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August 11, 1961

SURGE SUPPRESSORS FOR THE PRTR PROCESS TUBE FLOW METERS

G. M. Hesson, W. L. Thorne, and J. M. Batch

PURPOSE

The purpose of this report is to present the results of experiments made to devise a means of suppressing fluctuations in the PRTR tube flow meters.

INTRODUCTION

Each tube of the PRTR is provided with flow monitoring equipment consisting of a venturi flow meter in the inlet piping, sensing lines containing valves, and a Panellit flow transmitter. The flow transmitter does three things: (1) it converts the pressure drop signal of the venturi to a visual readout, (2) it provides an electrical signal for recording, and (3) it provides a signal to the safety circuit which causes a reactor scram should the flow increase or decrease beyond pre-set valves.

After startup of the PRTR, it was found that the readings of flow meters on those process tubes which connect near the inlet of the bottom ring header were fluctuating excessively. The fluctuations were up to ± 8 per cent which is nearly as large as the ± 10 per cent span between the high

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and low flow trips. The fluctuations when superimposed on the normal reactor flow changes would cause spurious flow trips. As an interim measure during the power tests at low reactor powers, the meter fluctuations were reduced by throttling the valves in the sensing lines from the flow venturi to the flow meter. This was recognized as being questionable for a permanent solution since this practice introduces an unknown and variable lengthening of the response characteristics of the meter. An experimental program was therefore undertaken to determine the degree of valve throttling which might be appropriate for fluctuation suppression and to devise other and better methods of suppression.

SUMMARY AND CONCLUSIONS

The response characteristics of the Panellit flow transmitter assembly, including its sensing lines and suppression devices, were determined by recording the transmitter readings for a period of about two seconds after a step change in pressure to the transmitter was made. Suppression techniques investigated included throttling of valves in the sensing lines to the flow transmitter and inserting various lengths of small diameter tubing in the sensing lines. The experiments show that:

1. Throttling of valves in the flow transmitter sensing lines is not a satisfactory way of decreasing the fluctuations. The valves must be closed to about 1/4 turn open before they decrease fluctuations significantly. Further closure to about 1/8 turn open causes an excessive lengthening of the response characteristics of the transmitter. This provides only a very narrow range of valve positions which are permissible and effective.
2. The increased hydraulic flow resistance of three to five foot lengths of 1/16-inch tubing in the sensing line causes the flow transmitter system to become nearly critically damped. This will eliminate the oscillatory behavior of the readings and will do so without causing an intolerable lengthening of the response of the transmitter.

EXPERIMENTAL APPARATUS

A schematic diagram of the experimental apparatus is shown in Figure 1. A PRTR Panellit flow transmitter was connected with about 4 feet of 3/16" copper tubing to a pair of PRTR flow meter sensing line block valves. The valves were connected with coiled 40 to 80-foot long lengths of 3/16-inch copper tubing across a venturi. The venturi was not a PRTR prototype, but was one which would provide a 10 to 25 psid pressure drop signal to the flow transmitter. The variation in flow through the venturi to give the variation in pressure drop required by these tests was accomplished by the use of two parallel flow paths to the venturi. One path contained an air operated piston valve; both contained throttling valves. With the air operated valve

Figure 1. Schematic Diagram of Experimental Apparatus

closed a given flow could be established through the open path. With the air operated valve open a different and greater flow could be established through the two parallel paths. A rapid transition from one flow to the other could be attained by operation of the air operated valve.

The deflection of the Panellit flow transmitter was recorded on a oscillographic recorder (Minneapolis Honeywell Viscorder) to provide information concerning the response of the instrument to pressure changes. In addition the pressure drop across the venturi as measured with a strain gage pressure transducer was recorded.

The experimental apparatus, then, was a reasonable mock-up of a tube flow measuring system of the PRTR except that the 40 or 80 foot sensing lines were coiled. Calculations were made which showed that the effect of coiling the lines should have a negligible effect upon the response of the instrument.

EXPERIMENTAL PROCEDURE

The two alternate flows to the venturi were adjusted to give pressure drops of about 16 and 20 psid. These two pressures are those associated with PRTR tube flows of about 80% and 90% scale readings on the flow transmitter readout, respectively. The air operated valve was closed to give the smaller pressure drop signal. The recorder was then turned on and the air-operated valve operated to give approximately a step change in pressure drop signal to the larger pressure drop. The foregoing procedure was repeated using several degrees of closure of the block valves in the sensing line ranging from full open to essentially closed and with both the 40 foot and 80 foot long sensing lines.

