for allowing us to test an 8-inch Monovar, in particular Leon Goldman, for his cooperation in arranging the loan of the valve. Jerry Fitzwater, Civil Engineering Technician, D-8560, collected most of the data.