NRC Form 366 (9-83)

U.S. NUCLEAR REGULATORY COMMISSION
Approved OMB NO. 3150-0104
Expires 8/31/85

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1): Monticello Nuclear Generating Plant

DOCKET NUMBER (2): 0 5 0 0 0 2 6 3

PAGE (3): 1 OF 0 4

TITLE (4): Crack in Reactor Recirculation System Decontamination Connection Due to High Cycle Fatigue

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBERS
										0 5 0 0 0
1 1	2 5	8 7	8 7	- 0 2 3 -	0 1	0 2	2 9	8 8		0 5 0 0 0

OPERATING MODE (9): N

POWER LEVEL (10): 0 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following)(11)

[ ]	20.402(b)	[ ]	20.405(c)	[ ]	50.73(a)(2)(iv)	[ ]	73.71(b)
[ ]	20.405(a)(1)(i)	[ ]	50.36(c)(1)	[ ]	50.73(a)(2)(v)	[ ]	73.71(c)
[ ]	20.405(a)(1)(ii)	[ ]	50.36(c)(2)	[ ]	50.73(a)(2)(vii)	[ ]	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
[ ]	20.405(a)(1)(iii)	[ ]	50.73(a)(2)(i)	[ ]	50.73(a)(2)(viii)(A)		
[ ]	20.405(a)(1)(iv)	[X]	50.73(a)(2)(ii)	[ ]	50.73(a)(2)(viii)(B)		
[ ]	20.405(a)(1)(v)	[ ]	50.73(a)(2)(iii)	[ ]	50.73(a)(2)(x)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER
Therese A. Lavalle, Engineer II	AREA CODE 6 1 2 2 9 5 - 5 1 5 1

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFAC TURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFAC TURER	REPORTABLE TO NPRDS
B	A D	P S P	S 0 3 0	Y					

SUPPLEMENTAL REPORT EXPECTED (14)

[ ] YES (If yes, complete EXPECTED SUBMISSION DATE) [X] NO

EXPECTED SUBMISSION DATE (15): MONTH | DAY | YEAR

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typwritten lines) (16)

While performing the Reactor Coolant Pressure Boundary Leakage Test, a crack was discovered in a two inch decontamination connection on the Reactor Recirculation System A loop. The plant was shutdown for a refueling outage.

Metallographic examination revealed that the crack was caused by high cycle fatigue. It is believed that the fatigue failure resulted from cyclic stresses caused by forced resonant vibration in the decontamination connection.

The decontamination connection was modified so that its natural frequency does not coincide with the frequency of any expected Recirculation System forcing functions. Other Recirculation System branch connections were evaluated. Two other decontamination connections were in the range of concern and were modified. It is believed that no other connections are susceptible to this failure mode.

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Monticello	0|5|0|0|0| 2| 6| 3	8|7	0 | 2 | 3	0 | 1	0|2 OF 0|4

TEXT (If more space is required, use additional NRC Form 366A's) (17)

DESCRIPTION

On November 25, 1987, with the plant shutdown for refueling and while performing the Reactor Coolant Pressure Boundary Leakage Test, operations personnel discovered a leak coming from a two inch decontamination connection (PSP) on the Reactor Recirculation System (AD) A loop. The decontamination connection is located in an isolable portion of the Recirculation System between the recirculation pump (P) suction and discharge valves (ISV) (see figure). Investigation by maintenance personnel revealed that the source of the leak was a crack in the two inch pipe at the toe of the weld to the half coupling on the main recirculation pipe (see figure). This section of the recirculation system was then isolated and drained for investigation and repair. It is believed that the crack went through wall during the previous operating cycle.

CAUSE

Metallographic examination revealed that the crack was caused by high cycle fatigue. Analysis and testing revealed that the natural frequency of the decontamination connection coincided with vane passing frequency of the recirculation pump. It is therefore believed that fatigue failure resulted from cyclic stresses caused by forced resonant vibration in the decontamination connection.

