WR28-1-85-121

SENSING LINE AIR BUBBLE MIGRATION TESTS FOR WATTS BAR NUCLEAR PLANT

TENNESSEE VALLEY AUTHORITY
OFFICE OF NATURAL RESOURCES AND ECONOMIC DEVELOPMENT
DIVISION OF AIR AND WATER RESOURCES
ENGINEERING LABORATORY
NORRIS, TENNESSEE

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P PDR

Tennessee Valley Authority
Office of Natural Resources and Economic Development
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Engineering Laboratory

SENSING LINE AIR BUBBLE MIGRATION TESTS

FOR WATTS BAR NUCLEAR PLANT

Report No. WR28-1-85-121

Prepared by
Jack R. Missimer, Ph.D., P.E.
and
C. Ann Brackett
Research and Test Section

Norris, Tennessee
June 1986

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ABSTRACT

Tests were conducted to evaluate the severity of the air entrapment problem in sensing lines at Watts Bar Nuclear Plant. The evaluation focused on specific fittings and installation procedures used at the plant. Included in the evaluation were tests on: (1) corrugated flexible hose used to connect the process line to the root valve; (2) four representative root valves; (3) 1/2-inch schedule 160 SS sensing line pipe; and (4) a Rosemount differential pressure transmitter. Based on the results of the tests, guidelines are provided for the installation of the corrugated flexible hose and for back-flushing (purging) the sensing line and root valves to remove entrapped air.

Previous tests had determined bubble migration velocities in 1/2-inch schedule 80 SS pipe. Since 1/2-inch schedule 160 SS pipe is also used for sensing lines, tests were conducted to determine bubble migration velocities for that size also.

The response of a Rosemount differential pressure transmitter to pressure pulsations created by a resonating water column was qualitatively demonstrated. For the cases investigated, the noise created was small (less than 10 percent of the signal), but the need to ensure the removal of all entrapped air from the sensing line was adequately demonstrated.

INTRODUCTION

Liquid-filled sensing lines are used extensively at Watts Bar Nuclear Plant for both flowrate and liquid level measurement. The measurement technique typically utilized requires pairs of sensing lines to be connected to differential pressure transmitters. It is suspected that the differential pressure measurements are subject to inaccuracies caused by air becoming trapped in the sensing lines. The Engineering Laboratory is currently engaged in a program to develop on-line monitoring techniques to detect the presence of air voids in sensing lines. In conjunction with this program, the Engineering Laboratory was requested to evaluate several of the sensing line installations at Watts Bar Nuclear Plant to quantify the severity of the air entrapment problem. The evaluation focused on specific fittings and installation procedures used at Watts Bar Nuclear Plant.

DESCRIPTION OF TESTS

The evaluation consisted of a series of tests to quantify the severity of the air entrapment problem associated with each of the following components:

1. Corrugated flexible hose;
2. Four representative root valves;
3. 1/2-inch schedule 160 SS pipe; and
4. Rosemount differential pressure transmitters.

Corrugated Flexible Hose

Corrugated, flexible stainless steel hose is used at Watts Bar Nuclear Plant to connect rigid sensing lines to root valves when relative displacement is expected due to elevated process temperatures. Figure 1 shows the general test setup used to conduct tests to evaluate the potential for air entrapment in the hose. Initially, the flexible hose was attached to a board by three metal clamps and two plastic straps, as

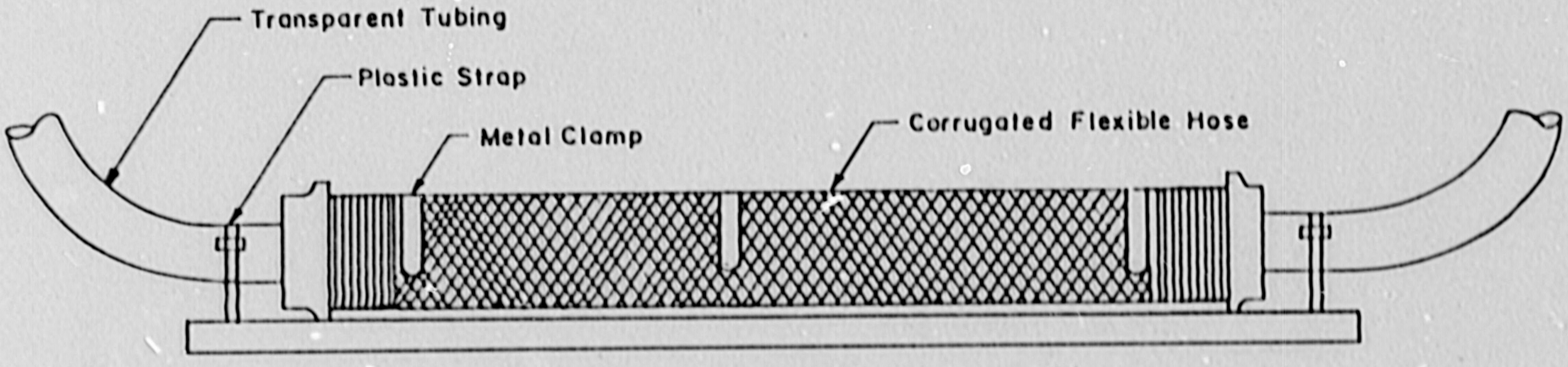

Figure 1. Test Setup for Straight Corrugated Flexible Hose

shown. Flexible transparent tubing with a 1/2-inch ID was attached to each end of the hose and tied so that it rose above the hose. The entire assembly was placed on a scale and supported such that the board, and therefore the hose, was inclined at an angle of 1/8-inch per foot. The weight of the assembly was recorded as the "drained weight" and then water was poured into the tubing until the water level was above the hose. During the filling process the hose was agitated to remove all entrapped air. The weight of the column of water in each of the two pieces of transparent tubing was calculated and subtracted from the total weight to obtain the weight of the water in the hose. The weight of the water in the hose was approximately 110 grams (g), giving an equivalent internal volume of 110 cubic centimeters (cc) (see Table 1).

To entrap air in the hose, the hose was drained and then refilled without agitation until the water level in the transparent tubing was once again above the hose. The calculated weight of the water columns in the transparent tubing was then subtracted from the measured total weight of the assembly in the unagitated state. The result was the equivalent weight of water that the entrapped air void displaced. Table 2 gives the results of five tests to determine the entrapped air using this technique. The volume of entrapped air ranged between 3 and 10 cc. This is between 3 and 9 percent of the total internal volume of the hose assembly.

The hose manufacturer recommends that the hose not be subjected to more than a 1/2-inch local vertical displacement. To examine the potential for air entrapment in this configuration, a 1/2-inch vertical displacement of the hose was introduced in the center of the hose as shown in Figure 2. The hose was slowly filled from each end without agitation to determine the air entrapment in this configuration. Table 3 shows the results of five tests conducted using this arrangement. The entrapped air volume ranged from 57 to 71 cc, or 52 to 65 percent of the total internal volume of the hose assembly.

Table 1. Measurements with No Air in Hose

Test No.	Weight (g)	Water Column Length (cm) Left	Right
1	1786	4.45	2.54
2	1786	4.45	2.54
3	1786	4.45	2.54
4	1786	4.45	2.54
5	1786	4.45	2.54

Table 2. Measurements with Air Bubble in Straight Hose

Test No.	Weight (g)	Water Column Length (cm) Left	Right	Air Bubble Size (cc)
6	1778	4.45	2.54	8
7	1783	4.45	2.54	3
8	1776	4.45	2.54	10
9	1781	4.45	2.54	5
10	1781	4.45	2.54	5

Table 3. Measurements with Air Bubble in Displaced Hose

Test No.	Weight (g)	Water Column Length (cm) Left	Right	Air Bubble Size (cc)
11	1745	12.70	9.53	71
12	1755	10.80	8.26	57
13	1744	11.43	9.53	71
14	1750	11.43	9.53	65
15	1754	12.07	9.53	61

