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January 9, 1996
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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

South Texas Project
Unit 1
Docket No. STN 50-498
Voluntary Licensee Event Report 95-012
Residual Heat Removal Pump Impeller Cracks due to Improper Manufacturing Processes

South Texas Project submits the attached Unit 1 Voluntary Licensee Event Report 95-012 regarding Residual Heat Removal pump impeller cracks. This event did not have an adverse effect on the health and safety of the public.

If you should have any questions on this matter, please contact Mr. E. D. Halpin at (512) 972-7849 or me at (512) 972-7162.

S. E. Thomas
Manager, Design Engineering

DBS/dbs

Attachment: Voluntary LER 95-012 (South Texas, Unit 1)

IE22

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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)
South Texas Unit 1	05000 498	1 OF 4

TITLE (4) Residual Heat Removal Pump Impeller Cracks due to Improper Manufacturing Processes

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 NAME	DOCKET NUMBER 05000
09	26	95	95	-- 012 --	00	01	09	96	FACILITY NAME	DOCKET NUMBER 05000

OPERATING MODE (9)	1	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)			
POWER LEVEL (10)	100	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)	X OTHER
		20.405(a)(1)(iii)	50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	(Specify in Abstract below and in Text, NRC Form 366A)
		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)	VOLUNTARY

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
David Schulker - Consulting Engineering Specialist	(512) 972-8517

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
B	BP	P	P025	N						

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 September 26, 1995, Unit 1 was in Mode 1 at 100% power when maintenance personnel, replacing gaskets on Residual Heat Removal (RHR) Pump 1C, noticed cracks on the pump impeller. The RHR pump had been removed from service on September 25, 1995 at approximately 0400 for preplanned maintenance. The impeller was visually inspected and evaluated by South Texas Project Technical Support Engineering. Based on this inspection and discussions with the control room staff, the impeller was removed for additional examination and replaced with a spare on September 27, 1995. On September 28, 1995, the cracked impeller was shipped offsite for examination to determine the cause and mechanism of impeller cracking. RHR Pump 1C was returned to operable status on September 29, 1995 at 0200 hours.

The cause of this event was improper manufacturing of the impeller. Corrective actions include replacement of the RHR Pump 1C cracked impeller with a spare impeller, completion of a detailed engineering evaluation and report, establishing appropriate engineering hold points to ensure quality manufacturing performance for future purchases of spare RHR impellers, and future visual inspections of Emergency Core Cooling System (ECCS) pump impellers as opportunities arise during other corrective/preventative maintenance activities.

DESCRIPTION OF EVENT:

On September 26, 1995, Unit 1 was in Mode 1 at 100% power when maintenance personnel, replacing gaskets on RHR Pump 1C, noticed cracks on the pump impeller. The RHR pump had been removed from service on September 25, 1995 at approximately 0400 for preplanned maintenance. The cracked impeller was shipped offsite to facilitate a detailed metallurgical examination. Utilizing a spare RHR pump impeller, RHR Pump 1C was returned to operable status on September 29, 1995 at 0200 hours.

The RHR pumps are Model 8X24 SPF single stage pumps manufactured by the Pacific Pumps Division of the Ingersoll-Dresser Pump Company. The pumps were manufactured in accordance with Westinghouse Equipment Specification 952455 as ASME III, Class 2 active pumps. The original RHR pump impellers, including the cracked impeller removed from RHR Pump 1C, were manufactured in 1977-1978 at the Hanford Foundry for Pacific Pumps, Inc. (now owned by Ingersoll-Dresser, Inc.).

The RHR impeller is of the radial, single-suction, closed type design. Water enters the suction eye on the bottom of the pump and is discharged radially to the periphery of the impeller. The impeller is constructed of ASTM A296, Grade CA40, martensitic stainless steel.

Visual and dye penetrant examinations revealed cracks at three different locations: axial cracks on the outside diameter surface of the suction wear ring, cracks adjacent to weld repairs in the impeller vanes, and circumferential cracks in the radius region above the suction wear ring.

Additionally, South Texas Project enlisted industry expertise in the review of analyses and in the impeller cracking root cause determination. While common causal factors exist for all of the identified cracks, different root causes led to crack initiation/propagation.

The axial cracks on the suction wear ring were initiated by stress corrosion cracking. This determination is based on the crack morphology, fractographic examination, and micrographic examination. The root cause of the axial cracks was improper flame hardening of the wear ring which caused the wear ring material to become susceptible to stress corrosion cracking. Specifically, the flame hardening was not applied to sufficient depth and was improperly overlapped. This resulted in increased residual tensile stresses in the material, thereby increasing its susceptibility to stress corrosion cracking.

