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10CFR50.73

April 21, 1994
NRC-94-0026

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

References: 1) Fermi 2
NRC Docket No. 50-341
NRC License No. NPF-43

2) Licensee Event Report
93-015, dated January 25, 1994

Subject: Licensee Event Report (LER) No. 93-015-01

Please find enclosed LER No. 93-015-01, dated April 21, 1994, for a reportable event that occurred on December 26, 1993. A copy of this LER is also being sent to the Regional Administrator, USNRC Region III.

If you have any questions, please contact Joseph M. Pendergast, Compliance Engineer, at (313) 586-1682.

Sincerely,

DRGipson

Enclosure: NRC Forms 366, 366A

cc: T. G. Colburn
J. B. Martin
M. P. Phillips
K. R. Riemer
P. L. Torpey

Wayne County Emergency
Management Division

IE22

NRC FORM 366 (5-92)	U.S. NUCLEAR REGULATORY COMMISSION	APPROVED BY OMB NO. 3150-0104 EXPIRES 5/31/95
	LICENSEE EVENT REPORT (LER) (See reverse for required number of digits/characters for each block)	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.

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Fermi 2	05000 341	1 OF 7

TITLE (4) Failure of Reactor Recirculation Pump B Discharge Valve B3105-F031B to Close

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
										05000
12	26	93	93	015	01	04	21	94	FACILITY NAME	05000

OPERATING MODE (9)	3	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)							
POWER LEVEL (10)	0		20.402(b)		20.405(c)		50.73(a)(2)(iv)		73.71(b)
			20.405(a)(1)(i)		50.36(c)(1)	X	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)		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)
Joseph M. Pendergast - Compliance Engineer	(313) 586-1682

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

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

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

On December 26, 1993 at 0520 hours while preparing to place Division 2 of the Residual Heat Removal [RHR] system into service for the Shutdown Cooling [SDC] mode of operation, valve B3105-F031B, the "B" loop recirculation pump discharge valve, failed to fully close. The plant was brought to Cold Shutdown within the 24 hours as required by the applicable Technical Specification Action Statement and SDC was established using division 1 RHR. On December 28, maintenance personnel inspected the valve's limit switch compartment and found three wires from the torque switch to the limit switch broken at the crimp of their respective lugs. The three wires were relugged and reconnected. On December 29, at 0235 hours the valve was successfully stroked and declared operable.

The root cause was determined to be the coincident natural frequency of the wire bundle and the valve's yoke, in conjunction with the pump operating speed causing the vibration induced fatigue observed.

Corrective actions include changing the resonant frequency of the wire bundles by restraining or retraining the bundles, using a more flexible wire, changing procedures, and training.

REQUIRED NUMBER OF DIGITS/CHARACTERS
FOR EACH BLOCK

BLOCK NUMBER	NUMBER OF DIGITS/CHARACTERS	TITLE
1	UP TO 46	FACILITY NAME
2	8 TOTAL 3 IN ADDITION TO 05000	DOCKET NUMBER
3	VARIES	PAGE NUMBER
4	UP TO 76	TITLE
5	6 TOTAL 2 PER BLOCK	EVENT DATE
6	7 TOTAL 2 FOR YEAR 3 FOR SEQUENTIAL NUMBER 2 FOR REVISION NUMBER	LER NUMBER
7	6 TOTAL 2 PER BLOCK	REPORT DATE
8	UP TO 18 -- FACILITY NAME 8 TOTAL -- DOCKET NUMBER 3 IN ADDITION TO 05000	OTHER FACILITIES INVOLVED
9	1	OPERATING MODE
10	3	POWER LEVEL
11	1 CHECK BOX THAT APPLIES	REQUIREMENTS OF 10 CFR
12	UP TO 50 FOR NAME 14 FOR TELEPHONE	LICENSEE CONTACT
13	CAUSE VARIES 2 FOR SYSTEM 4 FOR COMPONENT 4 FOR MANUFACTURER NPRDS VARIES	EACH COMPONENT FAILURE
14	1 CHECK BOX THAT APPLIES	SUPPLEMENTAL REPORT EXPECTED
15	6 TOTAL 2 PER BLOCK	EXPECTED SUBMISSION DATE

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

Initial Plant Conditions:

Operational Condition: 3 (Hot Shutdown)
Reactor Power: 0 percent
Reactor Pressure: 110 psi
Reactor Temperature: 330 degrees Fahrenheit

Description of the Event:

On December 25, 1993 at 1315 hours an automatic Reactor shutdown occurred following a failure of the Main Turbine [JJ]/Generator [EL] system.

On December 26, at 0520 hours while preparing to place division 2 of the Residual Heat Removal [(RHR)(BO)] system into service for the Shutdown Cooling [SDC] mode of operation, valve [V] B3105-F031B, the "B" loop recirculation [AD] pump [P] discharge valve, failed to indicate fully closed after attempting to close the valve. Operations personnel [Utility Licensed] were unable to verify that the discharge valve was open or closed from the control panel indication. The valve's control panel indication was in the mid-position.

