Northern States Power Company

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May 2, 1994

Report Required by
10 CFR Part 50, Section 50.73

US Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

MONTICELLO NUCLEAR GENERATING PLANT
Docket No. 50-263 License No. DPR-22

Crack on Jet Pump Riser Brace Due to Fatigue

A revised Licensee Event Report for this occurrence is attached. This report modifies corrective actions identified in the original LER submitted on October 16, 1989 and in revision 1 to LER 89-021 submitted on December 12, 1989. This letter contains no new NRC commitments.

Please contact Marv Engen, Sr Licensing Engineer, at (612) 295-1291 if you require further information.

for Roger O Anderson
Director
Licensing and Management Issues

c: Regional Administrator - III, NRC
NRR Project Manager, NRC
Sr Resident Inspector, NRC
State of Minnesota
Attn: Kris Sanda

Attachment

JE22

NRC FORM 366 (5-92) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104
EXPIRES 5/31/95

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
MONTICELLO NUCLEAR GENERATING PLANT	05000 - 263	1 OF 10

TITLE (4): Crack on Jet Pump Riser Brace Due to Fatigue

EVENT DATE (5)			LER NUMBER (6)			REPORT NUMBER (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
09	16	89	94	-- 89-21 --	02	05	02	94		05000
										05000

OPERATING MODE (9): N

POWER LEVEL (10): 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (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)	XX OTHER (Specify in Abstract below and in Text, NRC Form 366A) Update Report
20.405(a)(1)(iii)	50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	
20.405(a)(1)(iv)	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 (Include Area Code)
Pete Kissinger, System Engineer	(612) 295-1081

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
X	AD	SPT	G080	No					

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE)	NO X				

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

A crack was discovered on the upper support brace of one jet pump riser by use of an underwater camera. The crack location is on the lower leaf on the right side (while facing out from vessel centerline) of the upper support brace on the riser for jet pumps 7 and 8.

This event is being reported because of its potential safety significance and generic nature.

Visual inspection of all other riser braces in the vessel were completed. There are no other crack indications on the other leaves of this riser or any other riser in the vessel.

The crack is believed to be the result of high cycle fatigue due to excitation of the resonance of the upper brace leaf due to recirculation pump vane passing frequency. Originally, a finite element analysis concluded that vane passing frequencies at pump speeds greater than 94% were the most probable cause of the cracking. Experimental confirmation of the analytical results in the form of a pressure pulsation test, with an appropriate full scale mockup of the Monticello jet pump and riser brace assemblies, was performed by General Electric Company. Based upon data from this experimental program, we have modified our corrective actions. A safety evaluation was completed to show that this crack has no effect on plant safety.

DESCRIPTION:

On September 16, 1989, with the plant in cold shutdown and the core unloaded, In-Service Inspection (ISI) personnel, during routine inspection, discovered a crack on the upper support brace (SPT) of one jet pump riser (See Figures 1 through 5). Northern States Power and General Electric personnel were performing the ISI.

This event is being reported because of its potential safety significance and generic nature.

The crack is located on the lower leaf on the right side (facing out from the vessel centerline) of the upper support brace on the riser for jet pumps #7 and #8. The crack indication runs about 3/4 of the way across the top of the leaf about 1/2" from the point where it is welded to the vessel wall.

The risers are supported by an upper brace which consists of two leaves on each side of the riser and a lower brace which consists of one thicker leaf. All remaining leaves on this riser and the 9 other risers in the vessel were examined during the 1989 refueling outage with no other indications found. Subsequent re-examinations during the 1991 and 1993 refueling outages revealed no additional cracking of these components of the subject jet pump or any other jet pump.