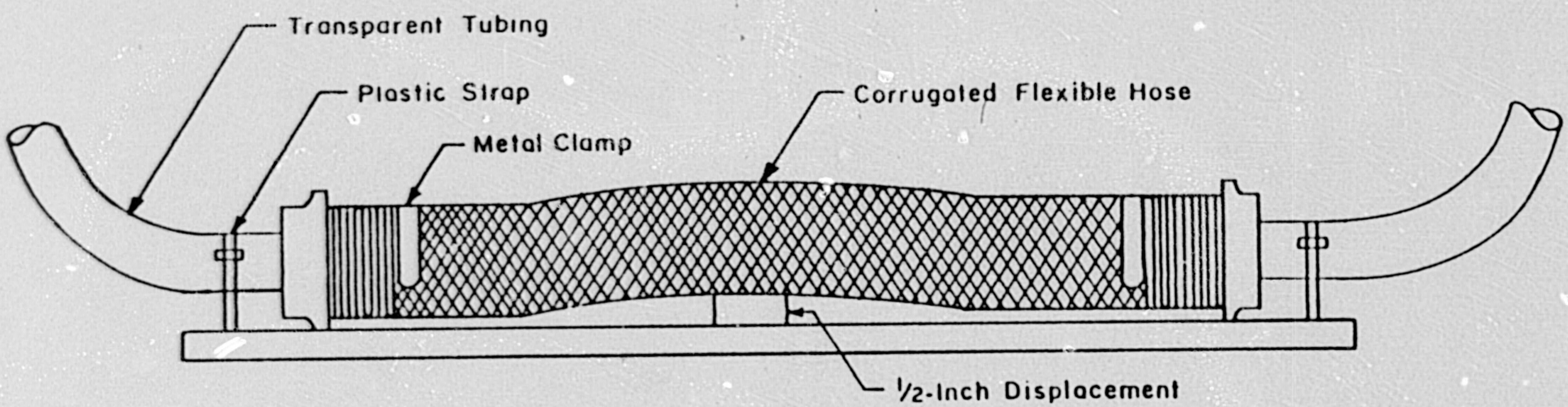

Figure 2. Test Setup for Displaced Corrugated Flexible Hose

Bubble Migration in 1/2-Inch Schedule 160 SS Pipe

Bubble migration was examined in an 18-foot length of 1/2-inch schedule 160 stainless steel sensing line. The test setup used (see Figure 3) is the same one previously used for bubble migration studies in 1/2-inch schedule 80 pipe [1]. Both 1/2-inch schedule 80 and schedule 160 are used at Watts Bar Nuclear Plant for sensing lines. Plastic tubing was attached to each end of the lines and fastened above to maintain the lines full of water. Hydrophones were mounted at three locations on the lines to monitor the migration of the air bubbles. The hydrophones operated in an alternating mode of pulsing and listening. When the line in the vicinity of the hydrophone was full of water, a strong reflected pulse was received. As an air bubble passed below the hydrophone, the reflected pulse was attenuated. The first and second hydrophone positions were 6 to 12 inches apart, and gave a rough indication of the bubble's migration velocity. The distance between the second and third hydrophone positions was 108 inches, and timing over this distance was used to more accurately determine the bubble migration velocity. Bubble sizes of 2, 5, 10 and 25 cc and pipe slopes of 1/8, 1/4, 1/2 and one inch per foot and 10, 20, 30 and 45 degrees were examined. The air bubbles were injected into the sensing line by inserting a syringe through the plastic tubing into the lower end of the sensing line. Using this technique it could be ensured that the bubble did not hang on the entrance of the sensing line. After each test, water was run through the line to ensure that all air was purged.

Figure 4 shows the measured migration rates of 2 to 25 cc bubbles at small angles of inclination. For larger angles of inclination, between 10 and 45 degrees, the migration velocities for a 5 cc bubble are shown in Figure 5. Figure 6 incorporates the results of the present tests into data from previous tests and from Reference 2. The present results are consistent with previous results.

Root Valves

Four root valves were tested to determine the amount of air that could become entrapped in the valve. The four valves are representative

Figure 3. Test Setup for Bubble Migration Tests

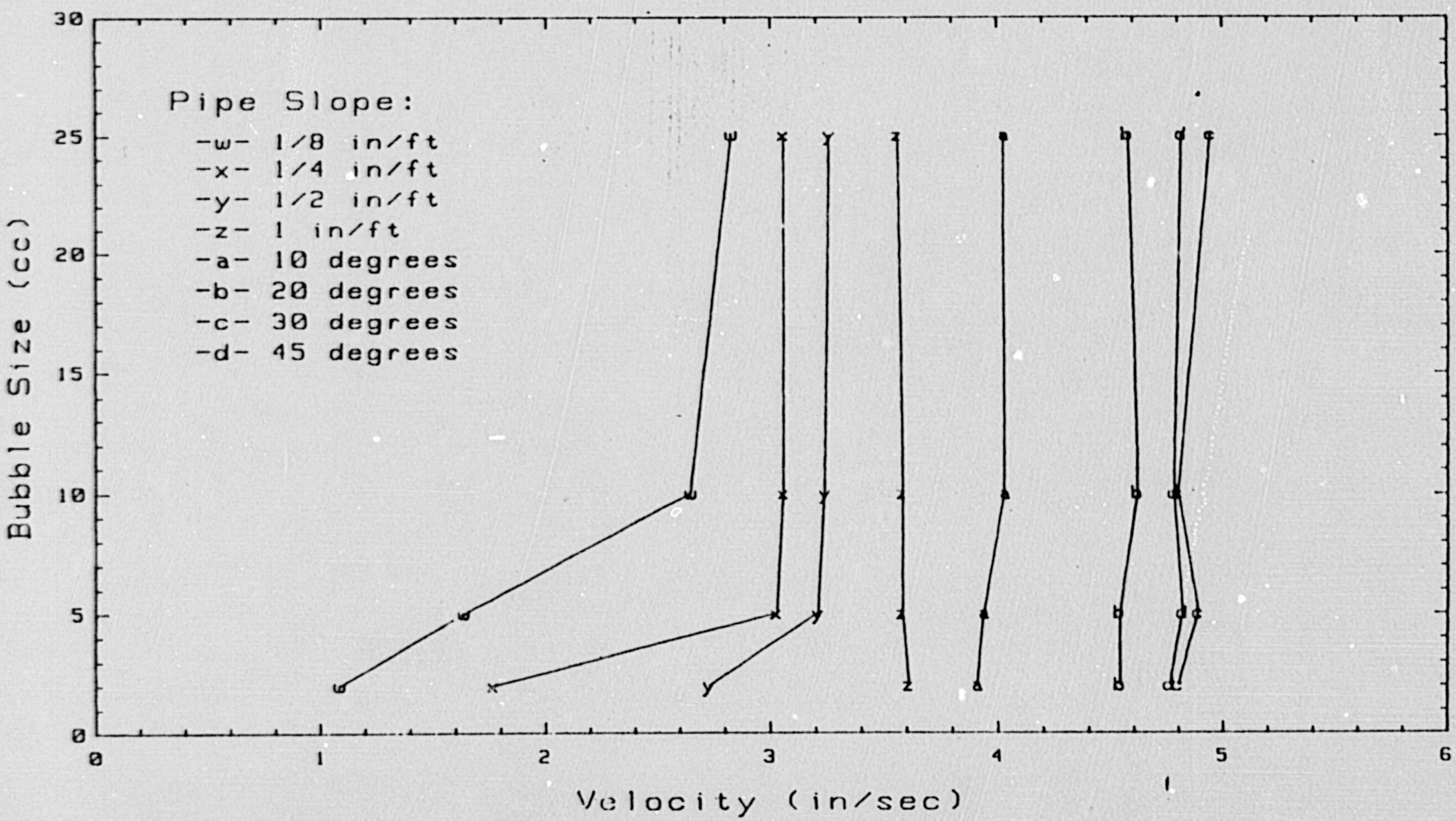

Figure 4. Bubble Migration in 1/2-Inch Schedule 160 SS Pipe at Small Inclination Angles

