Form DFC-11
(7-52)
Bureau of Reclamation

INFORMATIONAL ROUTING

PAP 66

PAP 66

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Denver, Colorado

January 6, 1955

AUTHOR

Memorandum

To: Chief, Hydraulic Laboratory Branch

From: Head, Hydraulic Equipment Section

Subject: Hydraulic model tests pertaining to the calibration of the hollow-jet valves of the Falcon Dam Outlet Works

During recent years there has been a trend to use outlet valves as devices for measuring releases of water from reservoirs. In instances where the field installations have been identical to those used in model studies, good accuracy has been obtained. In these cases there has been sufficient lengths of straight pipe upstream of the valves to assure good velocity and pressure distribution at the pressure measuring section arbitrarily selected at one pipe diameter upstream of the valve inlet. When the model tests were made it was realized that variations in approach piping would affect the head-discharge relationship, but such cases would not be standard and so would have special consideration as the designs were developed. The pressure taps upstream of the Falcon Dam outlet valves all being immediately downstream of bends made the calibration of the Falcon Dam hollow-jet valves a special problem.

Two hydraulic models and one aerodynamic model were used for the calibration tests on the Falcon Dam outlet valves. The aerodynamic model represented a portion of the piping upstream of the Y-branch in the United States Outlet Works. This model was used to determine to what extent the conduit system upstream of the Y-branches would have to be represented in the hydraulic models. The hydraulic models represented the United States and Mexican outlets. Since a 6-inch valve was used in both cases, the scale ratios were 1:12 and 1:15, respectively, for the United States and Mexican outlet works. The hydraulic models are shown on Figure 1.

In order for calibration curves obtained from model valves to be applicable to the prototype valves, the model pressure heads and valve openings must correctly represent those of the prototype. The flow lines must be similar, particularly in the valve and in regions where pressure taps are located. Considerable preliminary

PAP 66

testing was required on the models of the Falcon Dam Outlet Works valves and upstream piping to determine to what extent the prototype piping would have to be represented in order to fulfill these requirements. It was believed that the valves, the piping immediately upstream, the Y-branches, and a portion of the piping upstream of the branches would be needed. Because of the nearness of the pressure taps to bends in the prototype conduit system, it was considered important that they be located accurately in the model, so field locations were requested and the model taps installed accordingly.

The approaches to the outlet branches were of first importance since if the velocity distribution into them was quite symmetrical the penstocks systems upstream could be represented by short sections of straight pipe. An examination of the two designs showed the United States side would be more likely to contain an unsymmetrical velocity pattern in the pipe ahead of the outlet branch than the Mexican side because of the type of branch connecting it to one of the turbine penstocks. An inexpensive model of lightweight metal was constructed and tested using air as a fluid to ascertain the velocity distribution entering the Y-branch. The model represented a part of the power penstock, the branch from the penstock and the length of outlet pipe from this branch to a point a short distance above the outlet branch. From Pitot traverses at the end of the model piping it was found that a very symmetrical velocity pattern existed. This was proof that a good velocity distribution would exist at the entrance of the Y-branch and that it would only be necessary to construct the piping of the hydraulic models to provide this type of distribution. From the tests it was concluded that conditions for the Mexican Outlet Works would be less severe and its model could be constructed to give a good velocity pattern at the entrance of the Y-branch. Location of the models in the laboratory provided 8-1/2 feet of straight pipe upstream of the United States Outlet Works branch and 20 feet upstream of the Mexican Outlet Works branch. These lengths were considered more than adequate.

After the extent of the upstream piping had been established, tests were made to determine in what detail the piping, bends, and valves downstream of the branches would have to be represented for the calibration tests.

Tests were conducted on both models with one leg of the branch represented in its entirety including valve, and the other with sufficient piping to contain a calibrated orifice. A study of the pressures just upstream of the valve for various discharges disclosed that operation of one leg of the branch would not affect the pressure discharge relationship in the other. These tests proved that a calibration of one valve with the other branch leg completely closed would apply for all flows.