ANALYSIS

This event had no effect on the health and safety of the public. It is believed that the crack went through wall during the previous operating cycle because there was no evidence of leakage at the decontamination connection during the Reactor Coolant Pressure Boundary Leakage Test conducted during the previous refueling outage in 1986. Since the crack existed during full power operation, as evidenced by crack surface appearance and by high contamination levels in the area, the event occurred under the worst possible set of initial conditions. Unidentified and identified reactor coolant system leakage, based on primary containment sump monitoring, just prior to the refueling outage was only a small fraction (approximately 5%) of Technical Specification limits.

CORRECTIVE ACTIONS

The decontamination connection was modified so that its natural frequency does not coincide with the frequency of any expected Recirculation System forcing functions. Welds in the three remaining decontamination connections were examined using liquid penetrant and no indications were found. Analysis revealed, however, that two of the three decontamination connections were potentially susceptible to a similar failure mode. These connections were, therefore, also modified as a preventive measure. Early evaluation of other Recirculation System branch connections indicated that no other connections are susceptible to this failure mode.

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TEXT (If more space is required, use additional NRC Form 366A's) (17)

Ongoing reviews indicate that some recirculation branch connections require additional study and testing. Failure of these branch connections is not likely because the duration and magnitude of the excitation source are small. Thus, these components do not pose an immediate concern related to pipe failures. Additional study and testing (and any required modifications) will be completed by the end of the refueling outage scheduled for Spring, 1989.

ADDITIONAL INFORMATION

Failed Component Identification

The pipe was manufactured by Sandvik, Incorporated. It was 2", schedule 80, manufactured to ASME material specification SA 312 TP 316L.

Previous Similar Events

None

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U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

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EXPIRES 8/31/85

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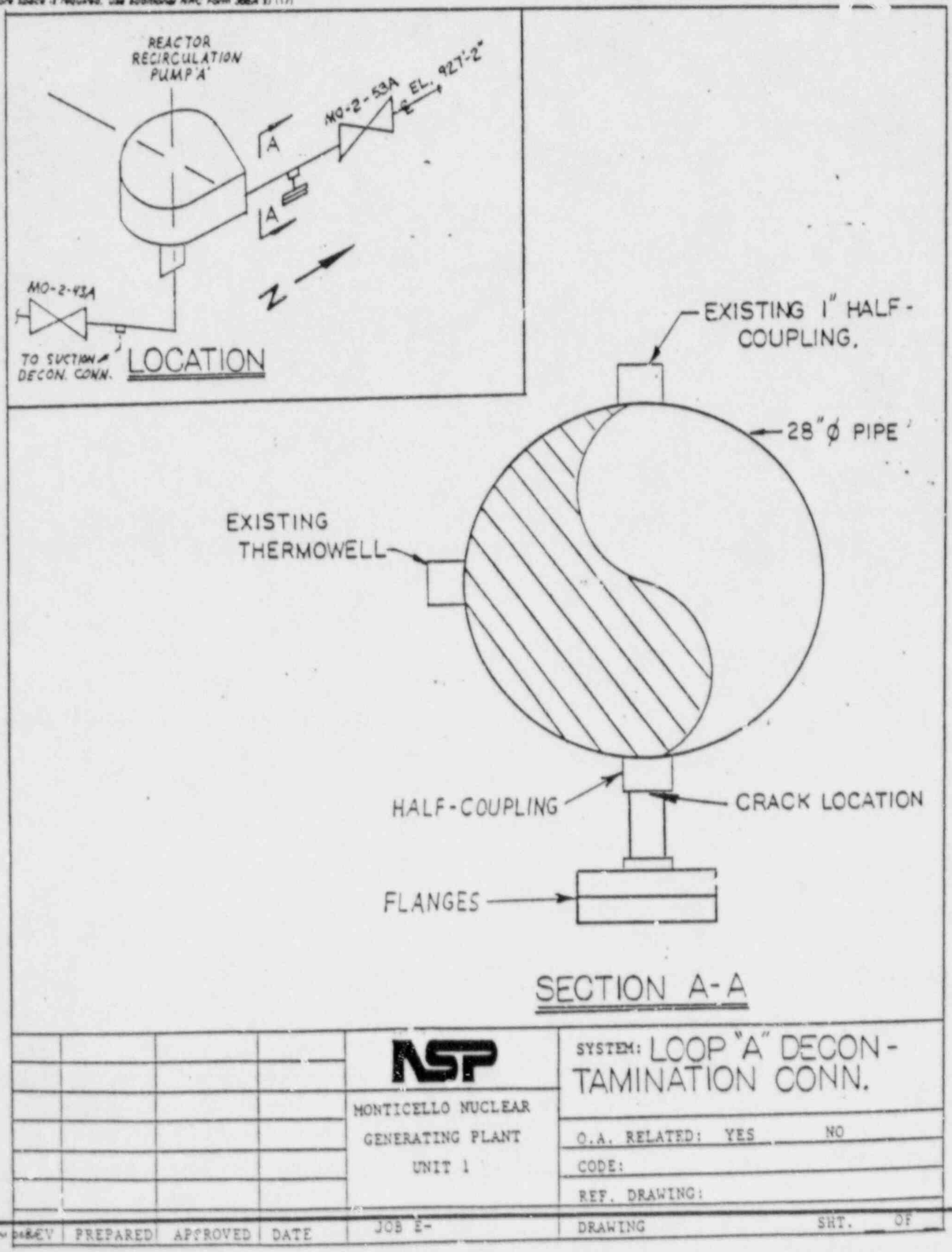
Monticello	0 5 0 0 0 2 6 3	8 7	— 0 2 3	— 0 1	0 4 OF 0 4