CAUSE:

A study was originally performed in 1989 to determine the cause of the cracking. The results of that study indicated that the most likely cause of this crack was high cycle fatigue. The natural frequency of the riser brace in its uncracked state coincided with the vane passing frequency of the reactor recirculation pumps (AD) at a speed in the range of 92% to 98% (127 Hz to 135 Hz). The subsequent experimental program carried out at the General Electric facilities in San Jose, California confirmed cycle fatigue as the most plausible cause of the observed cracking. The resonant frequency of the riser brace was determined by this program to be 116.4 Hz based on <u>nominal</u> dimensions of the riser brace leaves and that the actual riser brace frequency varies as a strong function of the riser brace leaf <u>as-built</u> dimensions (thickness and length) and axial loading of the brace. Based on just the allowed thickness tolerance of the riser brace leaf, the most important resonant frequency could actually lie anywhere within a wide range of 108.5 to 152.20 Hz (78% to 109% recirculation pump speed).

Visual inspections indicate that the cracked lower leaf has some cross-sectional reduction (thinning) which may have been caused by grinding performed during weld fit-up. This thinning is unique to this riser brace leaf and appears to have reduced the cross-sectional area by about 30%. It also appears that there is some lack of fusion in the weld at the point on the leaf where the crack initiated. These factors, thinning, work hardening from grinding and lack of weld fusion, may have contributed to the cracking of this riser leaf by making it more susceptible to any of the possible crack initiating mechanisms (i.e. resonance, IGSCC, ductile tearing).

ANALYSIS:

The lower riser brace leaf (Leaf #3 in Figure 1) has a calculated natural frequency of 358 Hz, which is well removed from resonant conditions. Therefore resonance is not expected to occur at the lower brace. Evaluation of normal and accident jet pump loading indicates that stresses with only the lower brace in place are within acceptable limits. This shows that the loss of the entire upper brace would not affect the operability of the risers or the associated jet pumps.

All of the riser brace leaves have been visually inspected by Inservice Inspection personnel during the 1989, 1991 and 1993 refueling outages with no other crack indications or thinning found. The 1992 test program performed at GE facilities shows that adequate operational strategies are in place that minimize the concern for additional fatigue cracks. Operation of the Hydrogen Water Chemistry system reduces the possibility of IGSCC occurring in other riser brace leaves.

The operational strategies that are in place are based on the combined analytical and test program results and understanding. The first mode of resonance (out of phase motion) occurs in these riser brace leaves at recirculation pump speeds in the range of 70% to 80%; but, the stresses during this mode of resonance are not large enough to be a fatigue concern. The second mode of resonance (in phase motion), which was originally calculated to occur in the 92% to 98% pump speed range, is the only mode which is capable of producing stresses with an amplitude high enough to produce fatigue cracking. Insights from the 1992 test program, however, have shown that no benefit is derived from placing upper limits on the allowable recirculation pump speeds. The sensitivity of the second modal resonance frequency to the as-built riser brace leaf thickness indicates that a prohibitively broad range of pump speeds would have to be proscribed to ensure that no potentially resonant frequencies would be encountered. The test program also indicated that prolonged resonance of the riser brace leaf is self-limiting. As a crack proceeds and grows after initiation, the frequency of the second mode resonance and the amplitude of vibration decreases as the crack increases in length. The test program also indicated that resonant frequencies have a narrow width of only a few Hz. Thus, sudden and rapid crack growth is unlikely since the initiation and/or growth of a crack alters the natural resonance of the riser brace leaf. If the riser brace leaf should completely break off on one end, its subsequent resonant frequency is significantly different due to the altered geometry and complete severance of the riser brace leaf is improbable.

The as-clad weld surface of the vessel has an additional weld pad buildup at these locations and riser braces are then welded to the pad. The crack is entirely within the base-metal of the brace, follows the toe of the weld and has no indications of branching. This is indicative of fatigue cracking and not IGSCC. Crack propagation into the weld metal by fatigue is highly unlikely because of geometry and the nature of the stress loading. Propagation into the weld metal by IGSCC is unlikely because of the greater weld metal resistance to IGSCC.

