PAP 167

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BUREAU OF RECLAMATION
HYDRAULIC LABORATORY

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DATE: July 11, 1962

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FROM : H. T. Falvey

SUBJECT: Cavitation studies--Effect of curing time on dye used as an erosion indicator and a comparison of dye results with erosion obtained on weak concrete

One proposed method for evaluating cavitation damage is to paint the area under study with blue machinists dye and note the regions in which cavitation removed dye after a given time interval. The study area is repainted and another test is run with a different cavitation index. A comparison of the regions in which dye was removed for the different cavitation indices gives a qualitative evaluation of the damage likely to occur under various prototype operating conditions.

This procedure is satisfactory if identical areas of dye are removed for repeated tests at a constant cavitation index and if the removal of dye is caused only by cavitation erosion. However, during cavitation tests in a 6-inch diameter plastic pipe immediately downstream from a diaphragm operated, globe type, automatic regulating valve, the dye removal tests were not repeatable. This nonrepeatability made the results unreliable and no confidence could be placed in the findings.

One explanation for these erratic results appeared to be that the curing period of the dye affected the rate of dye removal. Therefore, a series of tests were made holding the cavitation index constant, but varying the curing time of the dye coating. Figure 1 illustrates the extensive degree of dye removal in a 2-hour test period with a curing time of 2 hours at the start of the test. Figure 2 shows relatively small degree of removal for a similar 2-hour test period, but with a curing time of 5 hours. With a curing time of 2 days, no removal of dye occurred for the 2-hour test run. The value of the cavitation index for the dye erosion tests and the concrete erosion tests was 0.33, based on the equation:

$$K = \frac{h_{12} - h_{vp}}{H_t - h_{12}}$$

where: h_{12} is the piezometric pressure 12 pipe diameters downstream from the valve

h_{vp} is the vapor pressure of water (about minus 27 feet of water at Denver)

H_t is the total head just upstream from the valve (total head = velocity head = pressure head).

PAP 167

Following the dye tests, another series of tests was made to determine the degree of cavitation damage in a 6-inch-diameter concrete pipe constructed from a weak concrete mix. The water-cement weight ratio was 1.0 and the sand-cement weight ratio 6.0. No coarse aggregate was used in the mix. The tests were made with the same cavitation index as the dye tests to compare damage patterns. The curing time of the concrete pipe was 7 days for the first test in the series.

The test procedure consisted of setting the proper cavitation index, allowing the test to run for 2 or 3 hours, and at the end of each test interval obtaining photographs of the pipe invert where the previous dye studies had indicated cavitation erosion. This procedure was repeated until cumulative test times of 2, 4, 6, and 11 hours were obtained in the concrete pipe section.

The erosion damage was minor in the concrete pipe with only a small amount of laitance being removed after 11 hours of testing. (Figures 3 and 4). The areas in which the laitance was removed coincide roughly with the areas of dye which were removed with a dye curing time of 5 hours.