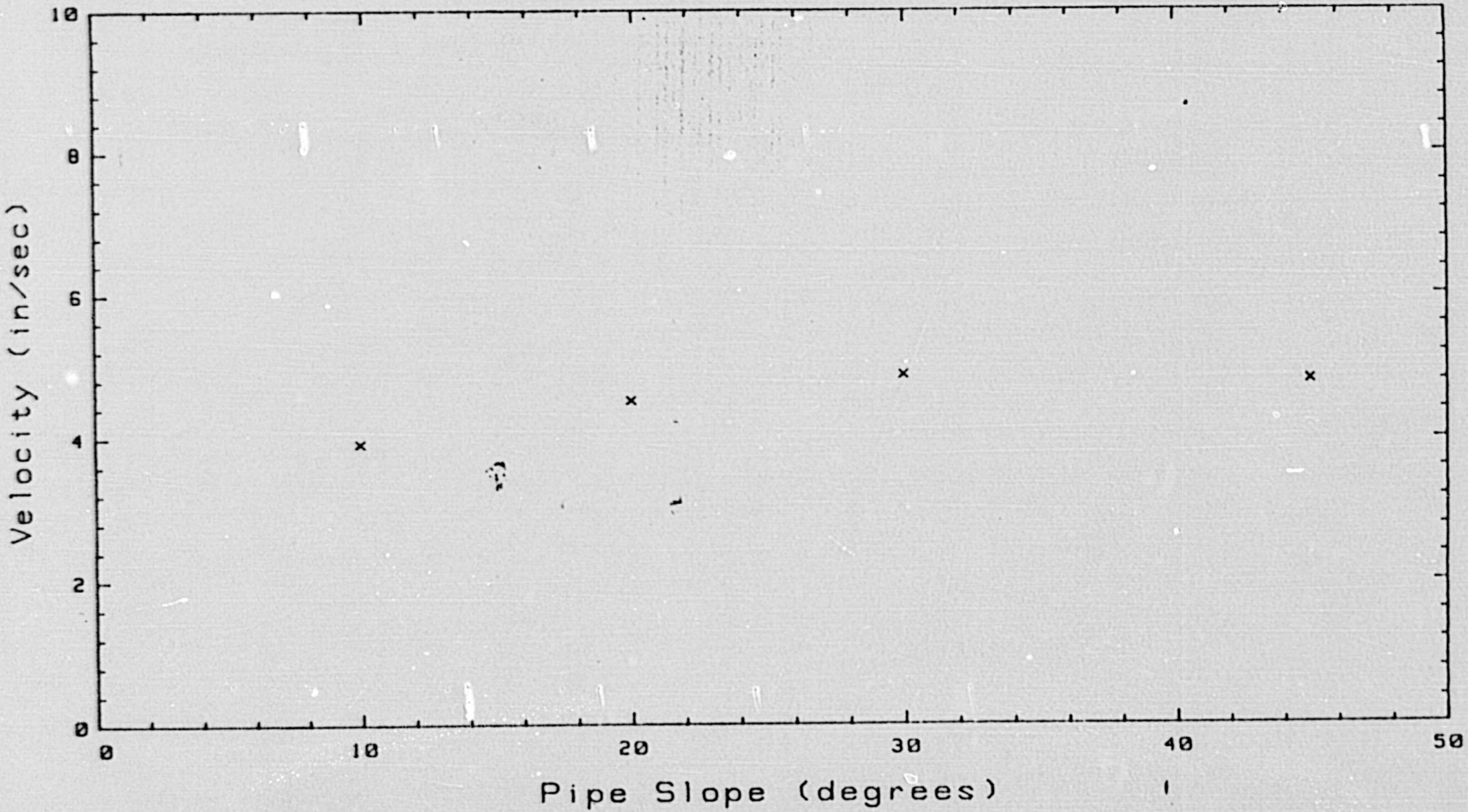

Figure 5. Bubble Migration in 1/2-Inch Schedule 160
SS Pipe at Large Inclination Angles

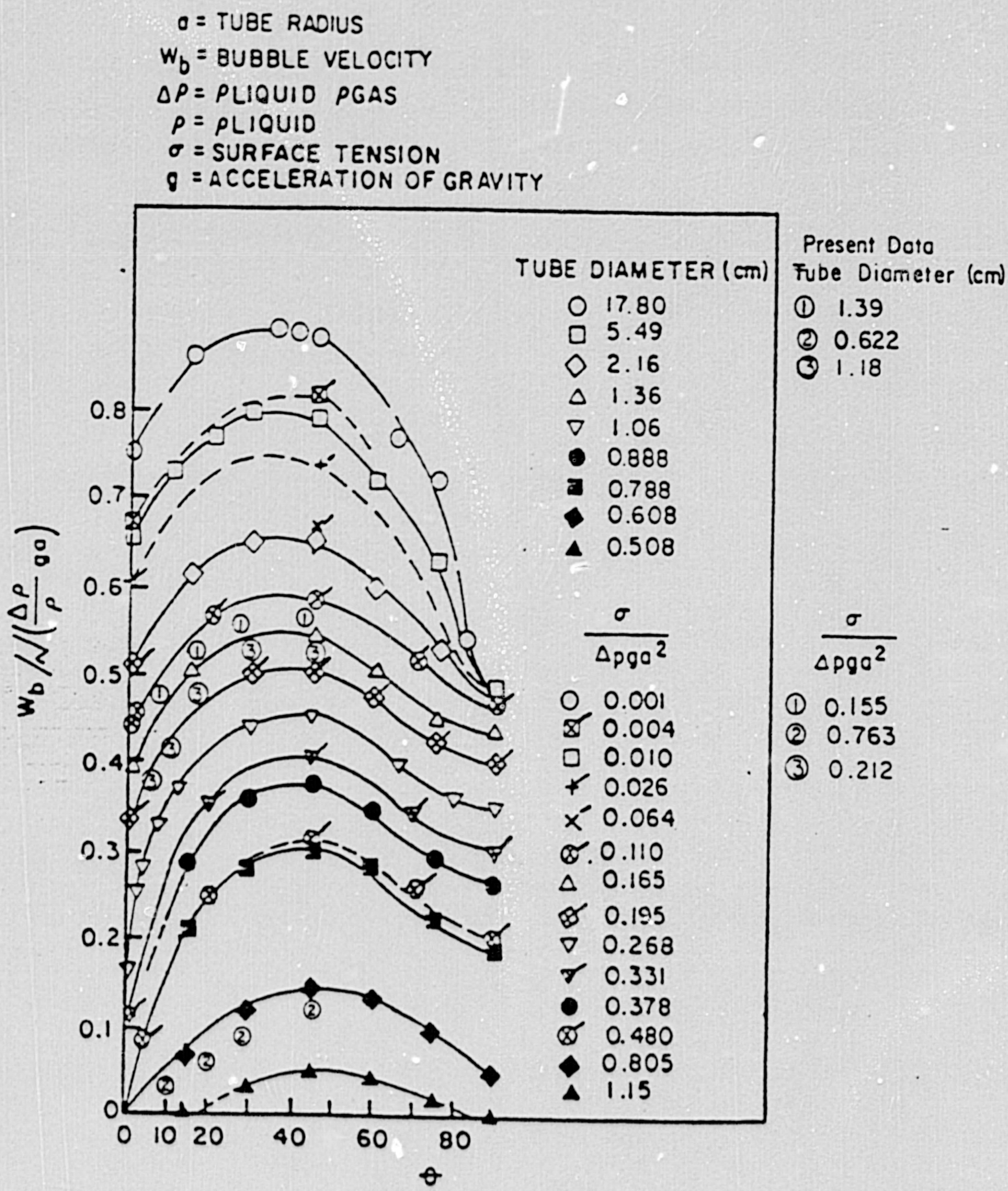

Figure 6. Variation of Normalized Velocity with Inclination Angle, Liquid-Air System. Air Bubble Moving into Fluid: Unflagged Symbols-Water; Flagged Symbols-Acetone. [2].

of the various valves used as root valves on sensing lines at Watts Bar Nuclear Plant. The valves chosen were a 1/2-inch Kerotest globe valve, a 3/4-inch Kerotest globe valve, a 1/2-inch Hancock globe valve, and a 1-inch Yarway globe valve. Figure 7 shows a schematic of the internal flow path of each valve.

The tests consisted of attaching flexible tubing to the valves and mounting the valves in a horizontal position with the valve stem upward as shown in Figure 8. The valves were filled with water from each side of the valve simultaneously such that an air pocket was allowed to collect in the valve cavity. The height of the water column in the flexible tubing on each side of the valve was measured. The valve was then agitated to allow the air trapped in the valve cavity to escape, and the height of the water columns was again measured. Table 4 presents the results of the tests.