The cracks adjacent to the vane weld repairs were initiated by stress corrosion cracking. Chemical composition testing of the weld repairs that cracked indicated that the weld filler material was an austenitic wire instead of a martensitic wire as specified in vendor procedures. The use of an austenitic weld filler on a martensitic base material resulted in larger residual tensile stress due to the different coefficients of thermal expansion between the steels. Also, this stress loading would be exacerbated when thermal stresses are applied. The root cause of the weld repair area cracks was the use of improper weld filler material during weld repairs. The use of dissimilar metals in these repairs increased the heat affected zone's susceptibility to stress corrosion cracking.

The circumferential cracking above the suction side wear ring was also initiated by stress corrosion cracking. This determination is based on fractographic and micrographic examination of the crack morphology. Over-machining in the radius region of the impeller coupled with flame hardening along the wear ring probably contributed to increased residual tensile stresses in these areas. It is likely that stress corrosion cracking initiated the cracks in this area and also facilitated propagation until the cracks arrested in the thicker vane material. The root cause of the cracks in the radius region was improper machining of the impeller. The residual stresses, in combination with the induced thermal stresses, made the material susceptible to stress corrosion cracking.

CAUSE OF EVENT:

The cause of this event was improper manufacturing of the RHR pump impeller. Inappropriate manufacturing processes included improper flame hardening of the wear ring, incorrect weld material utilized in weld repairs, and over-machining of the radius region.

EVENT ANALYSIS:

On September 25, 1995 at approximately 0400, RHR Pump 1C was removed from service for preplanned maintenance. The allowed outage time for a single train of RHR in accordance with the South Texas Project Technical Specifications is seven days. Utilizing a spare RHR pump impeller, RHR Pump 1C was returned to operable status on September 29, 1995 at 0200 hours, well within the Technical Specification allowed outage time for the RHR pump.

A recognized industry expert was contracted to evaluate the condition of the cracked RHR pump impellers for continued service. This evaluation included stress and fracture mechanics analyses. Potential failure modes were postulated based on the examination of the RHR Pump 1C impeller. These potential failure modes involved the propagation of cracks from areas of over-machining, weld repair, and/or flame hardening. The consequences of the potential failure modes were considered from the standpoint of either catastrophic fracture or excessive distortion. The conclusions are summarized below.

> Axial stress corrosion cracking was reported to have initiated in the flame hardened wear ring surface. The dominant service loading of this crack is a design thermal shock. Since the number of thermal transients is small, it was determined that a substantial margin exists against crack propagation by fatigue or fracture. Even if this ring is assumed to be completely fractured, the radial distortion of the ring would not result in interference between the shroud and the stationary wear ring. In short, a through wall axial crack in the impeller wear ring, which propagates the entire axial distance of the wear ring, will not lead to a catastrophic failure of the impeller.
>
> Circumferential stress corrosion cracks were initiated in the vicinity of the minimum wall thickness undercut on the outer diameter of the shroud above the flame hardened wear ring surface. The cracks extended circumferentially and were propagated by stress corrosion cracking resulting from the effect of flame hardening on the adjacent thin section. However, since the pump manufacturer reported that

the impeller would be subjected to a pulsating pressure during mid-loop operation, the possibility of fatigue crack growth in thin locations of the ring-to-shroud transition was explored. It was found that fatigue growth would not occur in locations where the minimum wall thickness is ≥ 0.100". It was predicted that fatigue cracks could grow in the thinnest of the undercut locations under the pressure pulsations assumed by the manufacturer. However, examination of three other impellers by South Texas Project showed that no other impeller was undercut below 0.175". Fatigue cracks would be deflected from the circumferential direction by intersecting vanes and could subsequently propagate parallel to a vane. These circumferential cracks would arrest in the thicker material along the vanes, where the range of stress intensity decreases below the threshold necessary for crack growth.

Finally, consideration was given as to whether other pumps, including ECCS pumps, might contain impellers in a similar state as found in RHR Pump 1C. The evidence indicates that the cracking identified in the 1C RHR impeller is an isolated condition, and no generic problems exist. This determination is based on a review of the root causes of the failures and the associated supporting analyses. Additionally, the analyses demonstrate that RHR Pump 1C remained capable of performing its intended function, even with the observed cracks in the impeller.

CORRECTIVE ACTIONS:

The following corrective actions have been or will be taken:

1. The RHR Pump 1C cracked impeller was replaced with a spare impeller.

2. A detailed engineering evaluation was conducted and documented in the Final Engineering Report.

3. South Texas Project will take advantage of corrective/preventative maintenance opportunities to perform visual inspections of ECCS pump impellers.

4. South Texas Project will establish appropriate engineering hold points to ensure quality manufacturing performance for future purchases of spare RHR impellers.

ADDITIONAL INFORMATION:

None