TEXT (If more space is required, use additional NRC Form 366A's) (17)



NRC FORM 366A (9-83)

NUCLEAR FUELS AND ENGINEERING SERVICES DEPARTMENT
San Jose, California

cc: G.A. Deaver
J.L. Thompson
E.G. Leff

December 7, 1987

TO: D.E. Larsen,
Northern States Power Co.

FROM: L. K. Liu, Technical Leader [signature]

SUBJECT: Monticello Decon. Pipe Modification

This is to provide you with a summary of the results of GE's investigation into the cause of the recirc. discharge decon. pipe crack and GE's repair recommendations.

I. CONCLUSIONS

1. The crack in the decon. pipe weld is caused by high cycle fatigue induced by resonant vibration of the decon. pipe at the vane passing frequency of the recirc pump.

2. Shortening the decon. pipe length to 2.5 inches would effectively preclude recurrence of vibration fatigue failure.

II. RECOMMENDATION

It is recommended that the decon. pipes on the discharge side of recirc. loops "A" and "B" be shortened to 2.5 inches. On the suction side, only the loop "B" decon. pipe needs to be shortened to 2.5 inches.

III. SUMMARY OF RESULTS

1. ANALYSIS RESULTS

Metallographic examination of the crack in the decon. pipe indicated that the crack was due to high cycle fatigue. The crack had initiated from the outer diameter of the pipe. Based on this it was conjectured that the high cyclic vibratory stresses resulted from a resonant vibration of decon pipe. High amplitude resonant vibration occurs when the natural frequency of the decon. pipe coincides with the vane-passing frequency of the recirculation pump.

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1/4

To evaluate the validity of this resonant vibration theory, the fundamental natural frequency of the decon. pipe with the attached flange was calculated through a finite element model. The finite element model consisted of interconnecting pipe elements to which the heavy flange was attached.

Element properties included shear area, moment of inertia, rotary inertia and material mass. The fundamental frequencies were determined through the MSC/PAL 2 code, a PC-based version of NASTRAN. The calculated frequencies for various pipe lengths and temperature conditions are given in Tables I and II for the discharge and suction sides respectively.