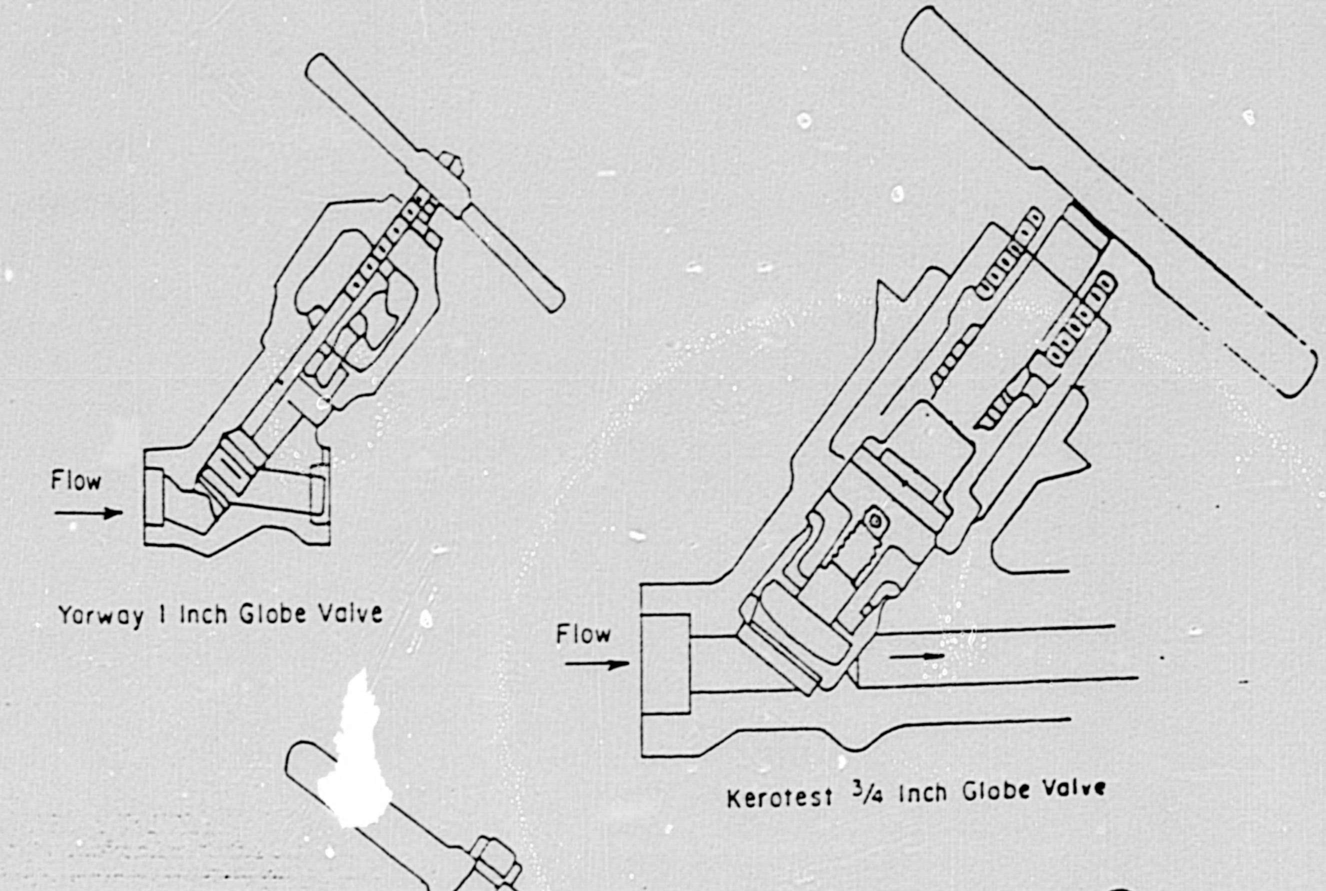

Figure 7. Schematic of Internal Flow Path of Selected Valves

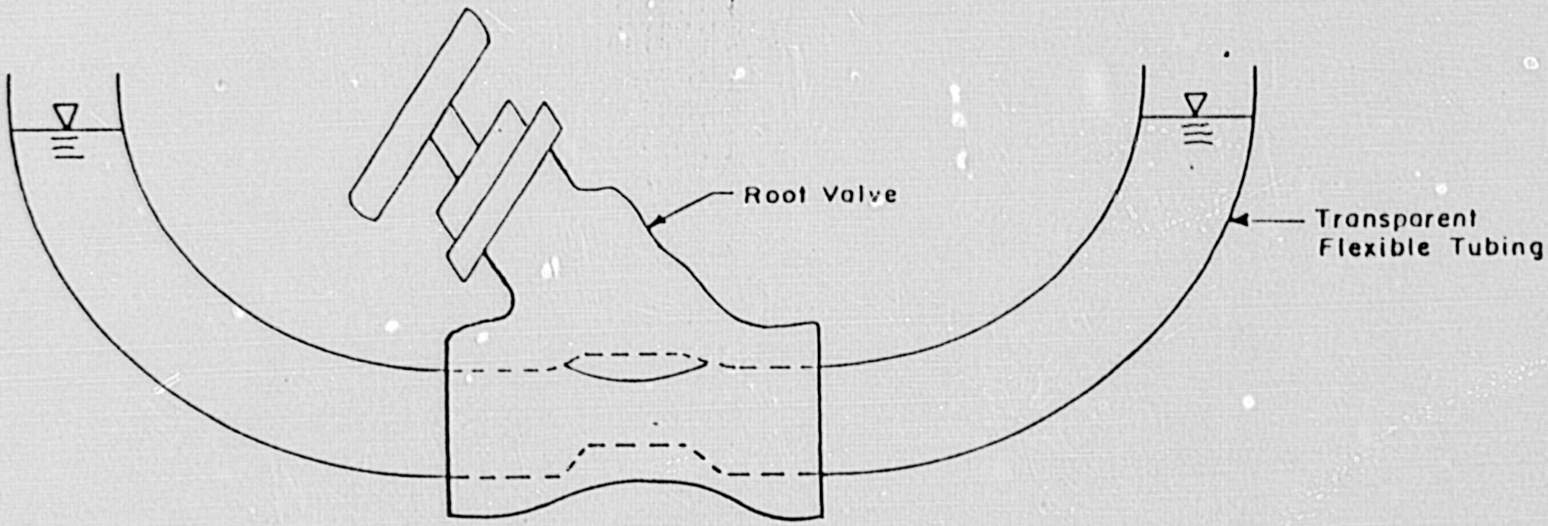

Figure 8. Test Setup for Determining Amount of Air That Can be Entrapped in Selected Root Valves

Table 4. Entrapped Air Capacity of Sensing Line Root Valves

Test No.	Height of Water in Hose (in.) Left Side w/o Air	Left Side w/ Air	Right Side w/o Air	Right Side w/ Air	Trapped Air (cc)
Kerotest 1/2-inch					
1	6.0	5.5	7.0	4.6	9
2	6.1	4.4	7.0	5.2	11
3	6.1	4.3	7.2	5.1	13
4	6.0	4.2	7.1	5.0	13
5	6.1	4.2	7.0	4.9	13
6	6.1	4.3	7.0	4.7	13
7	6.1	4.3	7.0	5.1	12
				Avg. =	12
Kerotest 3/4-inch					
1	5.7	4.5	8.1	7.1	7
2	5.1	3.7	8.5	6.7	10
3	6.2	5.2	8.0	6.9	7
4	6.4	5.2	8.2	7.0	8
5	5.0	3.6	7.1	5.4	10
6	6.2	3.6	7.7	5.4	16
7	5.9	4.3	7.5	5.5	12
8	6.0	4.2	7.9	5.9	12
9	5.2	3.6	6.6	4.9	11
				Avg. =	10
Hancock 1/2-inch					
1	11.0	10.5	7.0	6.5	7
2	11.0	10.7	7.5	6.6	9
3	10.1	9.7	6.6	5.7	9
4	10.1	9.8	7.0	6.9	3
5	11.0	9.6	6.6	5.7	17
6	10.1	10.0	7.0	6.0	8
7	10.1	10.0	7.1	6.1	8
				Avg. =	9
Yarway 1-inch					
1	5.7	5.5	5.1	4.6	9
2	6.6	6.2	6.0	5.6	10
3	7.8	7.1	7.0	6.5	15
4	6.7	6.2	6.1	5.8	10
5	6.0	5.6	5.4	5.1	9
6	5.8	5.6	5.4	5.1	6
7	6.8	6.2	6.1	6.0	9
8	6.1	5.8	5.6	5.3	8
9	6.1	5.7	5.3	5.1	8
				Avg. =	9

Back-Flush Tests

Tests were conducted to quantify the flowrate of water necessary to back-flush air voids from a sensing line typical of those found at Watts Bar Nuclear Plant. The Watts Bar full-scale sensing line model was used for these tests. The primary advantage of using this model is that it is constructed of transparent PVC tubing. The transparent tubing allowed visual verification of the air void location and movement within the line. The PVC has an internal diameter of 0.625 inches compared to a 0.546-inch diameter of the 1/2-inch schedule 80 pipe used in the plant. The tests, however, were only used to estimate the necessary back-flush flowrate to within an order of magnitude.

Figure 9 is a schematic of the full-scale Watts Bar sensing line model. The low pressure line is the more complicated configuration and has more potential for air entrainment. It is also the most difficult to clear of air bubbles using back-flushing due to its configuration. For these reasons it was used for the tests. The model was initially drained for each test and then allowed to refill with water. After the refilling process, bubbles remained at several locations. These locations are shown in Figure 10 as locations A through F and a vertical leg. Several back-flush flowrates were tested to determine the necessary flowrate to purge these remaining bubbles. Table 5 presents the results of these tests.

The four root valves were also tested to determine the flowrate that would force air bubbles to pass through the valves. The valves were attached to the high point vent on the low pressure line in a horizontal configuration with the valve stem positioned upward (see Figure 11). Several back-flush flowrates between 1/2 and 1 gpm were used to purge the air bubbles from the full-scale model low pressure sensing line through the root valve. The objective of the tests was to determine for each valve the flowrate that would easily pass the bubbles through the root valve. The results of these tests are shown in Table 6.