Because of the location of the pressure taps near the downstream ends of pipe bends, it was expected that the pressure heads at the taps would vary with location on the periphery of the pipe. Heads at each of the taps were measured for all four valves. Since the taps were not located exactly symmetrical with the axes of the bends, the pressure heads at each were expected to be different, those to the outsides of the bends being higher than those to the insides. Initially, it was presumed that the average pressure at the section would be registered in the manifold and that this would permit use of calibration curves for similar valves connected to straight conduits. Measurements at the model taps of the United States outlet valves showed the pressures to the outside of the bend to be as much as 4 percent different from those to the inside of the bend, and those of the Mexican outlet valves to be as much as 31 percent different. It was found that the pressure head for the two top taps (on outside of bend) differed only slightly. The same was true of the two lower taps (those on the inside of the bends).

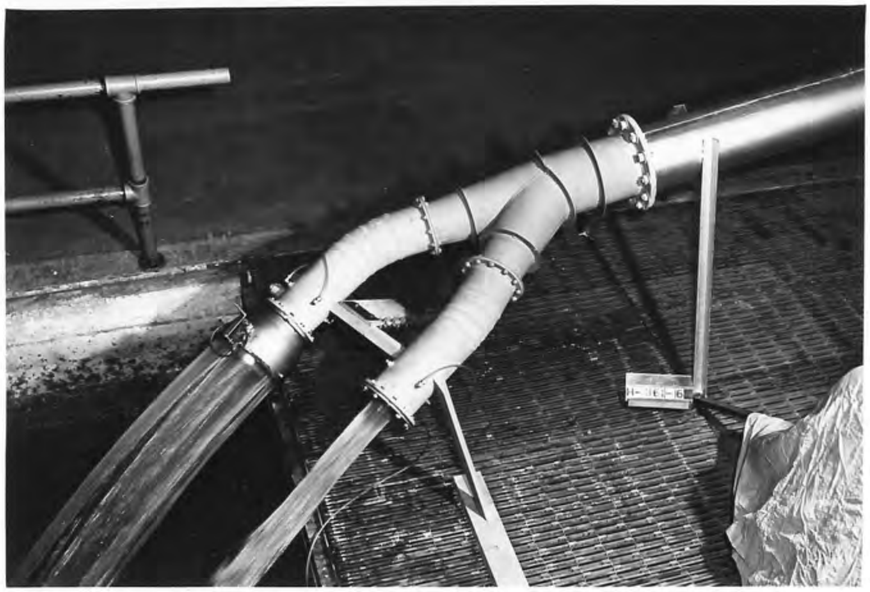
With a manifold connecting all four taps there would be flow from the higher to the lower pressure openings and the pressure within the manifold would be between the two extremes. The magnitude of this manifold pressure would vary depending on the tap opening and other water passage sizes. A calibration with this arrangement would be possible but would be applicable for only the particular arrangement and water passage size ratios. An accumulation of foreign material in any opening would change the pressure in the manifold and thus the pressure discharge relationship. This would decrease the measurement accuracy. Corrosion in the openings might result in the same type of action, thus the use of all four taps of a section connected to a manifold was not considered satisfactory.

Since the pressure heads at the two taps on the inner curve of the bend were nearly the same and those at the two taps on the outer curve of the bend were nearly the same, the circulation within a manifold using either set of two taps would be small and excessive corrosion or blocking of a tap would not noticeably affect the accuracy. The use of the taps at the outer surface of the bend was recommended because heads of greater magnitude would be involved and it was felt that this would result in more accurate recordings of the head.