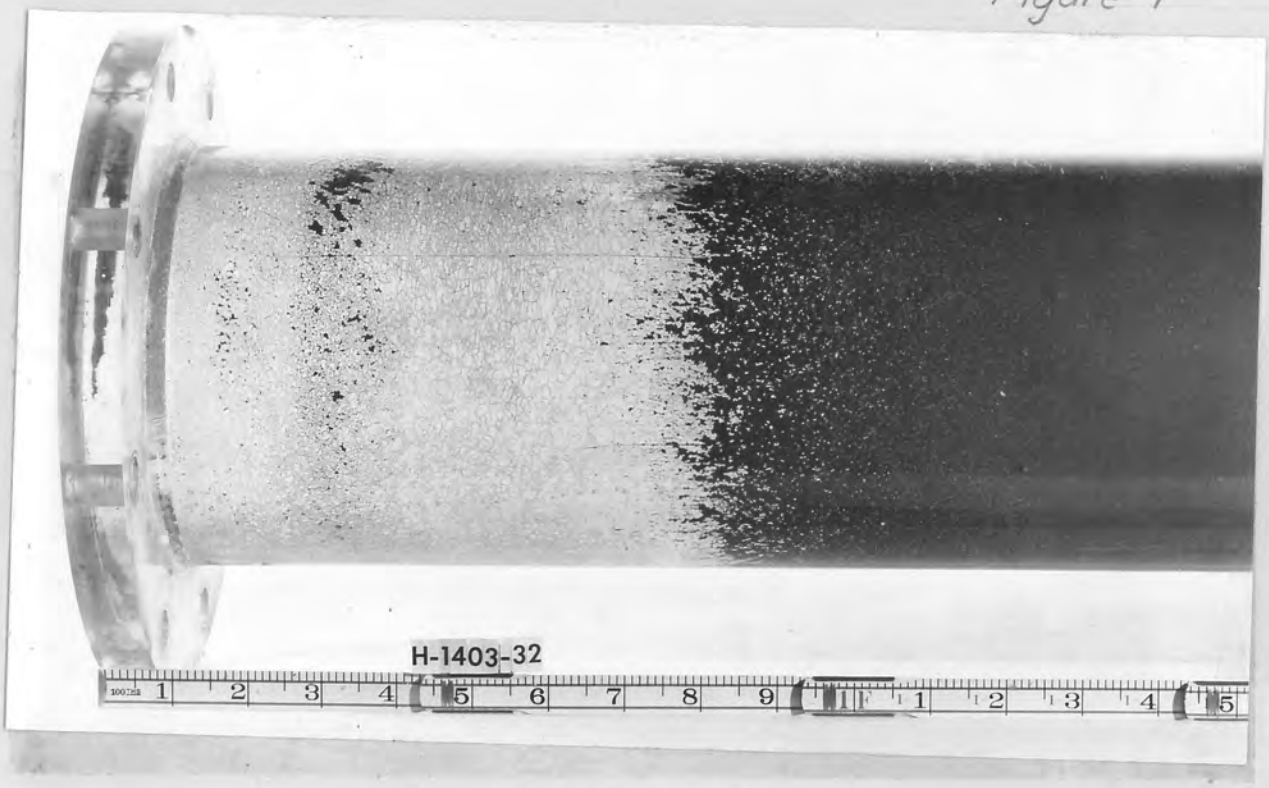
Further tests were desired with more severe cavitation, but they could not be made because of pump limitations. Therefore, the test program was terminated.

CONCLUSIONS

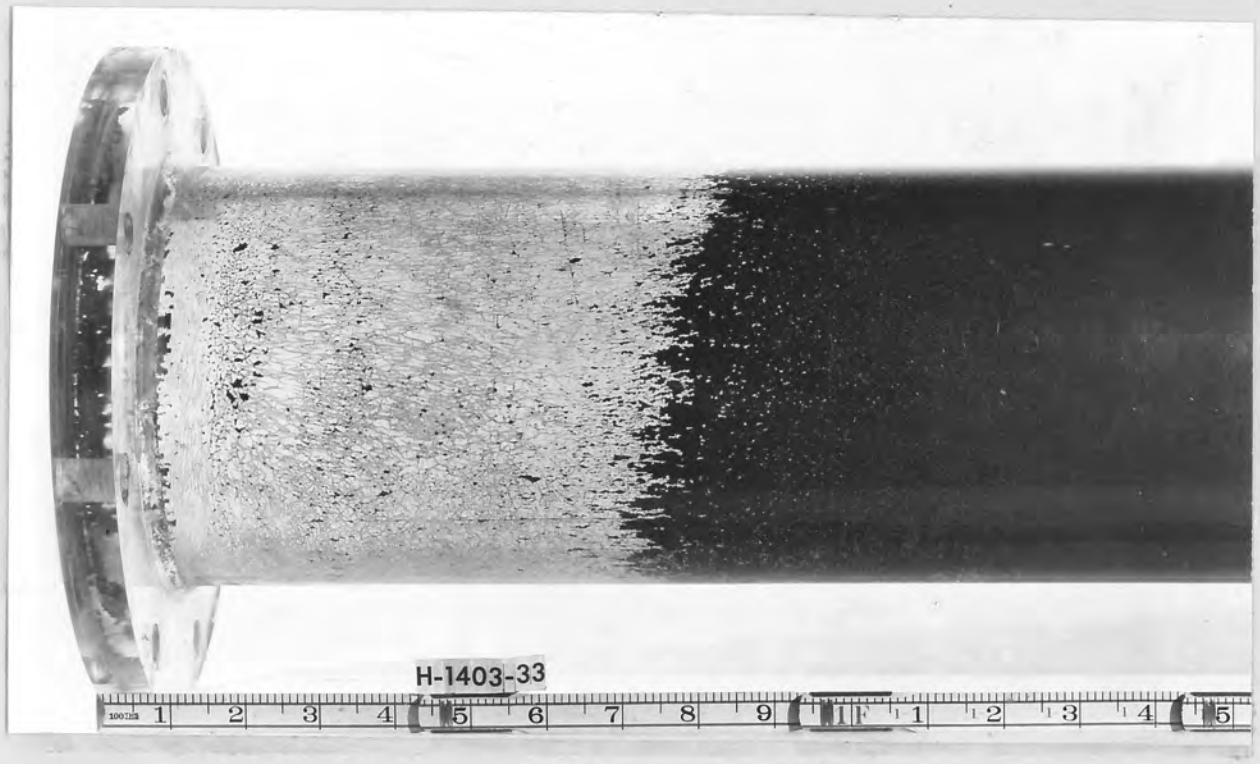
These results indicate that the curing time of the dye is an extremely important factor when using dye as an indicator in cavitation erosion studies, especially when the damage is minor. Therefore, if dye is used to estimate areas of probable cavitation damage, every effort should be made to maintain the same curing time for each dye removal test. In general, a minimum dye curing time of 5 hours at room temperature is recommended for consistant results.