The potential effect of loose parts has also been evaluated. If the cracked riser brace leaf becomes detached from its current position on the jet pump riser, the part would fall to the bottom of the shroud annulus region and rest undisturbed on the top of the jet pump support plate. This is based on the fact

that the riser brace leaf is shielded from the recirculation inlet nozzle by jet pumps #8, #9 and #10 (See Figure 6) making it unlikely that it could be entrained by the recirculation suction flow during its fall to the bottom of the shroud annulus region. As the part is not expected to migrate to the core region via the recirculation loop flow, there is a negligible potential for fuel bundle flow blockage and subsequent fuel damage. For the same reason, there is virtually no potential for interference with control rod drive operation. However, if the jet pump riser brace directly above the recirculation loop suction nozzle is assumed to fail, the riser brace leaf may be carried into the recirculation piping due to suction flow. The following paragraphs describe the potential consequences of a loose part migrating to other portions of the recirculation system and reactor vessel.

Considering the size of the part, it is possible that it may cause some damage to the recirculation pump internals. However, there is no safety implication with respect to the plant's operation since this postulated recirculation system failure is bounded by the recirculation pump seizure event previously analyzed for and documented in Chapter 14 of the Updated Safety Analysis Report (USAR). The impact energy of this loose part exiting through the pump impellers will not be sufficient to damage the pump casing and degrade the pressure boundary integrity.

To cause flow blockage at a fuel bundle, the part must migrate to the vessel lower plenum and then be carried by flow towards the core region. Since the jet pump nozzle diameter is 3 inches, any part less than 3 inches in any one dimension is capable of exiting the jet pump nozzle and being discharged into the lower plenum of the reactor vessel. Based on the flow velocity regime at the vessel lower plenum, it is estimated that any part 2.4 inches or less in diameter could be lifted by the flow and carried toward the core region.

Parts of this size are expected to go through the fuel support inlet orifice but will be trapped at the lower tie plate grid. To initiate boiling transition in a fuel bundle, the part would have to cause a fuel bundle flow blockage of 59% or more, which corresponds to an 86% blockage at the lower tie plate. To achieve 86% flow blockage at the lower tie plate grid would require at least 4 pieces of 2.4 inches by 2.4 inches migrating to the same fuel bundle (out of 484 bundles in the core). The probability for such an event is about 9E-9 and is therefore considered negligible.

To cause potential interference with control rod operation, the part must migrate through the spacers located along the length of the fuel bundle and exit at the top of the core. It must then reverse direction against the flow to drop into a control rod guide tube via the bypass region. To complete this tortuous path, the part must be very small (less than 0.1 inches) and for such a small part, the control rod drive hydraulic forces are more than adequate to overcome any potential mechanical friction. Therefore, there is no potential for interference with control rod operation.

Since the riser leaf is made from stainless steel, an approved material for in-reactor use, there is no concern for corrosion or chemical reaction with other reactor materials.

CORRECTIVE ACTION:

Initially, recirculation pump speed was limited to 94% as calculations indicated that the resonant frequency was greater than 94%. Additional information is available at this time:

> The General Electric full scale test has shown that the resonant frequency may be lower than 94% and varies considerably with actual physical dimensions.
>
> The testing has demonstrated that the cracking is self-limiting.
>
> Two re-examinations during refueling outages have found no additional deterioration in the subject brace leaf or in others.

The plant safety evaluation concluded that if a brace leaf separated from the vessel and the jet pump, it would not cause a safety problem.

Considering that the recirculation pump speed cannot practically be limited to avoid resonant frequencies, and the conclusions of the test program, the limitation on recirculation pump speed has been removed.

These riser brace leaves will continue to be inspected during refueling outages in accordance with the Monticello Inservice Inspection Program.

A Nuclear Network transmittal was initially made to alert other utilities.