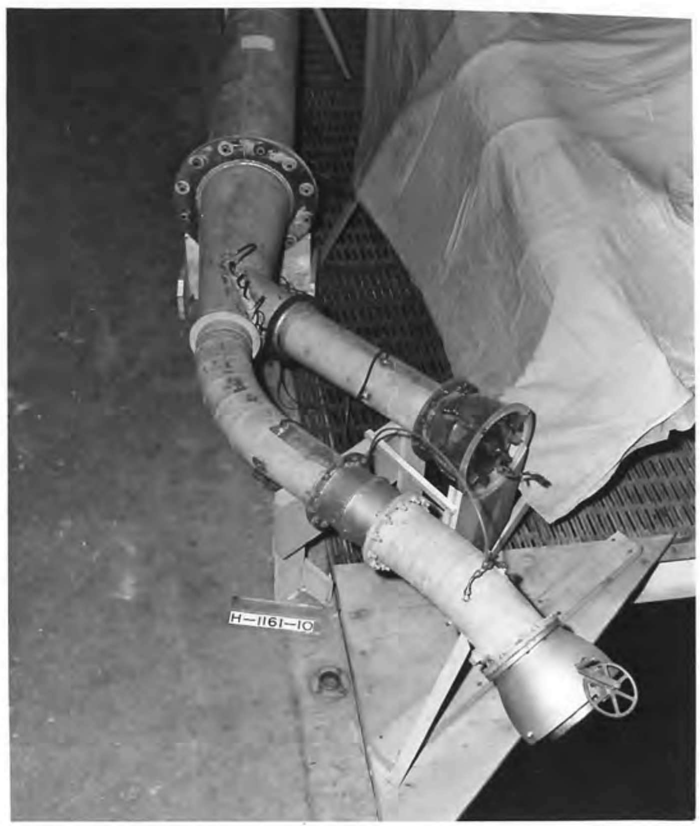
Calibration curves based on the pressure head at two top taps upstream from each valve were prepared for the 72-inch United States valves and the 90-inch Mexican valves, Figures 2 and 3. The calibration curves are based on pressure heads above elevation 188.02 for the United States valves and above elevation 188.71 for the Mexican valves (centers of valve entrances), as registered in a manifold connecting the two top taps upstream from the valves, and on valve openings in excess of 100 percent because the needle travel in these installations is greater than 1/3 of the valve entrance diameter.

Copy to: International Boundary and
Water Commissioner - 2

Blind to: Assistant Commissioner and Chief Engineer
W. H. Price
H. M. Martin
J. W. Ball
D. Colgate



United States Outlets
Right Outlet Complete
Orifice replacing left hollow-jet valve
Model scale 1:12



Mexican Outlets
Right Outlet Complete
Left outlet--Laboratory control valve in position of left butterfly valve
Model scale 1:15