On the basis of this study, no definite conclusions can be made concerning a correlation between cavitation erosion in a concrete pipe and the removal of dye from a plastic pipe. Further comparative investigations should be conducted in pipes that experience erosion to a greater degree than the pipes in this study.

Figure 1



TOP VIEW OF PIPE

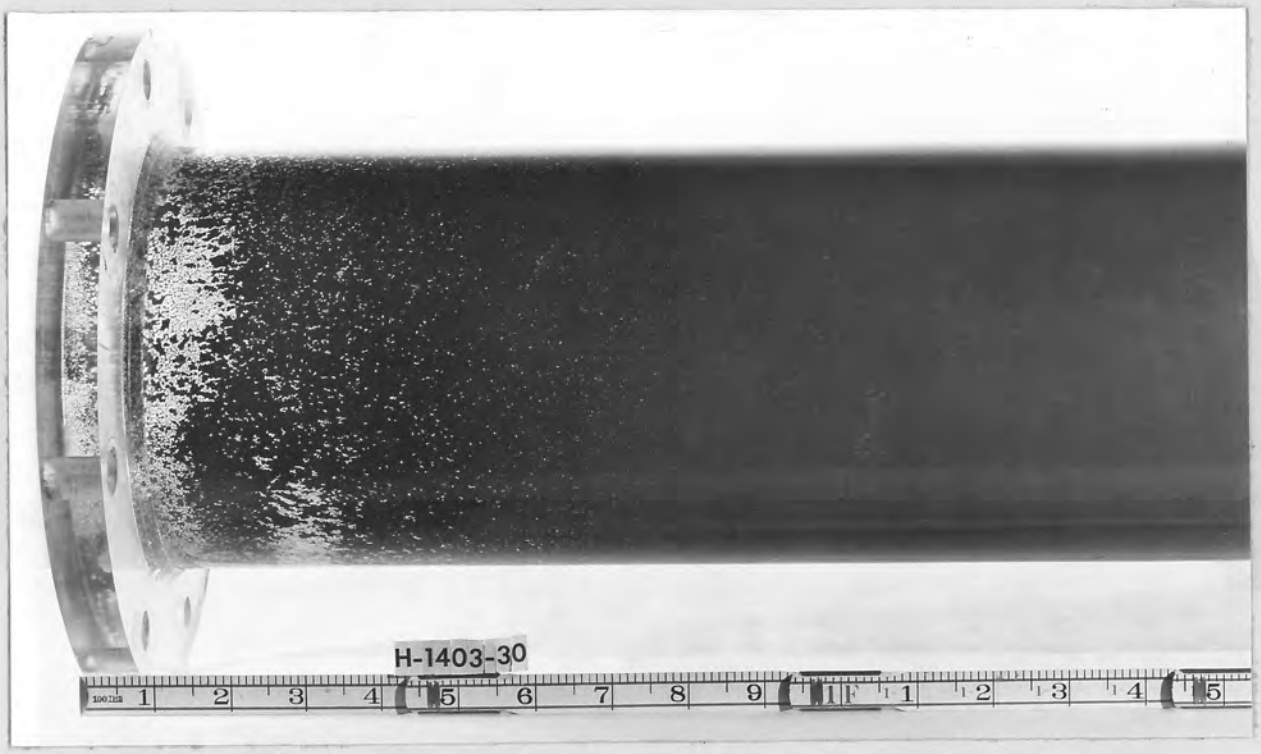


BOTTOM VIEW OF PIPE

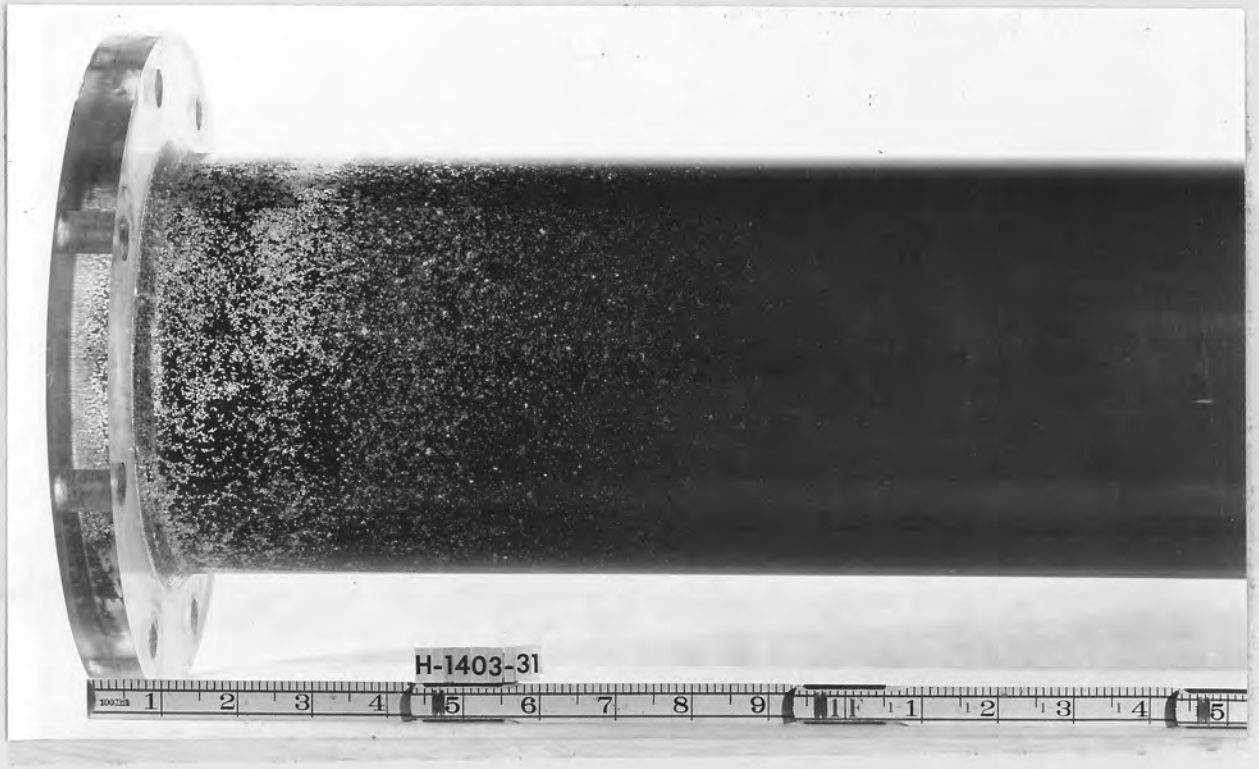
CLAYTON VALVE

Cavitation Index $K = 0.33$; Curing time for dye – 2 hours; Length of test – 2 hours