Initial troubleshooting at the motor control center determined the problem was at the valve which is located in the Drywell [NG]. Low Pressure Coolant Injection [(LPCI)(BO)] loop selection prefers and depends on valve B3105-F031B being able to close and therefore both LPCI subsystems were considered inoperable. Technical Specification Action Statement 3.5.1.b.4 was entered. Operations personnel directed the LPCI loop select logic to select the "A" loop in order to establish an operable injection flow path. The "A" loop of RHR was then placed in SDC and the plant was brought to Cold Shutdown within the twenty-four hours required by Technical Specifications.

On December 28, following de-inerting of the Drywell, valve B3105-F031B was visually verified not fully closed. The valve was approximately two-thirds open. Subsequently, maintenance personnel [Utility Non-Licensed] inspected the valve's limit switch compartment and found three wires out of a four-wire bundle from the torque switch to the limit switch broken at the edge of the crimp inside their respective lugs, located at the limit switch upper fingerboard. The wires were relugged and reconnected. On December 29, at 0235 hours the valve was successfully stroked and declared operable.

Cause of the Event:

This event occurred because three of the four wires between the torque switch and the limit switch fingerboard were broken. Open circuit wires numbered, 45, 43 and close circuit wire numbered 55, at the limit switch upper fingerboard terminations numbered 5, 5C and 1C (i.e., located on the upper limit switch outer edge terminals) were broken at the edge of the crimp inside their lugs. This condition disabled both the open and close circuits of this valve.

When access to the Drywell was made available, the limit switch compartment was inspected. There was no indication of arcing or heat residue. The limit switch and the torque switch were inspected and no discrepancies were found. All remaining wiring and terminations in the limit switch compartment were inspected and no other discrepancies were observed.

Subsequent to the initial inspection, all four wires between the torque and limit switches (i.e., the three broken wires and one that was not broken) were removed. These wires, together with one lug from which a wire was detached, were sent to the testing laboratory of the Technical and Engineering Services department of Detroit Edison for physical and chemical testing.

The wire failures occurred inside the lugs, just at the edge of the crimp. There was no evidence of cracking at any other location on the strands. The fingerboard end lug was removed from the unbroken fourth wire. The wire was examined and found to have one fractured strand. The other six strands had no visible sign of distress. The lug was the proper size and the crimp was the proper size, and had been properly compressed.

Examination of the failure ends in the scanning electron microscope revealed that the mode of failure was reverse bending fatigue. All strands in the wires had similar failure characteristics. The predominant fracture area was fatigue with a narrow band, on the ridge of the final fracture, characterized as ductile. Examination of the fractures through a wide field microscope revealed that the fracture propagated over a period of time. This was evident mainly by discoloration on portions of the fracture, progressively less toward the final fracture zone. This examination also revealed other fracture characteristics that strongly suggested that the fatigue was high cycle, low stress.

There was no sign of environmentally induced (e.g., corrosion assisted) fatigue. There was no nicking or cutting of the wire that would indicate a crimping problem. Hardness and bend tests were performed. The hardness was similar to that of new wire. Chemical tests were also performed. The chemical composition was similar for both the old and new wire samples tested.

Overall, results indicated vibration induced fatigue to be the failure mechanism. As a part of the investigation, the following additional actions were taken:

1. Replaced and relugged internal wires in the motor operator for the suction and discharge motor operated valves (MOVs) in both divisions of the reactor recirculation system. For better flexibility, conductors with a minimum of 19 strands were used. All wires removed were tested at Detroit Edison's testing laboratory and results indicated, no other vibration induced fatigue, and that some wires had broken strands but these breaks appeared to be due to handling, twisting or bending (ductile). It was noted that the training of the four-wire bundle on the B3105-F031B was different than the training of the other three reactor recirculation MOVs. It was longer and looser with greater mass and less stiffness.

2. Reviewed available vibration data taken since initial plant start up through power uprate. Data on reactor recirculation pumps and piping are well within acceptable levels.

3. The four-wire bundle was simulated to best represent its installed configuration and a shake test was performed. The bundle appeared to have a resonant frequency of approximately 23 Hz. This resonant frequency will change slightly with different lengths or bends.

4. A finite element computer analysis of the reactor recirculation system revealed that the valve yoke and motor operators have a resonant frequency between 20-25 Hz with peak displacements at approximately 24 Hz. This is consistent with the resonant frequency of 23.6 Hz obtained in the original valve manufacturer (Lunkenheimer) shaker test.

5. Field measurement of vibration data on the reactor recirculation discharge valve was taken when the valve was closed with division 2 of the RHR system in the Shutdown Cooling Mode. The valve yoke's displacement was at approximately 1 mil peak to peak and at approximately 18 Hz.