TABLE I
DECON. PIPE NATURAL FREQUENCIES
(DISCHARGE SIDE)

Pipe length (inches)	Loop Temperature (°F)	Fundamental Frequency (Hz)
4.75	cold	137
5.75	cold	120
4.75	550	130
5.75	550	114
5.50	550	118
4.00	550	145
3.50	550	157
2.00	550	198

TABLE II
DECON. PIPE NATURAL FREQUENCIES
(SUCTION SIDE,550 F)

Pipe length (inches)	Loop	Fundamental Frequency (Hz)
6.50	B	91.1
8.75	A	68.0*

*Approximate calculation

Of special interest is the fundamental frequency of 118 Hz. for a pipe length of 5.50 inches, which is the length of the decon. pipe where a crack had developed. The 118 Hz. frequency is very close to the vane passing frequency (equal to five times the pump running speed) of 125 Hz. at rated flow. From this it can be concluded that the probable cause of the high amplitude vibration is the coincidence of the natural frequency and the vane passing frequency.

2. SITE TEST

To validate the theoretical finite element model described above, an impact excited vibration test of the as-built decon, pipe was performed at the site. The test consisted of causing a natural vibration of the decon. pipe through impacting the pipe by an instrumented hammer. The resulting vibration was measured by an accelerometer attached to the flange. The resulting impulse signal from the instrumented hammer and the vibratory signal from the accelerometer are then fed into a structural dynamics analyzer. The resulting transfer function is then used by the analyzer to determine the natural frequencies and other structural properties. The resulting test frequencies for two different directions of vibration for the "A" and "B" loop discharge decon. pipe are shown in Table III.

TABLE III
TEST FREQUENCIES

DIRECTION	LOOP	FREQUENCY (Hz.)
Parallel to recirc. pipe	A	137
Perpendicular to recirc. pipe	A	134
Parallel to recirc. pipe	B	109
Perpendicular to recirc. pipe	B	106

Since the test pipe lengths are 4.75 and 5.75 inches respectively for the "A" and "B" loops, it is clear by comparing the appropriate rows in Tables I and III, that the test frequencies are reasonably close to the calculated frequencies. This validates the finite element model.

IV DISCUSSIONS

From the above results, it can be concluded that a pipe length of between 2.0 and 3.50 inches would remove the pipe natural frequency sufficiently away from the maximum vane passing frequency of 139 Hz. Considering the slight over-estimation of the calculated vs. test frequencies, and to add a small conservatism, it is concluded that a 2.50 inch pipe length would be most appropriate. Thus the recommendation for the discharge side decon,. pipes was made.

The natural frequemcies of the suction side decon. pipes, as shown in Table II, are about 68 and 91 Hz. for the "A" and "B" loops respectively. Based on the test data from a BWR 4/201 plant, where high pressure fluctuations were present at about 99 Hz., it is recommended that the "B" loop decon, pipe be shortened also. Test data also show that the pressure fluctuations decreased rapidly below a vane passing frequency of about 75 Hz. Thus it is concluded that no change need to be made for the "A" suction decon. pipe.

In addition to the four decon. pipes, the likelihood of the other branch lines (connected to the main recirc. pipe) being excited at the vane passing frequency was briefly examined. Based on this cursory examination, no other branch line would be subject to a resonant vibration at the vane passing frequency. Further more detailed studies on these branch lines are continuing.

APPROVED:

J. Jacobson, Manager
Equipment Design Engineering

NUCLEAR FUELS & ENGINEERING SERVICES
San Jose, California

December 8, 1987

cc: L. K. Liu
D. A. Laper
E. O. Swain

To: E. G. Leff

From: J. L. Thompson

Subject: CERTIFIED RECONCILIATION OF MONTICELLO RECIRCULATION STRESS REPORT FOR REDUCTION IN LENGTH OF DECONTAMINATION BRANCH CONNECTION

Reference: Stress Report ASME Section III Class 1 Analysis of Recirculation Lines for Monticello Generating Plant Unit 1 Job No. 10040 Document Number SR-10040-SS1 (Rev. 2).