Figure 2



TOP VIEW OF PIPE

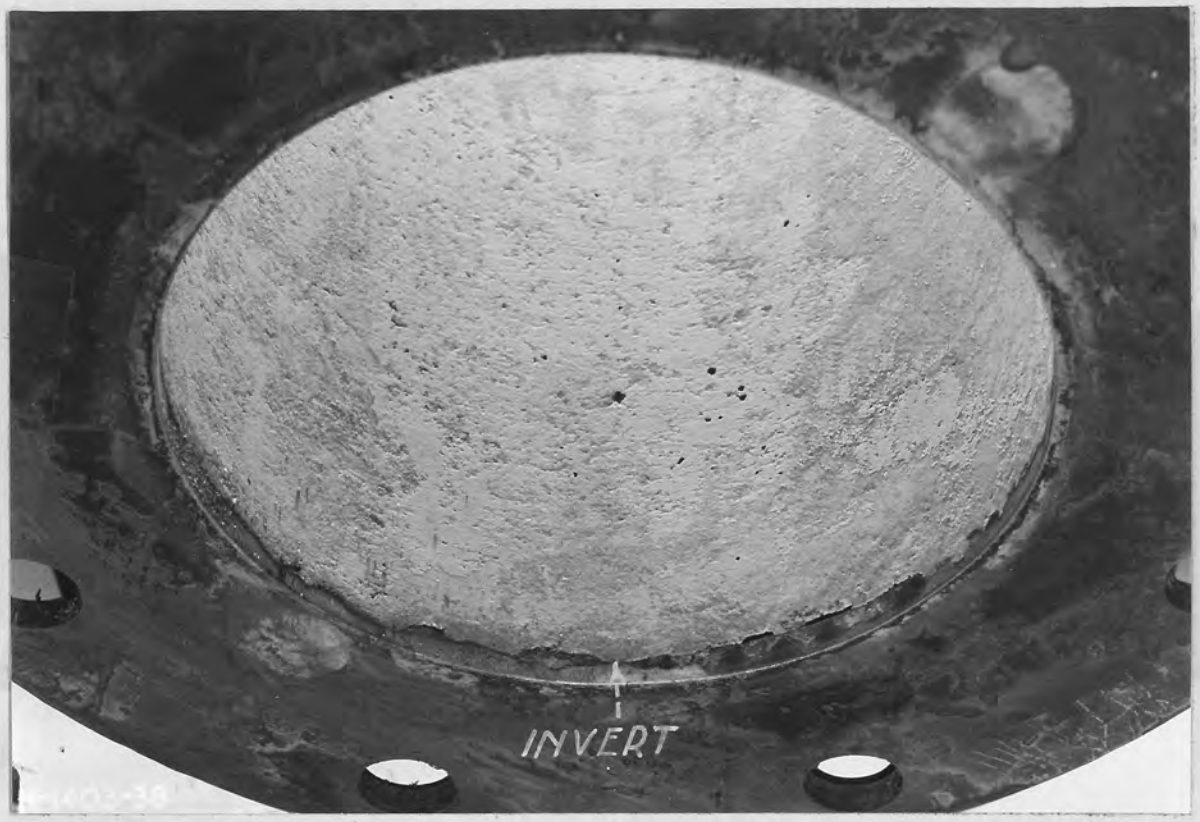


BOTTOM VIEW OF PIPE

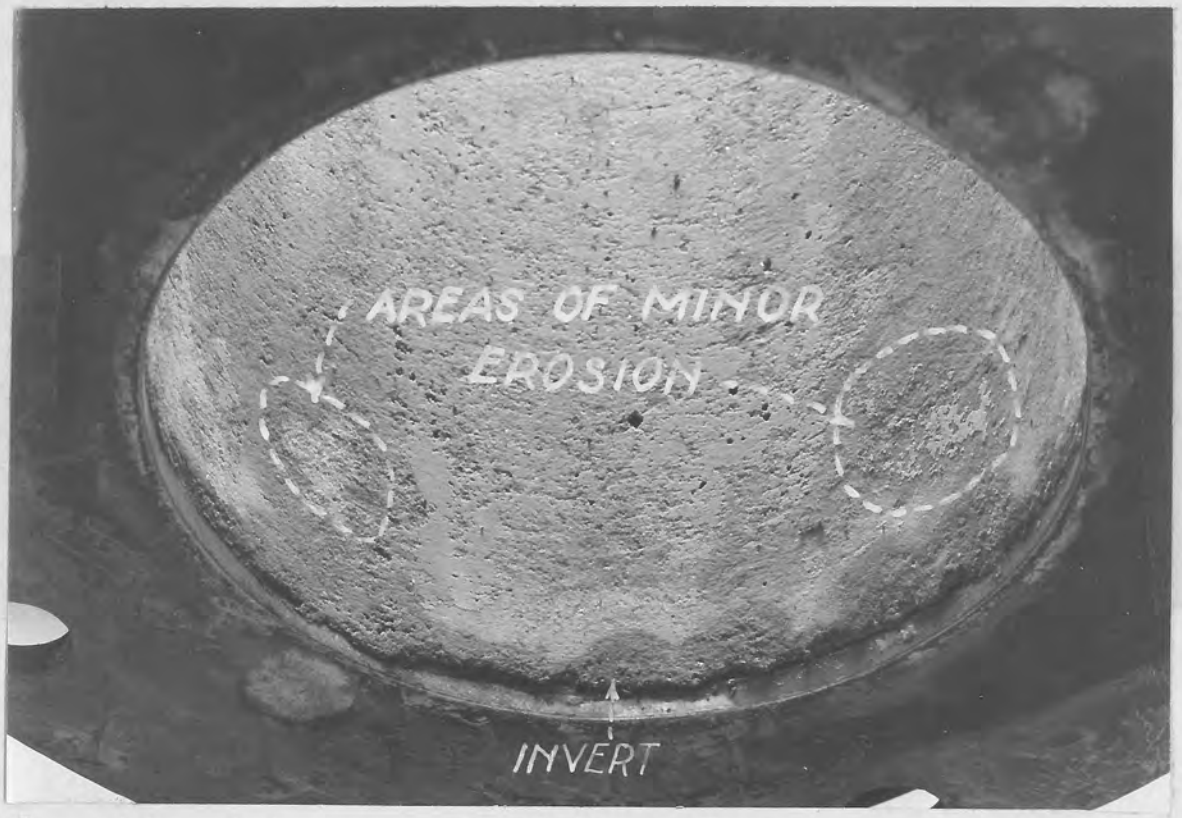
CLAYTON VALVE

Cavitation Index K = 0.34; Curing time for dye - 5 hours; Length of test - 2 hours

Figure 3



Test duration 2 hours ; K= 0.33 ; 15 days curing time



H1403-39

2 additional hours ; K= 0.30 ; 17 days curing time