ADDITIONAL INFORMATION:

1. Failed Component Identification: GE Designed Jet Pump Riser Brace

2. Previous Similar Events: NONE

3. Attached Figures.

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APPROVED BY OMB NO. 3150-0104
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LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Monticello Nuclear Generating Plant	05000 - 263	94	- 89-21 -	02	6 OF 10

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

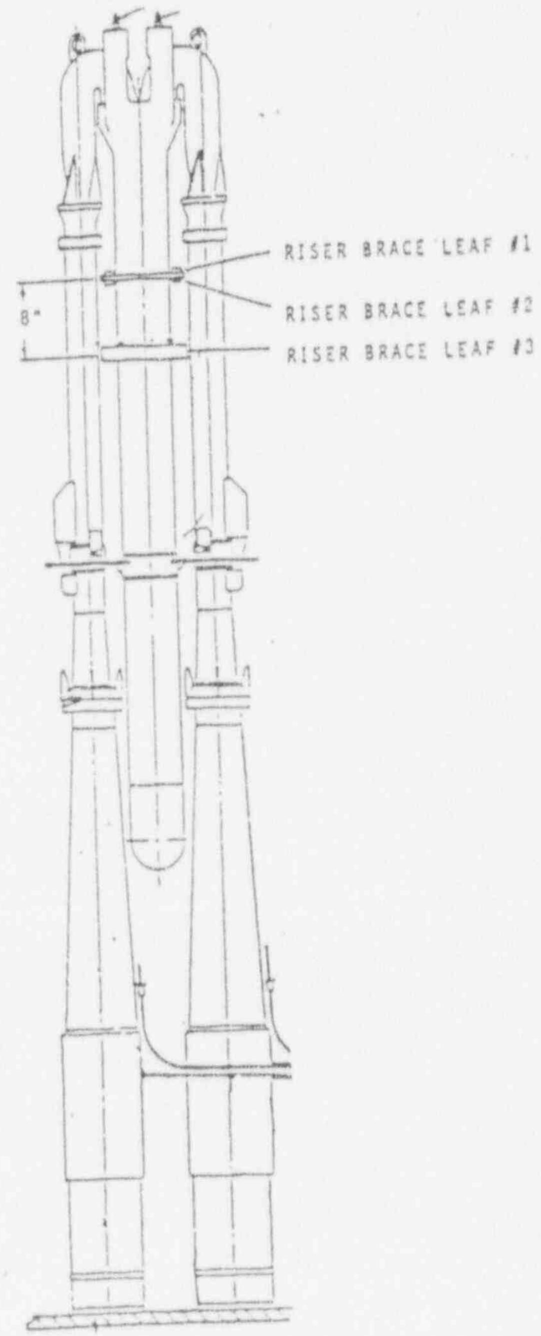

Figure 1. Jet Pump Assembly

NRC FORM 366A (5-92) U.S. NUCLEAR REGULATORY COMMISSION

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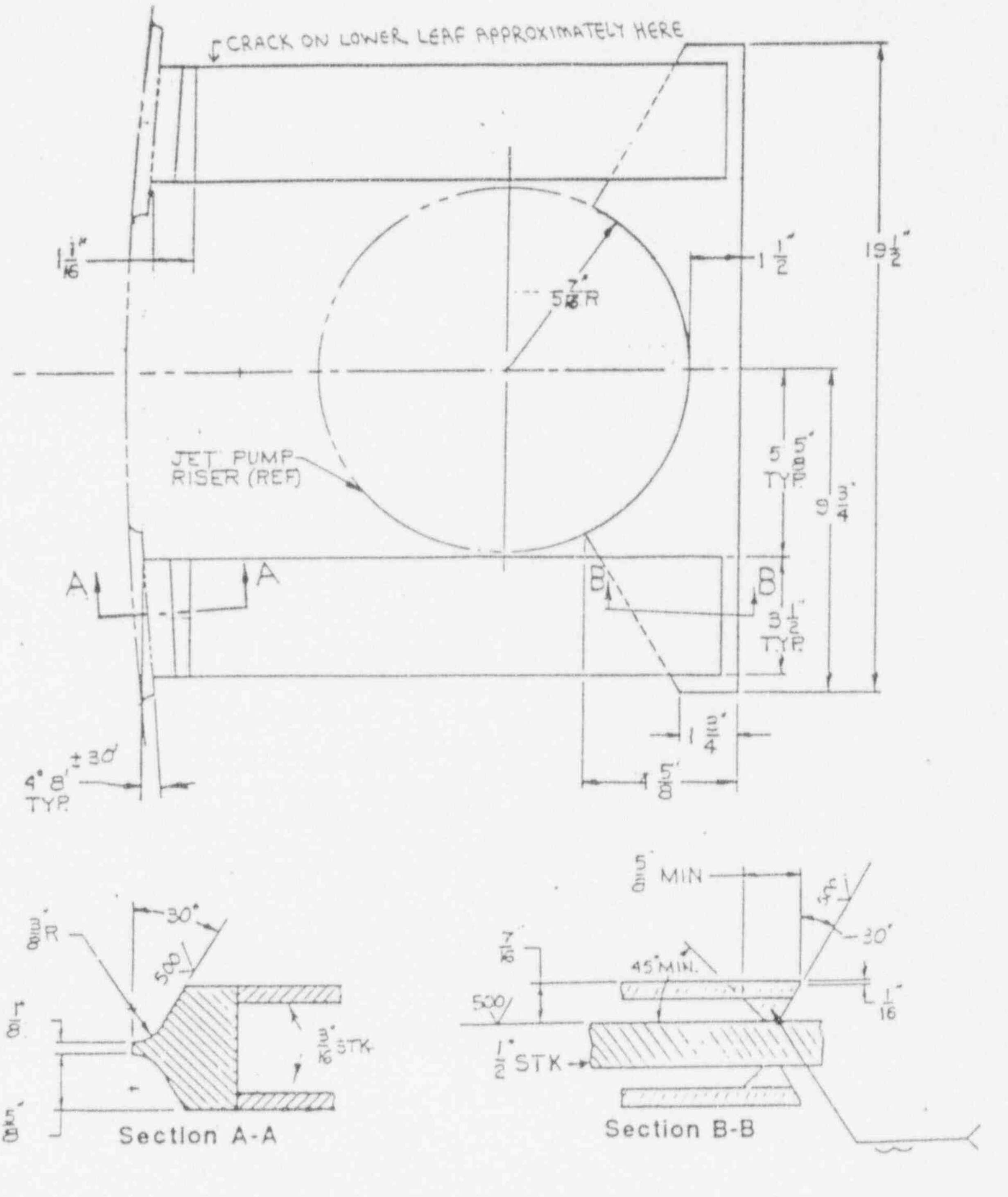

Figure 2. Upper Jet Pump Riser Brace

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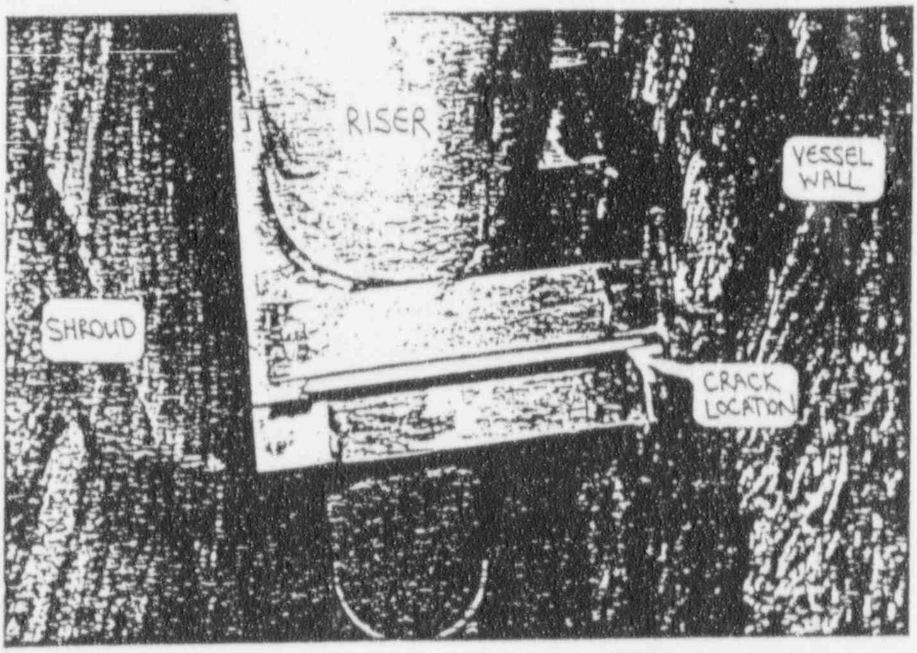