6. To further substantiate the investigation, Detroit Edison personnel reviewed the failure history of the reactor recirculation loop components and the past performance of these discharge valves. No similar failures were found. Detroit Edison personnel further surveyed the industry and consulted

with Limitorque, the original manufacturer of the motor operator. There has not been a similar failure reported by organizations contacted.

The root cause of this event was determined to be the coincident natural frequency of the wire bundle and the valve yoke, in conjunction with the pump operating speed, causing the fatigue failure mechanism observed. The reactor recirculation pump is a variable speed pump. With the valve yoke's resonant frequency at approximately 23 to 24 Hz, this corresponds to approximately 83% to 86% of the B reactor recirculation pump speed. In the last 3 years, the reactor recirculation pumps operated approximately 80 days in this speed range. This pump speed coincides with the natural frequency of the wire bundle. The vibration displacement is further amplified when this pump speed also coincides with the natural frequency of the valve yoke on which the motor operator is mounted.

The pump was last operated within this speed range (i.e., 83% to 86%) from December 7, 1993 through December 14, 1993. The valve successfully stroked on September 19, 1993. The failure therefore, most likely occurred between December 7, 1993 and December 14, 1993.

A risk assessment of similar MOV failures was performed. Significant factors used for screening criteria were:

1. Only MOVs in variable speed systems were considered. This failure was caused by coincidental alignment of causal factors, one of which was the pump speed. Some amount of time was needed at causal factor alignment to create the damage. Any MOVs in constant speed systems that are routinely run, would have failed by now.

2. Only MOVs with a 2-arm yoke design were considered. The 2-arm yoke design has potential for a low frequency resonance resulting in higher vibration-induced displacements. Three or four-arm designs show opposition to displacement in all directions, effectively nullifying any resonant effects.

3. Only valves having a resonant frequency within the operating speed of the subject systems were considered. The coincident resonant frequency between the pump speed and the valve, further provides the amplification factor on the operator and on the wire bundle.

Based on these criteria, a total of 11 MOVs were identified as potentially having a similar susceptible failure. The training of these wire bundles will be inspected. If necessary, appropriate actions(s) will be taken to eliminate any susceptibility to this kind of failure prior to re-start from the current fourth refuel outage.

Analysis of the Event:

The failure of valve B3105-F031B to close is bounded by the Updated Final Safety Analysis Report section 6.3.3 for a large break Loss of Coolant Accident coincident with a LPCI injection valve failure. This single failure leaves two Core Spray [BM] divisions, the High Pressure Coolant Injection [BJ] and the Automatic Depressurization [RV] systems operable. The peak cladding temperature result for the design basis accident is 2084 degrees Fahrenheit.

An analysis was performed and was described by Licensee Event Report 88-032, "Recirculation Pump B Discharge Valve Failure to Close". The analysis did not take credit for the B3105-F031B valve closure. The analysis concluded that the majority of the LPCI flow would go through the downcomer region of the Reactor Vessel and out the postulated break. However, it is expected that at least 15 percent (or greater) LPCI flow would actually inject resulting in an acceptable Peak Cladding temperature calculation below 2200 degrees Fahrenheit per 10 CFR 50, Appendix K requirements. Further, analysis using realistic models and assumptions to evaluate this event without any LPCI flow and assuming a single failure (i.e., one Core Spray division and the High Pressure Coolant Injection [BJ] or Automatic Depressurization [RV] systems available) concludes adequate core cooling would be provided.

Corrective Actions:

The four wires (i.e., three broken and one unbroken) from the torque switch to the limit switch in B3105-F031B were replaced. The wires were replaced with more flexible wire, and retrained to mitigate vibration induced fatigue.

The remainder of the limit switch compartment internal wires within the "B" loop discharge valve operator B3105-F031B as well as B3105-F023B, the recirculation pump "B" suction valve, the "A" loop recirculation pump discharge valve B3105-F031A and suction valve B3105-F023A, have all been replaced and relugged. For other susceptible MOVs, an inspection will be performed and the bundles will be retrained as needed prior to re-start from the current fourth refuel outage.

NRC FORM 366A (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)
TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
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TEXT (If more space is required, use additional copies of NRC Form 366A) (17)

In order to prevent recurrence, affected maintenance procedures will be revised to address the potential coincident resonant frequency of the wire bundle and its associated system. This can be accomplished by removing or not installing tie wraps, restraining the bundle to other rigid structures, or retraining the bundle to mitigate vibration induced fatigue. Implementing any of these options would place the natural frequency of the wire bundle outside of the normal steady state operating speed of the associated system. To further increase the flexibility of the wire, conductors with a minimum of 19 strands will be used in future MOV applications. Training of craft personnel will then be performed incorporating the lessons learned from this incident. All identified actions will be completed prior to plant restart from the present refuel outage.

Previous Similar Events:

Licensee Event Reports 88-032 and 88-032-01 described a condition where the recirculation pump "B" discharge valve failed to close because of loose connections on the torque switch terminals and an improper installation and setting of the torque switch.