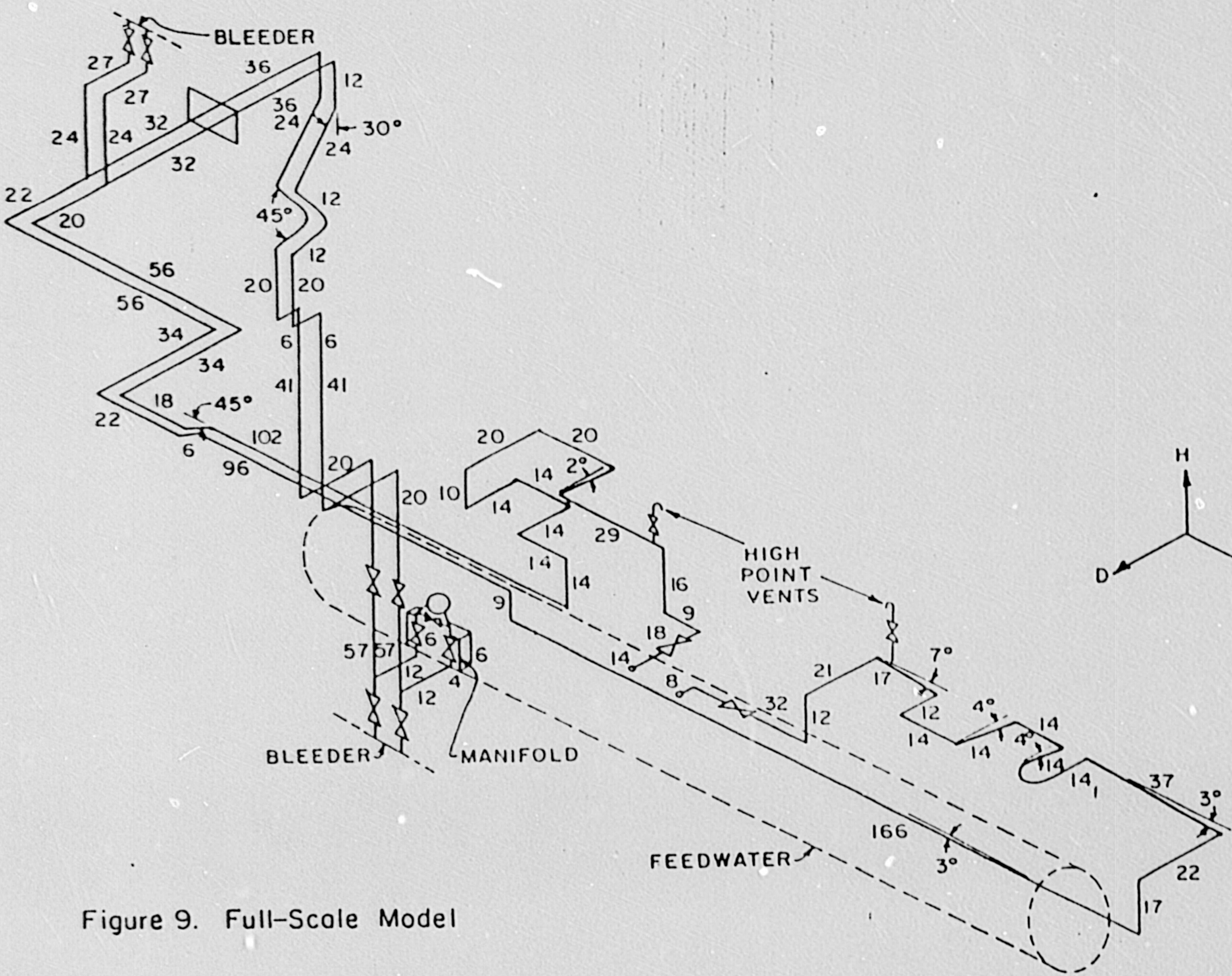

Figure 9. Full-Scale Model

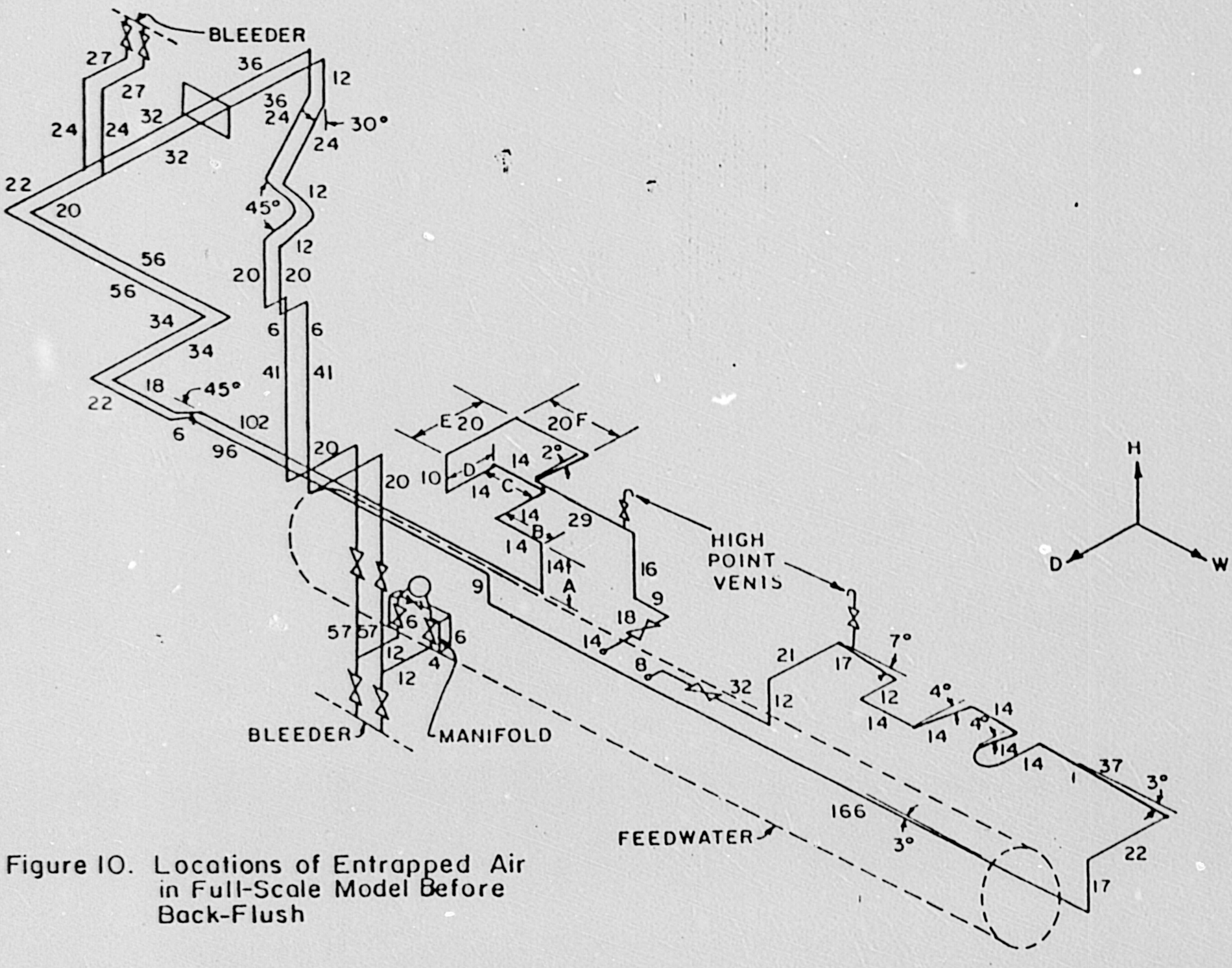

Figure 10. Locations of Entrapped Air in Full-Scale Model Before Back-Flush

Table 5. Results of Back-Flush Tests

Water Flowrate (gpm)	Average Length of Air Voids at Various Locations (inches) A	B	C	D	E	F	Vertical Leg
0.00	17	12	8	3	5	9	present
0.24	0	10	13	13	2	18	present
0.35	0	7	0	11	0	11	present
0.43	0	7	0	10	0	7	present
0.53	0	5	0	0	0	7	present
0.58	0	0	0	0	0	0	present
0.73	0	0	0	0	0	0	present
0.80	0	0	0	0	0	0	none

Table 6. Results of Back-Flush of Root Valves, Flowrates at Which Bubbles Pass Through the Valve

Kerotest 1/2-in.	Kerotest 3/4-in.	Hancock 3/4-in.	Yarway 1-in.
3/4 gpm	1 gpm	3/4 gpm	1 gpm