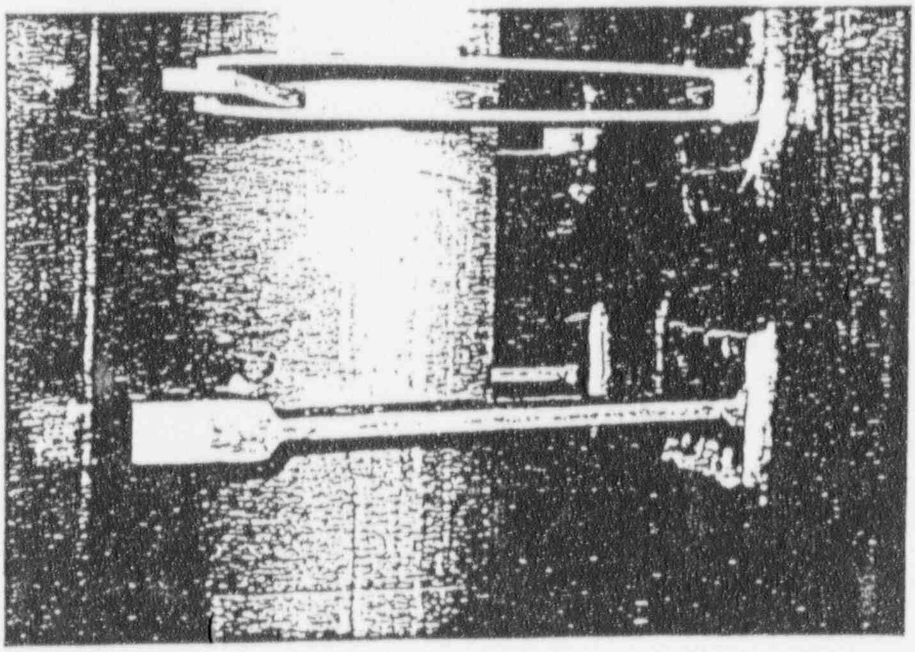

Figure 3. Construction Photos of Riser Braces

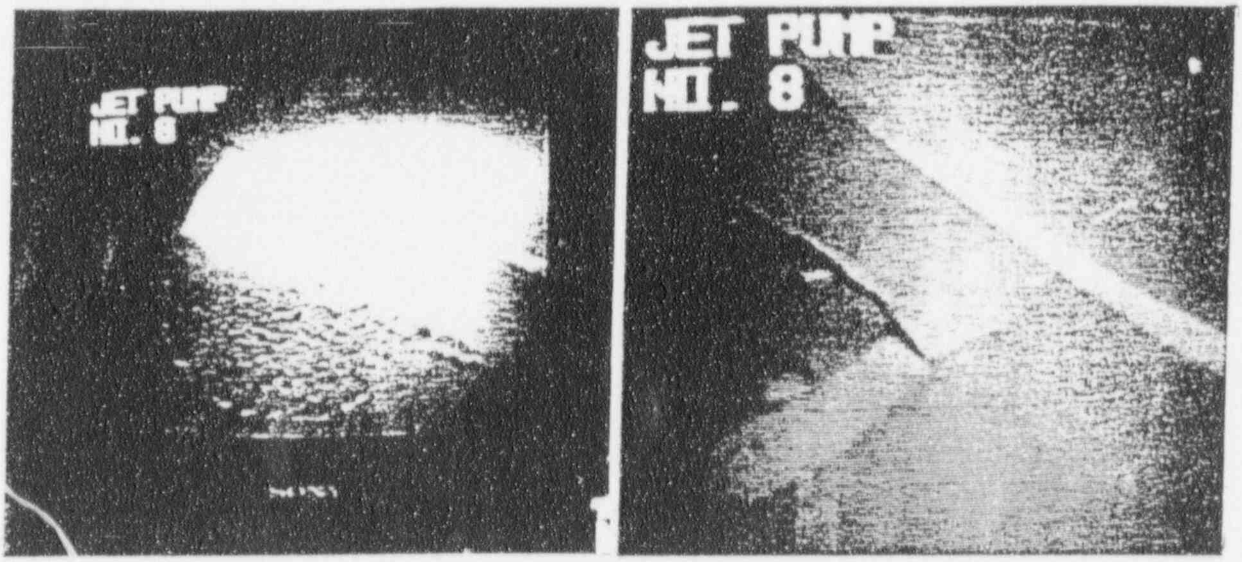