FALCON DAM HOLLOW JET VALVE CALIBRATION

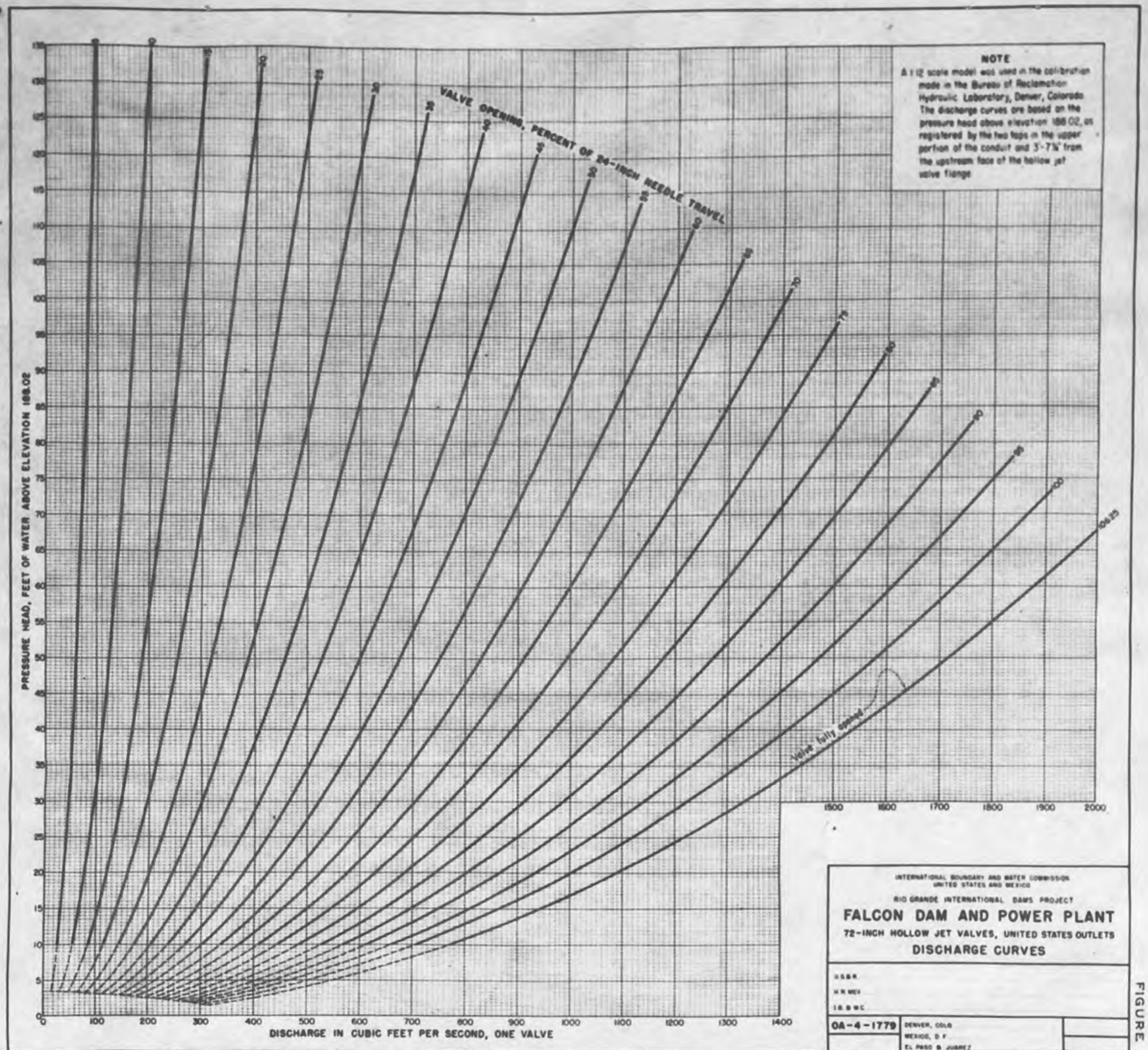

NOTE
A 1:12 scale model was used in the calibration made in the Bureau of Reclamation Hydraulic Laboratory, Denver, Colorado. The discharge curves are based on the pressure head above elevation 188.02, as registered by the two taps in the upper portion of the conduit and 3'-7⅜" from the upstream face of the hollow jet valve flange
VALVE OPENING, PERCENT OF 24-INCH NEEDLE TRAVEL
Valve fully opened
PRESSURE HEAD, FEET OF WATER ABOVE ELEVATION 188.02
DISCHARGE IN CUBIC FEET PER SECOND, ONE VALVE
INTERNATIONAL BOUNDARY AND WATER COMMISSION
UNITED STATES AND MEXICO
RIO GRANDE INTERNATIONAL DAMS PROJECT
FALCON DAM AND POWER PLANT
72-INCH HOLLOW JET VALVES, UNITED STATES OUTLETS
DISCHARGE CURVES
U.S.B.R.
H.R. MEX.
I.B. & W.C.
OA-4-1779
DENVER, COLO.
MEXICO, D.F.
EL PASO & JUAREZ