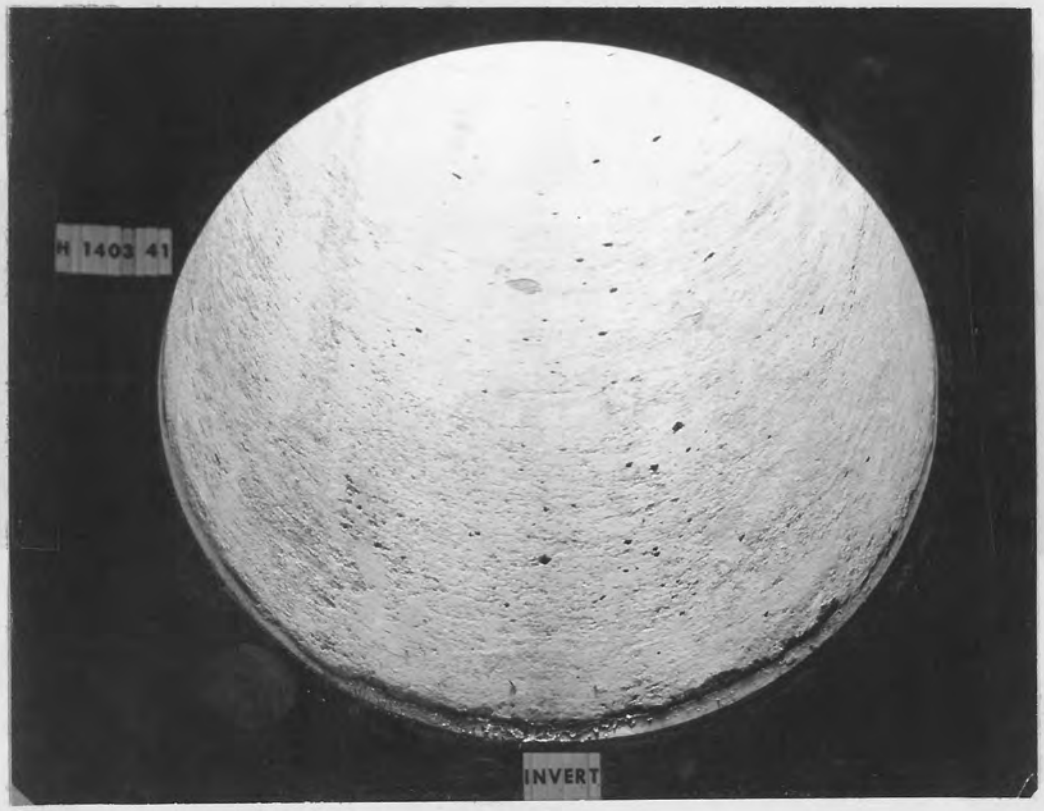
CLAYTON VALVE

Cavitation erosion in concrete pipe; water/cement = 1/1 ; sand/cement = 6/1

Figure 4

H 1403-40

Total test duration 6 hours, K = 0.32, 18 days curing time



Total test duration 11 hours, K = 0.33, 29 days curing time

CLAYTON VALVE

Cavitation erosion in concrete pipe, water/cement = 1/1, sand/cement = 6/1