Figure 4. Top View of Cracked Leaf

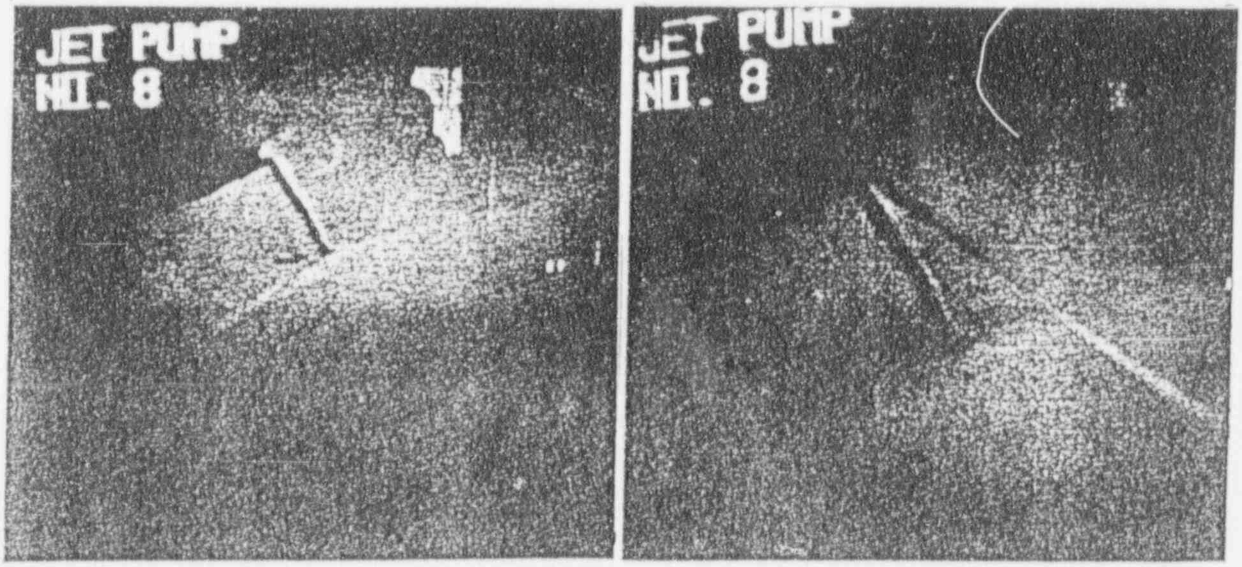

Figure 5. Side View of Cracked Leaf