FIGURE 2

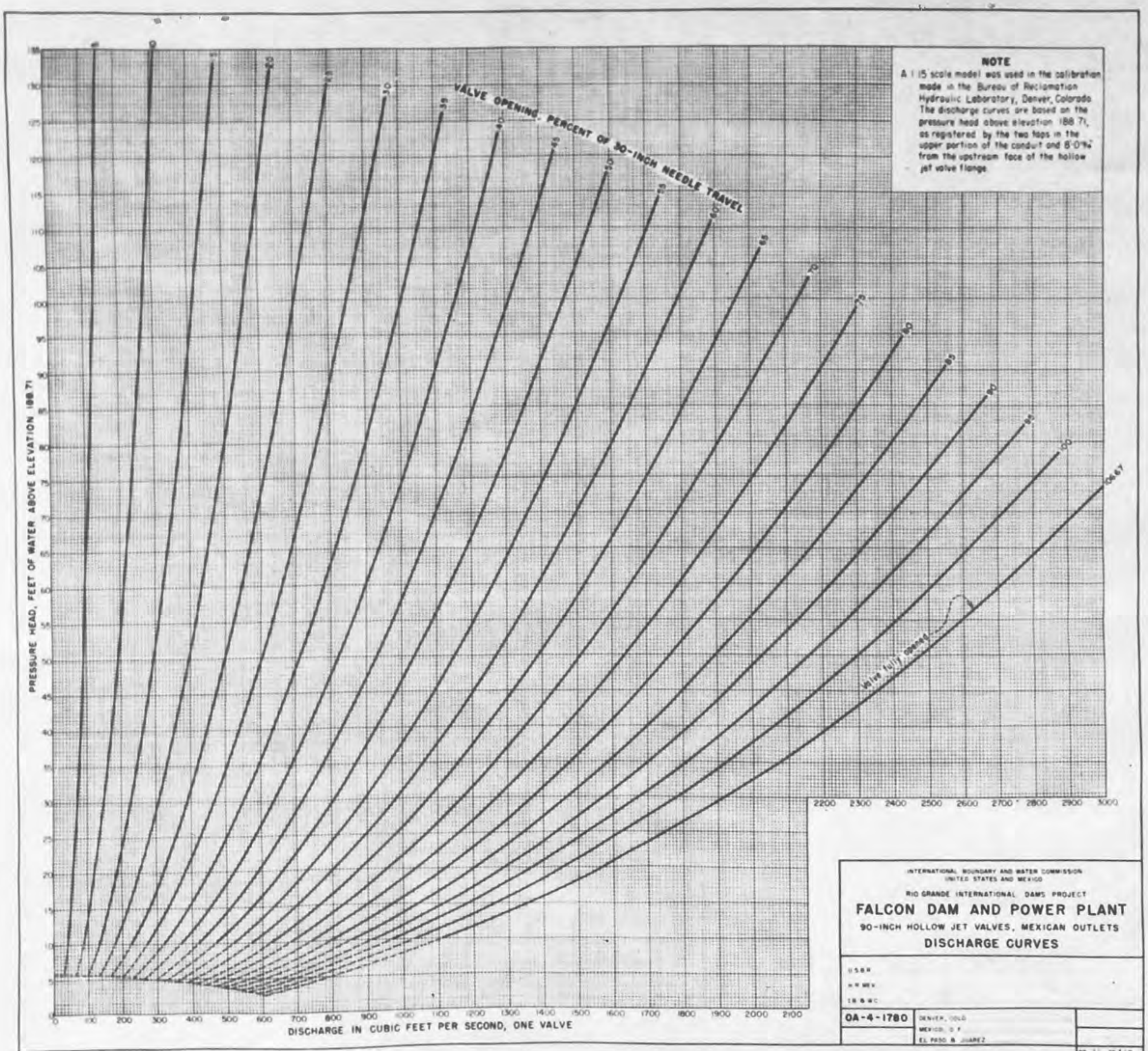

NOTE
A 1:15 scale model was used in the calibration made in the Bureau of Reclamation Hydraulic Laboratory, Denver, Colorado. The discharge curves are based on the pressure head above elevation 188.71, as registered by the two taps in the upper portion of the conduit and 8'-0¾" from the upstream face of the hollow jet valve flange.
VALVE OPENING, PERCENT OF 90-INCH NEEDLE TRAVEL
Valve fully opened
PRESSURE HEAD, FEET OF WATER ABOVE ELEVATION 188.71
DISCHARGE IN CUBIC FEET PER SECOND, ONE VALVE
INTERNATIONAL BOUNDARY AND WATER COMMISSION
UNITED STATES AND MEXICO
RIO GRANDE INTERNATIONAL DAMS PROJECT
FALCON DAM AND POWER PLANT
90-INCH HOLLOW JET VALVES, MEXICAN OUTLETS
DISCHARGE CURVES
0A-4-1780
DENVER, COLO.
MEXICO, D.F.
EL PASO & JUAREZ

FIGURE 3