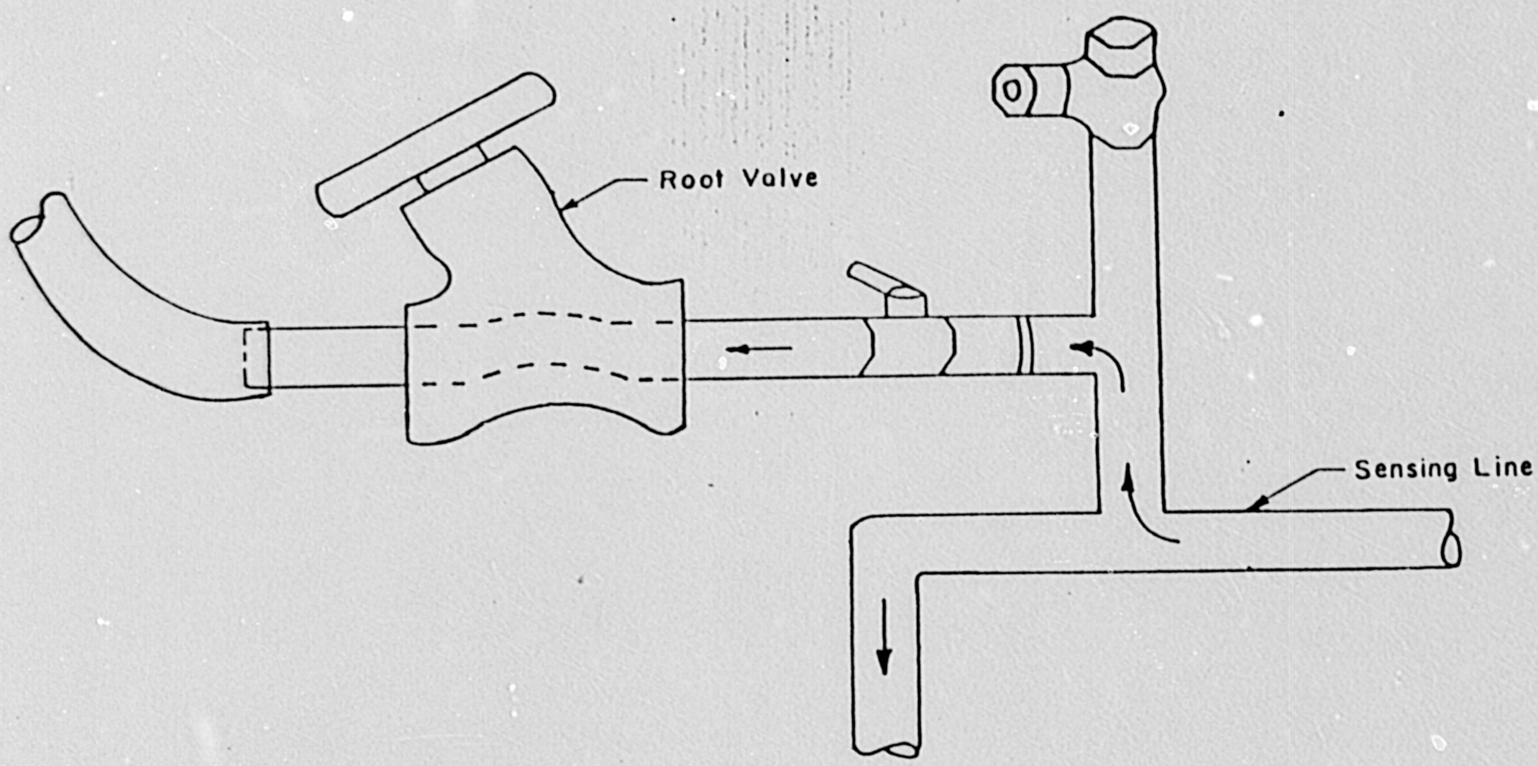

Figure II. Test Setup for Back-Flushing Root Valves

Rosemount Differential Pressure Transmitter

One of the problems occurring in the plants, especially for low differential pressure readings, is that the signal to noise ratio from the transmitter is occasionally too low to decipher the signal to the required accuracy. In some cases the noise is reported to be as much as 30 percent of the signal. Plant instrument mechanics attribute this condition to the presence of air in the line, since in most instances the condition will disappear after the line is purged.

To examine the influence of entrapped air on the Rosemount differential pressure transmitter, the transmitter was tested in the configuration shown in Figure 12. Recent tests [3] at the Engineering Laboratory have demonstrated that the presence of an air bubble in a sensing line can allow the water column in the line to set up a low frequency (typically less than 50 Hz) resonating motion. The frequency of the motion is dependent on the piping configuration in the vicinity of the bubble and the location of the bubble. The Rosemount transmitter is sensitive to pressure fluctuations less than approximately 20 Hz and would therefore respond to such resonant frequencies. Tests were conducted with air bubbles between 10 and 50 cc located as shown in Figure 12. A plunger was inserted in the top of one of the water columns and driven by a shaker. The shaker was driven by white noise to excite broad-band pressure pulsations in the water. The differential pressure transmitter did respond to the low frequency pressure pulsations as expected, thus demonstrating the susceptibility of the transmitters to pressure pulsations typical of resonating water columns.

CONCLUSIONS AND RECOMMENDATIONS

The corrugated hose, used to provide for relative displacement between the process line and the root valve, presents a significant potential for air entrapment only when improperly configured. To minimize the potential for air entrapment, the hose should be installed and maintained such that the entire hose lies in a straight line with a minimum slope of 1/8-inch per foot. With the hose installed in this

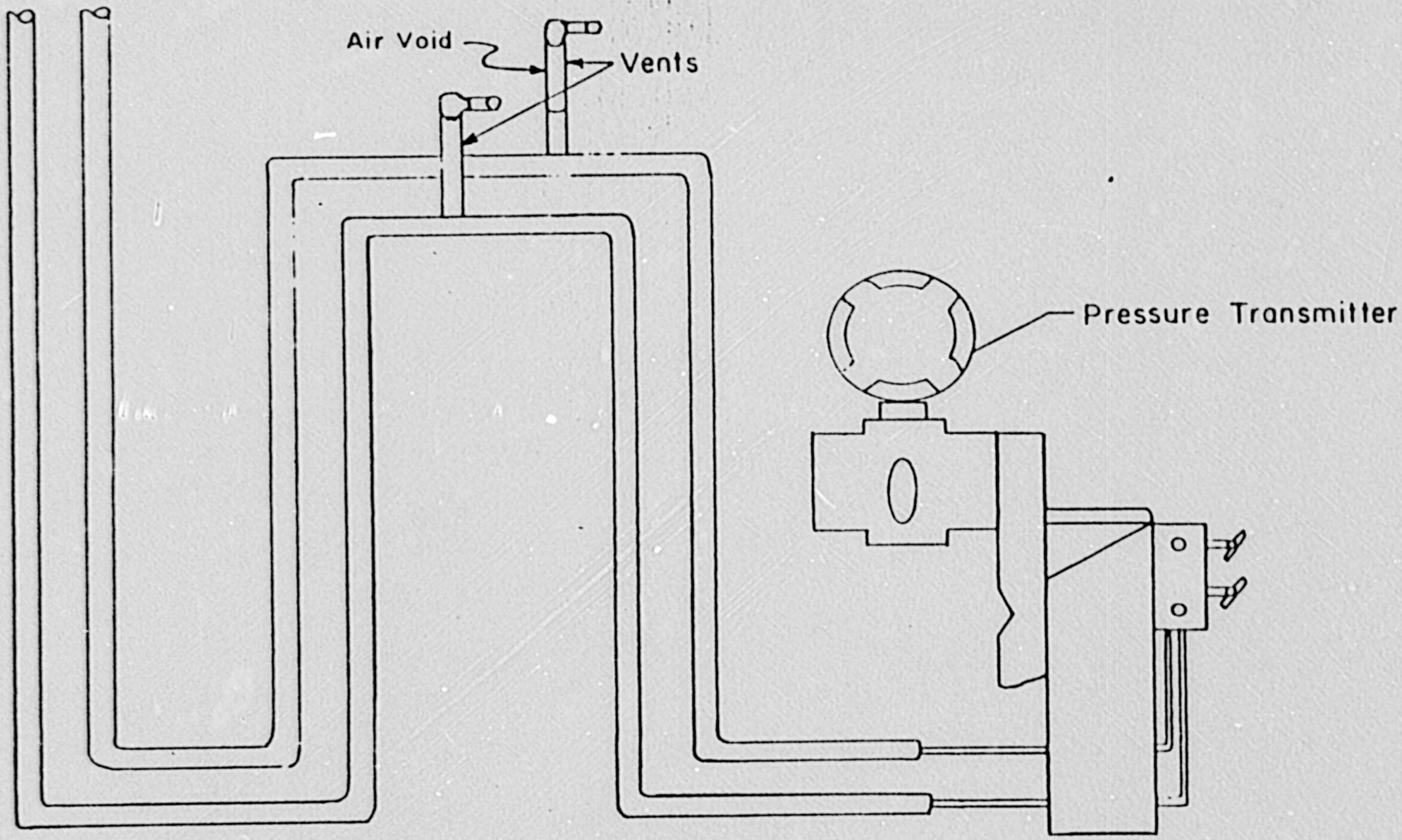

Figure 12. Schematic of Differential Pressure Transmitter Test Setup

manner at ambient conditions, maximum air entrapment should be on the order of 5 to 10 cc. This, in itself, should not affect the process signal and can be easily flushed through the high point vent.

The test results show that even a 1/2-inch displacement of the hose can result in 50 to 70 cc of entrapped air. A bubble of this size is cause for concern. For this reason, care should be exercised in the installation and maintenance of the corrugated flexible hose.

From an examination of the flow path through each of the four root valves tested, the worst case configuration for installation was determined to be a horizontal installation with the valve stem directed upward. In this configuration, none of the four valves tested trapped a significant amount of air. All four valves also passed air bubbles using a minimum back-flush flowrate of 1 gpm. As long as back-flushes are conducted utilizing an adequate flowrate and at appropriate times, the root valves should not present a problem to the process measurement.

The results of the bubble migration measurements in the 1/2-inch schedule 160 SS pipe indicate that the recommended minimum slope of one inch per foot should be adhered to. This is consistent with previous tests conducted using 1/2-inch schedule 80 SS pipe. Optimally the installation should maintain a 45 degree slope over as short a run as possible between the primary and secondary devices. Further, care should be taken in the installation of the pipe to prevent discontinuities in the inside wall. Such discontinuities, if they are present, will provide places for entrapped air bubbles to hang. Junctions of pipe sections and fittings should provide a smooth and continuous inside wall. Contaminants such as grease or dirt, if left on the inside of the pipe, can also create problems by effectively increasing the interfacial surface tension and thereby increasing the chances of a bubble remaining stationary at that location.

Back-flush tests were conducted to obtain an indication of the flowrate necessary to purge air bubbles from the line and pass them through the root valve. The tests indicated that a flowrate of 3/4 gpm could purge the air bubbles from the line but a flowrate of 1 gpm could be necessary to ensure the passage of the air bubbles through the root valve depending on the type of root valve. These flowrates are considered characteristic of the model and not absolute values to be applied to all installations. However, the numbers do adequately provide an estimate of the order of magnitude of the required flowrate. The 3/4 to 1 gpm should be used as a guideline to the absolute minimum acceptable back-flush flowrate for use in the plant.