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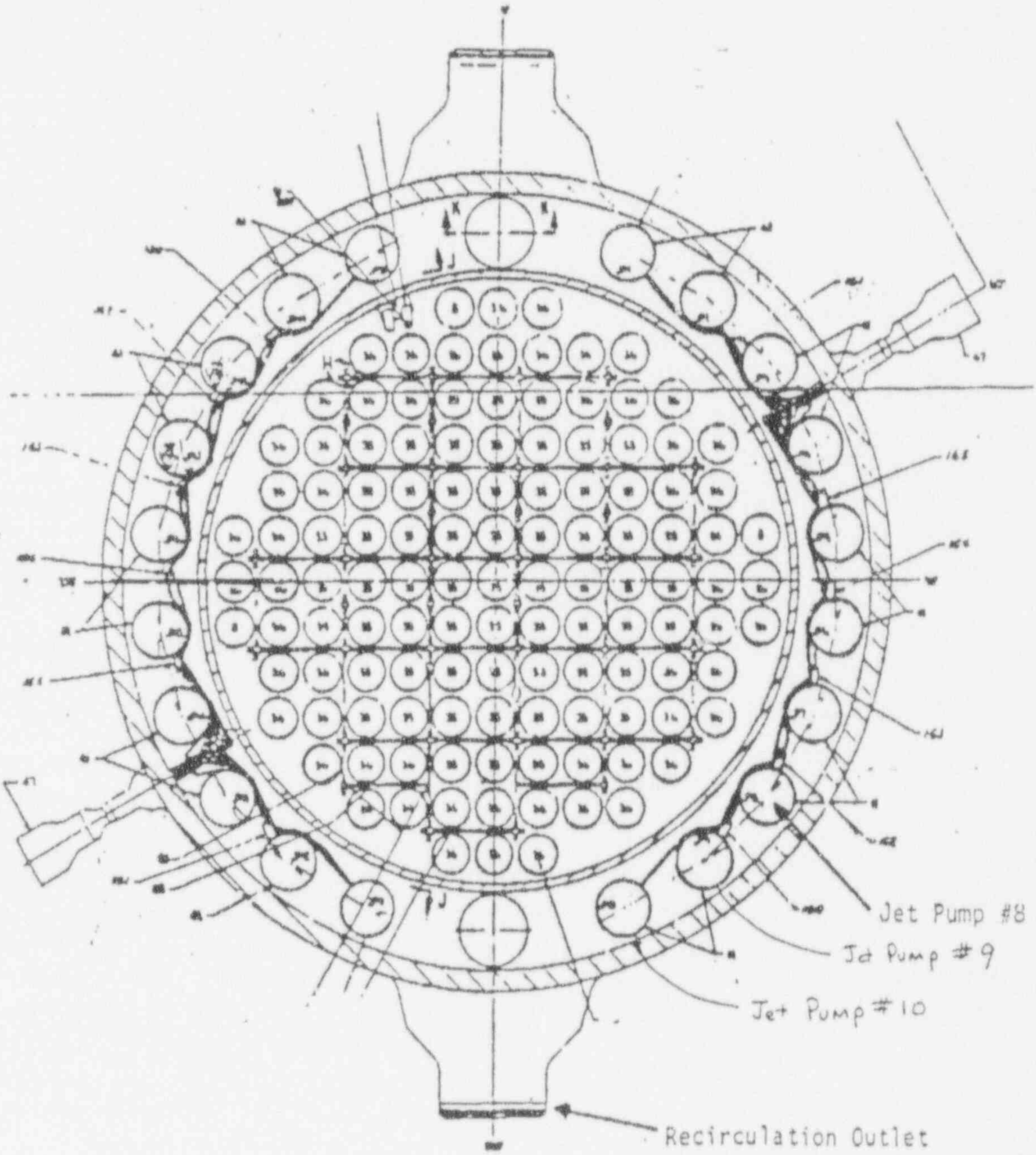

Figure 6. Jet Pump Arrangement