In order to prevent fatigue cracking of the two inch diameter decontamination branch pipe, GE has recommended that the length of the branch pipe be reduced from approximately six inches to two and a half inches. The reduction in length will increase the fundamental natural frequency of the three branch pipes with blind flanges from approximately 100HZ to 200HZ. The increase in frequency will move the branch and blind flange fundamental frequency above the pump vane passing frequency that is the postulated cause of the cracking. The purpose of this letter is to document that the validity of the referenced stress report in unaffected by the recommended change.

All the factors affecting the stress analysis of the two and a half inch branch connection off recirculation loops A and B have been evaluated as follows:

Internal Pressure	-	Pressure is not affected by the change.
Weight	-	Loads will be reduced because of the reduction of mass and shorter moment arm.
Thermal Expansion	-	Flanges are free ends with no expansion loads.
Thermal Transients	-	There are no geometry changes that will effect thermal transients.
Seismic Loads	-	The measured fundamental frequency of the branch and blind flanges are all above the rigid range frequency of 33HZ. Therefore, the increase in frequency due to shortening of the branch will not effect the dynamic response to seismic loads. The seismic loads will be reduced due to mass and moment arm reduction.

Operating Vibration - The increase in frequency of the flanged branch will reduce operating vibration by moving the fundamental frequency beyond the pump vane passing frequency.

Stress Indices - The reduction of the branch pipe length will not change the branch weld or pipe configuration; therefore, stress indices will not be effected.

Based upon the above evaluation, I a professional engineer, competent in the field of piping stress analysis certify that to the best of my belief and knowledge the reduction in length of the decontamination flange branch pipe will not effect the validity of the reference stress report.

Professional Engineer Jeffrey L. Thompson

Registration Number 9565

State of Registration Maryland Date: Dec. 8, 1987

NUCLEAR FUELS AND ENGINEERING SERVICES
SAN JOSE, CALIFORNIA

January 22, 1988
DL11/vm

cc: R. D. Patel
L. K. Liu
E. G. Leff

TO: Dale Larsen
Northern State Power

FROM: D. A. Laper, Engineer
Plant Piping Analysis
MC 760

SUBJECT: **MONTICELLO RECIRCULATION SMALL BRANCH PIPING VIBRATION**

REFERENCE:

1. Letter to E. Leff from L. Liu dated 12/7/87.
2. Letter to L. Liu from B. Parson, Subject: "Drawing Transmittal", dated 12/7/87.
3. Proposal No. 414-2572-EK1

BACKGROUND

High cyclic vibratory stresses resulted in the crack of the decon pipe weld. The analysis documented in reference 1 determined that the decontamination pipe natural frequency coincided with the vane passing frequency of the recirculation pump. Task F of reference 3 required the determination of whether or not other small branch lines have natural frequencies within the range of the pump vane passing frequencies. The vibration stress depends on the piping configuration for the stress indicies and the frequency contents of the applied excitations relative to the natural frequencies of the piping.

PURPOSE

The purpose of this letter is to report the findings of investigating several small branch piping configurations that could be affected by the input excitation at the vane passing frequencies.

CONCLUSIONS

1. The third mode (83 Hz) of Category 1 lines (lines attached to pumps and valves) of models SL-18, fall within the range of pump vane passing frequencies.

2. The free ends of Category 4 lines responded at 76 Hz and 123 Hz. Also, a portion of the lines may be affected by pump and motor running frequencies (one per Rev.).

3. Failure of the lines identified in (1) and (2) above is not likely due to the large distance between the excitation source and the affected piping. Furthermore, the resonant conditions occur during pump speed variations and not at steady state rated flow. Thus, these components do not pose an immediate concern related to pipe failures.

RECOMMENDATIONS

1) Confirm G.E. assumptions are reasonable.

2) Provide GE complete detailed information on piping, supports, and valves to analyze the RWCU line.