The response of a Rosemount pressure transmitter to pressure pulsations created by a resonating water column in a sensing line was qualitatively demonstrated. The "noise" created on the signal was small (less than 10% of the signal) for the cases investigated, but the phenomenon was adequately demonstrated and the need to ensure the removal of all entrapped air from the sensing line was reinforced.

REFERENCES

1. Wojnovich, M. S., J. R. Missimer, and C. A. Brackett, "Bubble Migration in Inclined Sensing Lines," TVA Report No. WR28-2-88-107, August, 1985.

2. Zukoski, E. E., "Influence of Viscosity, Surface Tension, and Inclination Angle on Motion of Long Bubbles in Closed Tubes," Journal of Fluid Mechanics, Vol. 25, Part 4, 1966.

3. Schohl, G. A., "An Active Technique for Void Detection in Sensing Lines," TVA Report No. WR28-1-85-120, January, 1986.

TVA 64 (OS-9-65)

UNITED STATES GOVERNMENT

Memorandum

TENNESSEE VALLEY AUTHORITY

TO : G. W. Curtis, Project Manager, Instrumentation Project, IOB-WBN

FROM : E. Ely Driver, Chief, Engineering Laboratory, ENG LAB-N

DATE : August 13, 1986

SUBJECT: RESULTS OF SENSING LINE TESTS

Attached is the final version of TVA Report No. WR28-1-85-121, which is a summary of the sensing line air bubble migration tests conducted at the Engineering Laboratory for Watts Bar Nuclear Plant.

Please call Chris Ungate (x1945-K) if there are further questions.

E. Ely Driver

E. Ely Driver

CAB:TSM
Attachment

Prepared by Ann Brackett

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ENCLOSURE 5

SEQUOYAH NUCLEAR PLANT

INSTRUMENT SENSING LINE SLOPE QUESTIONS

LETTER FROM P. R. WOHLD TO MEB FILES

DATED NOVEMBER 17, 1978

#1
IIIC

TVA 64 (OS-6-68)
UNITED STATES GOVERNMENT
Memorandum

7811200352

TENNESSEE VALLEY AUTHORITY

TO : Mechanical Engineering Branch Files

FROM : P. R. Wohld, Nuclear Engineer, W9C171 C-K

781124J0426 (3)

DATE : NOV 17 1978

SUBJECT: SEQUOYAH NUCLEAR PLANT - INSTRUMENT SENSING LINE PROBLEMS - REPORT OF OCTOBER 17, 1978 - FIELD TRIP FINDINGS

Attendees: EN DES - Jerry Dorris, Jim Staub, Peter Wohld
P PROD, Preop - Frank Siler
P PROD, Results - Boyd Patterson, Steve Hetzel
CONST - Charles Wagner, Bob Domain

On October 17, 1978, Jerry Dorris and Jim Staub from the Sequoyah-Watts Bar Project and I toured SQN to investigate reports of instrumentation problems related to air entrapment in instrument sensing lines. With us were P PROD personnel from the Preoperational Test and the Results sections and from Construction I&C. We looked at problem areas discovered during preoperational testing and potential problem areas.

The sensing line and instrument panel installations we looked at appear to have manifold geometric problems that prevent removing air from the sensing lines and instrument bellows by reasonable means. Solutions reflect back to vendor-supplied instrumentation, EN DES specified equipment layout, field routing by Construction, venting procedures by P PROD, and administrative handling by all. Following are specific problems and potential solutions as I see them:

1. General Electric transmitters are provided with the 3-valve manifold on top of the instrument. GE claims this is acceptable, but P PROD claims to have difficulty venting the instrument bellows. Symptoms of this problem are seen as unpredictable vibrations in the output of the transmitter. P PROD had trace recordings which showed the problem under process system operational conditions.

   Solutions:

   a. (Recommended solution) Use venting techniques to force water from below the transmitters and vent air through the top of the bellows and the 3-valve manifold.

   b. Obtain approval and remount the manifold on the bottom of problem instruments to see if this helps.

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c. Verify by laboratory test that the manifold is or is not a problem and act according to findings.

2. Some field routed sensing lines do not have high point vents, and some sensing lines are sloped improperly. Air, thus, trapped in the lines can cause an offset in the transmitter output as well as vibrations.

   Solution:

   Construction will correct.

3. Sensing line takeoff points from the process pipe allow bubbles in the process fluid to migrate into the sensing lines. This causes a need for increased surveillance and venting frequencies for the lines.

   Solution:

   Attach sensing lines on side or in lower quadrant of pipe.

4. Tubing, valves, and vent lines in the instrument panels are not large enough to allow the fluid velocity necessary to force air down and out of the 1/2-inch schedule 80 sensing lines that are coming down to the panel from a high point vent.

   Solution:

   Use a fill technique which forces water into panel lines while air is bled from the high point vent.

5. Proper fill and vent techniques are not utilized to handle the complex geometric layout problems.

   Solution:

   P PROD has considered a cart-mounted pump and reservoir system to pump water into panel connection points so that air can be vented in its natural direction of migration. Other techniques can be investigated if additional problems arise.

6. Some panel mounted tubing appears to have an improper slope that can contribute to the air entrapment problem.

   Solution:

   If P PROD has trouble filling and venting, Construction should rebuild with proper slope.

Mechanical Engineering Branch Files

NOV 1 7 1978

SEQUOYAH NUCLEAR PLANT - INSTRUMENT SENSING LINE PROBLEMS - REPORT OF OCTOBER 1 7, 1978 - FIELD TRIP FINDINGS

7. The routing of some lines is high enough and the system process pressure low enough under certain conditions that the instrument lines see a negative pressure. Vent valve leakage in this case would allow air to reenter the high points. Also, air can come out of solution due to a partial vacuum and will collect at high points.

   Solution:

   For these special cases, specify more favorable locations for sensing lines, panels, and sense line takeoff points.

In addition to the physical instrumentation problems, there is an administrative problem that does not promote expeditious review and resolution of the physical ones. With so many groups involved, it is too easy to pass the buck, and this is what happens. There should be a single individual or group assigned the responsibility for the instrument lines that can and will perform an early review of instrument line installations, coordinate investigation of problems identified, seek or recommend solutions, and otherwise "bird dog" problems until they are resolved. The appropriate test representative and others can help, but I believe the primary responsibility should be with one of the sections in P PROD.

Because of the instrument line situation, we have had system testing delays and test deficiencies. Ahead of us are more of the same along with the problems of correction and retest. This all can have an effect on the plant schedule and will be subject to reportability to NRC if we cannot turn the situation around.

I believe the necessary people are aware of the problems at Sequoyah Nuclear Plant Unit 1 and will handle problems as they are reported by the Preop Test or Results sections of P PROD. There is much that can be done, however, to promote expeditious handling of further unit 1 problems and to prevent future problems on unit 2 and future plants if the proper mechanism can be found.

P. R. Wohld

PRW:PJR
cc: E. G. Beasley, W9C165 C-K
D. R. Patterson, W10C126 C-K

DRP:PJR - NOV 1 7 1978
cc: F. W. Chandler, W8C126 C-K
R. M. Hodges, W7C126 C-K
Roy H. Dunham, W11A9 C-K
R. M. Pierce, 204 GB-K (2)
H. C. Russell, W5C126 C-K
J. P. Vineyard, W6D224 C-K

RHD:PJR - NOV 1 7 1978
cc: M. S. Fox, 716 EB-C (2)
MEDS, E4B37 C-K
H. H. Mull, E7B24 C-K
T. B. Northern, Watts Bar Nuclear CONST (3)
G. G. Stack, Sequoyah CONST (4)

I suggest SWP take the lead and work with EEB to issue a construction specification that will provide requirements to prevent recurrence of this problem at WBN and later plants. - DRP

809746/2

ENCLOSURE 6

SEQUOYAH NUCLEAR PLANT

INSTRUMENT SENSING LINE SLOPE QUESTIONS

LETTER FROM J. P. VINEYARD TO H. B. RANKIN

DATED DECEMBER 20, 1985

KMJ #7
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TVA 64 (OS-9-68)

UNITED STATES GOVERNMENT

Memorandum

B25 '851 20 003

TENNESSEE VALLEY AUTHORITY

TO : H. B. Rankin, Manager, Design Services, NUC PR, Sequoyah Nuclear Plant

FROM : J. P. Vineyard, Project Manager, Sequoyah Engineering Project, A8 Sequoyah - ENG

DATE : DEC 20 1985

SUBJECT: SEQUOYAH NUCLEAR PLANT - SENSE LINE SLOPE EMPLOYEE CONCERN

References: 1. P. R. Wohld's memorandum to Mechanical Engineering Branch Files dated November 17, 1978, "Sequoyah Nuclear Plant - Instrument Sensing Line Problems - Report of October 17, 1978 - Field Trip Findings" (MEB '781120 352)

(31) 3

2. R. M. Pierce's memorandum to D. R. Patterson dated December 5, 1978, "Sequoyah Nuclear Plant - Instrument Sensing Line Problems" (SWP '781205 011)

3. J. E. Staub's memorandum to SWP Files dated November 3, 1981, "Sequoyah Nuclear Plant - Condensate Pot Design and Test - STEAR 23" (SWP '811116 056)

4. My memorandum to you dated September 26, 1985, "Sequoyah Nuclear Plant - Special Test Experiment Activity Request (STEAR) 85-01" (B25 '850926 015)

2. Emp. Concern Files

Attached is the Office of Engineering's Sequoyah Nuclear Plant specific evaluation of the sense line slope concern requested by Mr. Abercrombie. Please direct any questions to J. E. Staub, Sequoyah extension 7070.

