Final Report

PERFORMANCE TESTS FOR
SRL SPLIT CASE FRAM 5 CENTRIFUGAL PUMPS

for

Denver Equipment Division

Joy Manufacturing Company

CER70-71AGM-12

Final Report

Performance Tests for

SRL Split Case Fram 5 Centrifugal Pumps

for

Denver Equipment Division

Joy Manufacturing Company

CER70-71AGM-12

Deflection Measurements

1) General - Measurements of the deflection of the shaft were taken at a point - inches from the face of the shaft bearing assembly as shown in figure 1. The displacement transducers used are of a type classed as linear variable differential transformers, that is, they produce a voltage that is proportional to the displacement of a central core. The particular models used, Hewlet Packard Model 7DCPT100, are capable of measuring deflections to a maximum of $\pm$.100 inch (at which point the maximum voltage output is $\pm$ 2.8 volts, i.e., a scale factor of .028v/001 inch, and are linear to $\pm$ .5% of full scale.

In use the transducers were clamped in aluminum blocks that were then bolted onto the bearing housing assembly (see figure). Note: for convenience in data recording the transducers were numbered 1 and 2 as shown. These blocks were designed to be rigid enough that they would not distort under conditions of machine vibration. Originally the end of the transducer adjacent to the shaft was equipped with a teflon tip which was to ride directly on the shaft. However, due to the machining striations in the shaft consistent measurements were difficult to obtain as the tip tended to move back and forth longitudinally along the shaft. As a result, a rider made of brass shim stock was placed between the shaft and the tip of the transducer (see figure). This rider removed the effect of the striations and resulted in more consistent readings. From time to time the riders were replaced as over a long period they tended to wear. The amount of wear during a test run however would be insignificant.

The voltage output from the transducers was recorded on either a Sanborn 7700 chart recorder or a Brush Mark 280 chart recorder. Both these recorders have a frequency response of 200 cps and are capable of amplification to .005 volts/chart line (approximately 5 chart lines/ .001 inch).

Measuring Procedure

Before the start of each set of deflection measurements each of the transducers was calibrated by inserting feeler gauges between the pump shaft and the brass leaf and recording the output on the chart recorders (figure). The resulting output for the various feeler gauge sizes was then averaged to determine the scale factor to be used in interpreting the transducer output data. A check calibration was normally run at the completion of data taking.

Once the calibration was completed the pump was started and brought up to the speed at which tests were to be run. The discharge was increased to its maximum value (sometimes this maximum was limited by the power input capabilities of the drive). Recordings were then made of the outputs of each transducer. The elbow meter differential (for discharge), the inlet pressure, the pump speed and the reading of the torque meter output were also recorded to allow comparison with data from efficiency tests. The discharge was then reduced approximately 1000 gpm and the data taking procedure repeated. This procedure was followed until the discharge had been reduced to zero, the recorder was then set to record the data from one of the transducers and the valve was opened continuously until maximum discharge was reached. (Note: as manual opening of the valve was required the valve opening rate was not constant). Usually for this test the output of #2 transducer was recorded as it normally showed the largest variation during the constant discharge tests.

After the valve was fully opened the speed was adjusted to a new valve and the overall procedure was repeated. Normally the machine was not shut down between runs.

Accuracy

As noted earlier the transducers were calibrated prior to the start of each series of tests and the average scale factor determined. Analysis of the calibration data indicated that the scale factor could be expected to be within ±15%, of the average valve. This is by far the major portion of the error under normal measuring conditions. Other sources of errors would be 1) reading the chart recordings. In this case the error would be about ± 1/3 of a chart division which is equivalent to ± .0001" per reading or ± .0002" for the difference between two readings. 2) movement of the mountings. Tests indicated that the mountings were rigid enough that they should introduce no appreciable error. 3) Variation in calibration of the chart recordings. To allow for any possible variation in the calibration of the chart recorders over the time between different sets of data taking, the data interpretation was made using the calibration for that run. The maximum difference between calibrations was about 5% (well within the 15% range). There was no indication or reason to suspect any variation within a run.

Normally the pump shaft was dry; however, in certain cases there was a problem with water on the shaft (the 14 x 12 pump with the steel impellor had a cracked porcelain sleeve which permitted large amounts of water on the shaft at all speeds and discharges. For the remaining cases there was a problem at high speeds - 700 to 800 rpm - near shutoff when excess water sometimes was on the shaft. These cases are noted in the data interpretation under these circumstances the possible error is difficult to evaluate as the variations in the thickness of the film of water on the pump shaft are unknown.

Results

The results for the various runs are tabulated in tables . Note that all deflections are relative, i. e., there is no absolute value, therefore it is only the difference between deflections that is meaningful.

The deflections were normally measured from the mid point of the wave pattern produced by the transducer output, see figure , to the zero voltage line of the chart recorder (use of the recorder eliminated any problems with variations in the zero position due to recorder characteristics and allowed adjustments in case of extreme deflections).

Normally the transducer output indicated a frequency that could be attributable to the out of roundness of the shaft however, under conditions of high flows and or high rotational speeds frequencys equivalent to 2 or 3 times the rotational speed appeared. (The 14 x 12 pump showed the greatest tendency to these higher frequency vibrations). Examples of these vibrations are shown in figure . The numerical values of these frequencies was not tabulated.

It did not seem possible to repeat individual runs as tests with the pump turning slowly before and after a series of runs generally produced markedly different deflections. This difference was assumed to be due to "set" in the bearings. For an individual set of runs at a constant speed the data seemed reasonably repeatable provided the nominal speed was not changed during the series of runs. For example, if the pump were stopped during a set of runs and then the speed and discharge were brought back to their values before the pump stopped the deflection would not necessarily be the same.

While gaining familarity with the deflection measuring equipment some measurements were made while NPSH tests were in progress on the 14 x 12 pump. Some extremely large (.01") deflections were recorded momentarily during the tests. These deflections were not repeatable. The deflections prior to and after these extreme values seemed normal indicating that possibly a large temporary vapor cavity had formed in the pump. These extreme deflections occurred only during the NPSH tests and were not noted at any other time.