3) Perform a detailed dynamic response analysis to confirm and further substantiate that stresses are sufficiently low so that crack initiation would not occur for the balance of plant life.

4) Perform a field test to confirm analytical projections at the next shutdown for lines designated to be needing further investigation. This test would obtain the excitation frequencies and amplitudes of the large pipes which support the smaller lines. This data could be applied to mathematical models and the stress calculated. Natural frequencies of the selected lines should also be determined by impact tests during the outage.

METHOD

Dynamic analysis of the first few modes of selected piping branches was performed to determine if the natural frequencies of the small branch piping falls in the pump vane passing frequency range of 70 to 160 Hz.

Using a PC and the Code CAEPIPE, the small branch lines were modeled out to the first few supports or anchor. Mode shape runs for the first 3 to 5 modes were reviewed to determine if the natural frequency of the branch line fell between 70 and 160 Hz. Due to the large number of branch lines and similar designs, the lines were grouped into categories and runs made in each category to reduce the number of runs.

The following assumptions were used in the dynamic models:

1) Piping, Schedule 80, full of water, no insulation.

2) 3/4" globe valves weight 7.5 lbs., CG on Pipe Center Line.

3) 1" valve weight 15 lbs., CG on Pipe Center Line.

SUMMARY OF RESULTS

Category 1 - small lines attach to pump and valves.

AB-P-032

Sheet 1 - (Model D-135)

Mode shape run indicates that valve mass is responding at 14 Hz and 22 Hz. Line containing decon branch was not analyzed due to previous field testing.

Sheet 2 - (Model SL-14)

Response of system is at critical location but first three modes are 18, 22 and 28 Hz which are below pump vane passing frequencies, but within pump and motor frequencies.

Sheet 3 - (Model D133)

Response of 1st and 2nd modes (14 and 16 Hz) are close to pump connection but below frequencies of concern.

Sheet 3 - (Model D129)

Line is low frequency (13 and 29 Hz) and the mass responding is located away from discharge valve.

Sheet 3 - (Model SL-18)

Third mode is a 83 Hz and located at first bend from suction valve connection. This line may require further investigation.

Sheet 4 - (Model V-85)

Response is low frequency (18, 22 and 44 Hz) (pump and motor frequencies).

Sheet 4 - (Model V-83)

Response is low frequency (pump and motor frequencies).

AB-P-031

Sheet 2 - (V-84)

Similar design to Model V-85 above.

Category 2 - 3/4" instrument lines running off recirculation piping, and first support is located 10' or more from the recirculation connection.

AB-P-001
AB-P-002
AB-P-003
AB-P-004
AB-P-006
AB-P-007
AB-P-008 Sheets 1 and 2
AB-P-0016
AB-P-0017

All above lines similar to model REW-15. The first three modes are 10, 19 and 23 Hz.

Category 3 - small instrument lines running off recirculation pipe. First support approximately 4' from recirculation line.

AB-P-013 Sheets 1 and 2
AB-P-019 Sheets 1 and 2
AB-P-022

Model P-013
The first three modes are 3, 23 and 48 Hz.

Category 4 - Unsupported mass (valve) cantilevered off small piping runs that connect to recirculation line. Design similar to decon pipe that cracked but lower frequency.

AB-P-009
AB-P-010
AB-P-020
AB-P-025
AB-P-026

Model REW-13A
The lower five modes have frequencies at 9 Hz, 16 Hz, 17 Hz, 36 Hz, 48 Hz. However the free end responded at 56, 78 and 123 Hz corresponding to the 6th, 9th and 10th modes.

Model P-020
Maximum response at the free end for the 5th mode (30 Hz).

Model P-010
Maximum response at the free end for the 2nd and 3rd mode (51 and 54 Hz).

D. A. Laper
D. A. Laper, Engineer
Plant Piping Analysis

Verified by: S. Kao
S. Kao

Approved by: L. K. Liu
L. K. Liu

Approved by: R. D. Patel
R. D. Patel