HLA
CRB
PRW

J. P. Vineyard

J. P. Vineyard

JPV:JES:MKA
Attachment
cc (Attachment):
RIMS, SL26 C-K
V. A. Bianco, A12 Sequoyah - ENG
G. T. Hall, A14 Sequoyah - ENG

Principally Prepared By: J. E. Staub, Extension 7070.

SQEP - Dec. 20, 1985
JPV1.KA

Due to a concern on the as-installed operability of some sense lines at WBNP SQN management requested OE to evaluate the acceptability of installed sense lines at Sequoyah. OE's evaluation is based on the following inputs: previous design (design review), operating experience, and present maintenance practices.

These three inputs are interactive in that design required certain maintenance practices, operating experience has caused changes in both design and maintenance practices, and finally knowledge of maintenance practices has aided design. This evaluation will start with base design then relate how operating experience during preoperational testing modified design and created certain maintenance practices, and finally how 5 years of experience has changed both base design and maintenance activities. The operating experience portion will also explain the acceptibility of apparent non-standard design.

The base concern expressed at WBNP was that certain sense lines used for low pressure or low differential pressure applications could be affected by entrapment of air in the sense lines. The affect of air in sense lines is two fold. First, since air is a much lower density medium than liquid, the calibration of instrumentation is affected by displacement of liquid by air in the sense lines. Second, since air is a compressible fluid, the stability of the hydraulic pressure at the instrument is affected by the "spring" created by compression and expansion of the air in the sense lines. This results in an erratic transmitter output.

To elaborate on the first problem of liquid displacement, standard design is to mount the instrument physically below the monitored process. The additional pressure caused by the height difference between instrument and process is then calibrated out of the instrument to give an indication of pressure at the process. In low pressure application the height difference can be a significant percentage of the signal. In differential pressure applications system pressure is neutralized since it is applied to both sense lines, however, liquid displaced by air is sensed as a change in differential pressure and thus misinterperated as a process change.

BASE DESIGN

To prevent air intrusion into sense lines the base design utilized instrument locations lower than process tap points and requirements for continuous down slope from the process tap to the instrument. The slope requirements were 1/8 in per foot minimum. This is according to general NOTE and NOTE 14 on 47W600-24. Where the above could not be accomplished, provisions are shown on 47W600-18 detail F18 for installation of high point vents. The purpose of the vent is to release air from the sense line at some midpoint in the sense line if slope can not be downward and continuous.

TVA construction installed the sense lines under the above design guide lines. Other design-provided information was sense point location on the process and instrument location. Construction was responsible for sense line routes between these end points.

OPERATING EXPERIENCE

Operating experience started during the preoperational phase of the plant. Problems and general comments were identified in a memo from P. R. Wohld to MEB files (MEB 781120352). Sequoyah-Watts Bar Design project responded by memo R. M. Pierce to D. R. Patterson (SWP 781205011) and addressed each item with corrective action. (Memos are attached).

ECN E2138 was written to rotate root valves identified by a design review. Rotating the root valve in these cases eliminated the need for high point vents. The design review mentioned above was limited to safety systems.

After the preop testing phase ended and plant operation phase began less obvious problems surfaced. Among these were main feed water flow sense lines that were erratic and offset. After lengthy investigation the root cause was narrowed to sense line routing that included high point vent and improper slope. These problems were corrected on ECN L5726.

Additional problems were discovered on the pressurizer level instrumentation. In this case a condensate pot is utilized to provide a constant head in the reference leg. The problem at the pressurizer has been providing a pathway from the pressurizer to the condensate pot that would allow two phase flow and would not water lock. To solve this problem NUCPR and OE have run two STEARs to test condensate pots and valve arrangements. These reports (SWP 811116056 and B25 850926015) are attached. DCR 2191 provides justification to the ultimate fix of this problem. This fix will install valves in a tested configuration.

A walkdown was accomplished on 12-13-85 involving OE and Instrument Maintenance. This walkdown reviewed systems and instruments that had a history of air in sense lines. This history involves starting up maintenance activities involved in placing portions of systems in service. From discussions prior to the walkdown, as certain portions of systems are place in service, maintenance backfills and bleeds sense lines until indicator stability is achieved. This may involve several sessions per instrument.

the walkdown substantiated root cause for these problems with many high points and inaccessible high point vents. No plant safety problem was identified even though there is a maintenance concern due to time and manpower required to place certain systems in service.

The recent WBNP concern addressed the reactor coolant flow sense lines. At SNP the reactor coolant flow sense lines have routings that would appear to be susceptible to air intrusion. Operating experience has shown air intrusion has not been a problem on these lines. Factors contributing to the operability of these sense lines are that reactor coolant is not drained down to the tap points, therefore no air is in the process line to migrate into the sense line. Secondly, maintenance uses a wet calibration procedure that does not introduce air into sense lines at the transmitter.

MAINTENANCE PRACTICES

In general, instrument maintenance practices at Sequoyah have evolved and developed significantly during the past five years of plant operation. To specifically address the sense line slope issue, several activities have been initiated, modified, and refined as needed to ensure proper calibration of process instrumentation. These activities include backfilling of sense lines, use of wet calibration techniques, and administrative detection of sense line fill problems.

Backfilling of sense lines is the primary means to correct any problem with air entrapment. Instrument maintenance instruction, IMI-118, contains the procedures for backfilling, venting, flushing, and draining of sense lines. This IMI also contains the procedures for filling of sealed sense lines. The individual instrument calibration procedures reference IMI-118 to ensure proper sense line fills are accomplished as required. Special equipment and materials are utilized to perform these operations.

In addition to backfilling, the use of a wet calibration technique has been developed since initial startup and has proven to be a significant aid in preventing air from entering sense lines during instrument calibrations. This technique uses a water box design which allows the calibration to be performed without draining any portions of the sense lines (as required with dry calibration methods). In most cases, backfilling is not even required after using this technique.

To further enhance the instrument maintenance program at Sequoyah, additional procedures are being prepared and revised to document better methods of detecting and correcting potential sense line fill problems. For applicable reactor trip and engineered safety features instruments, a new surveillance instruction is being prepared to administratively verify proper fills. This instruction will be performed during plant outages just prior to entering the modes at which the instruments are required to be operable. The procedure will require channel checks of the instruments to determine if any are indicating abnormally. For those instruments which indicate possible problems, an investigation will be conducted and backfilling will be performed in accordance with IMI-118 if required.

A review of SNP maintenance history has revealed very few problems associated with sense lines. For each case, however, appropriate corrective action was taken. In addition to those items previously addressed in this report, another problem that developed involved the sense line routing to GE-MAC transmitters. As originally designed, the sense lines were tubed into the top of the transmitter, and the bleed ports were located at the bottom. This configuration would not allow proper bleeding to remove air from the transmitter housing. Corrective action involved inverting the transmitter and rerouting the sense lines such that the transmitter bleed ports were on top. This allowed proper bleeding and completely resolved the problem.

In summary, the current and planned instrument maintenance practices appear to adequately address the sense line slope issue at Sequoyah. The five years of operating experience have helped form a sound program which employs both preventive and corrective maintenance activities to effectively deal with any problems that may develop.

CONCLUSION

No plant safety problem was identified by this evaluation. A concern with time to place systems in service was identified. To address this concern OE recommends a program to identify and document routing of safety related sense lines, to identify history trends and potential causes of adverse performance, and finally to recommend solutions to identified problems. Solutions may include sense line reroute, instrument relocation or other creative solutions.

ENCLOSURE 7

SEQUOYAH NUCLEAR PLANT

INSTRUMENT SENSING LINE SLOPE QUESTIONS

LIST OF TVA COMMITMENTS

1. TVA will provide NRC a copy of a Norris Laboratory report that confirms that a minimum of 1/8-inch slope with in-line coupling will migrate entrapped air. This report is in final preparation and will be sent to NRC by April 10, 1987.

2. Surveillance Instruction (SI)-604 will establish criteria for channel checks of essential instrument operability before restart. SI-604 will require instruments displaying problems associated with an entrapment to have the sense lines backfilled per the applicable maintenance instruction before restart of each respective unit.

3. New detailed maintenance instructions, MI-19.1.1 through MI-19.1.15, for technical specifications transmitters are being prepared as a restart item for each unit and will address sense line backfilling.

4. TVA Division of Nuclear Engineering (DNE) will evaluate outgassing of sense lines for those devices required to operate during and after a Design Basis Accident as addressed in ECTG Report 17301, and appropriate corrective action plans will be developed before restart of each respective unit.