An alternate to the use of throttled block valves in the sensing lines to reduce transmitter fluctuations would be to use the hydraulic resistance of a length of small diameter tube to effect a damping. Accordingly, a pair of 1-1/2 inch coils of 3 feet and of 5 feet of 1/16" tubing were fabricated and installed in the sensing lines between the valve block and the Panellit transmitters. The experimental tests were repeated using these damping devices with the 40 and 80 feet long sensing lines.

RESULTS

The experimental results are summarized in Table I which lists the sensing line length used, lists the damping technique used, lists the time for the transmitter to reach 63% of the change imposed upon it and lists the nature of the response to the change. The use of time to reach 63% of a change has significance for the case of a step change applied to a first order or a critically damped system. While neither of these criteria were found necessarily to apply to these experiments, the 63% time is a convenient way to measure the relative changes in instrument response due to the use of various damping techniques. Further, the 63% time value will be loosely used to determine the adequacy of the response.

TABLE I

<u>Sensing Line - Length, ft</u>	<u>Suppression</u>	<u>Time for Transmitter to Reach 63% of Charge, sec</u>	<u>Nature of Response</u>
40	None	.26	Oscillatory
40	Block valves 1/2 turn open	.25	Oscillatory
40	Block valves 1/4 turn open	.34	Damped
40	Block valves 1/8 turn open	1.0	Damped
40	Block valves 1/16 turn open	(a)	Damped
80	None	.30	Oscillatory
80	Block valves 1/2 turn open	.34	Oscillatory
80	Block valves 1/4 turn open	.35	Oscillatory
80	Block valves 1/8 turn open	(a)	Damped
80	Block valves 1/16 turn open	(a)	Damped
40	3 ft of 1/16" tubing	.39	~ critical
40	3 ft of 1/16" tubing	.41	~ critical
80	3 ft of 1/16" tubing	.43	~ critical
80	3 ft of 1/16" tubing	.43	~ critical
80	5 ft of 1/16" tubing	.54	slightly damped
80	5 ft of 1/16" tubing	.55	slightly damped

(a) Times were too long to be measured, but were of the order of several seconds.

The last column of Table I lists the nature of the response of the transmitter to the step change. The response may be either oscillatory, critically damped or over damped. An oscillatory or under-damped system will oscillate following a disturbance, with the oscillations, in general, having a greater magnitude than the disturbance. An overdamped system will not oscillate but will have a slowed response. A critically damped system is one which has just sufficient damping to prevent oscillations. Increasing the damping will reduce the oscillations and overshoot of the meter, but will do so at the expense of lengthening its response. Typical response characteristics are shown in Figure 2, in which are three experimental plots illustrating each of the types of response. Curve I shows an underdamped or oscillatory system and illustrates a fast response to the step change, but also a 30% overshoot. Curve II shows a system which is nearly critically damped and has a slightly slower response, but a negligible overshoot. Curve III shows an overdamped system with a significantly slowed response.

The objective of these experiments was to devise damping techniques which would reduce the magnitude of the fluctuations or oscillations, but would do so without unduly increasing the response. Consideration of the detection of small leaks (HW-63640, Rev 1) leads to the criterion of response of 0.5 seconds to reach 63% of a step change.

APPLICATION AND RECOMMENDATIONS

The information of Table I reveals that throttling of the block valves in the flow meter sensing lines is not a practical way of suppressing the transmitter fluctuations. Closure of the valves to within about 1/4 turn open will, it is true, accomplish a significant damping effect and will reduce the magnitude of the fluctuations. However, a further slight closure to about 1/8 turn open will increase the response time of the transmitter to unacceptable levels. There is, then, only a very small range of valve positions where fluctuation suppression is significant, but adverse response times are not encountered. The range is so small that its routine use would not be feasible.

However, the use of the hydraulic resistance of small tubing to obtain the desired damping was shown to be satisfactory. A 1-1/2 inch coil of 5 feet of 1/16 inch tubing makes the transmitter system slightly overdamped but makes the response, as conservatively defined in these experiments, slightly longer than the criterion. A similar 3 foot length makes the system slightly under-damped and leaves the defined response well within the criterion.

On this basis, the suppression device recommended is a coil of 1/16 inch tubing 3 to 4 feet long.

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Figure 2. Typical Experimental Response Results