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Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
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Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Response to NRC Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors," dated May 6, 1996

Reference: Letter dated November 1, 1996, NG-96-2279, to NRC from J. Franz (IES), Response to NRC Bulletin 96-03

File: A-101a, E-11

NRC Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors" was issued on May 6, 1996. This bulletin addresses the concern that debris could be transported to the suppression pool following a loss of coolant accident (LOCA), be deposited on the emergency core cooling system (ECCS) pump suction strainers and potentially decrease net positive suction head (NPSH).

Bulletin 96-03 identifies potential resolution options that could be implemented to ensure the capability of the ECCS to perform its safety function following a LOCA, including the installation of a large capacity passive strainer design. The bulletin requests licensees to complete the implementation of appropriate procedures and plant modifications by the end of the first refueling outage starting after January 1, 1997.

By letter dated November 1, 1996, IES Utilities submitted an initial response to the NRC. As described in the response, IES Utilities plans to implement the necessary physical modifications to the Duane Arnold Energy Center (DAEC) during refueling outage (RFO) 15 which is currently scheduled to begin on April 2, 1998. IES intends to install passive, large-capacity suction strainers supplied by General Electric. The new strainers will be installed on the core spray (CS) and residual heat removal (RHR) suction lines. IE73

The analytical methodologies for strainer sizing discussed in General Electric (GE) Licensing Topical Report (LTR) NEDC-32721P will be utilized. The NRC assessed strainer source term determination (based on the Boiling Water Reactors Owners' Group (BWROG) Utility Resolution Guidance (URG) methodology) in a safety evaluation (SE) issued for Edwin I. Hatch Nuclear Plant, Unit Docket No. 50-321. The SE was transmitted by letter dated June 17, 1997 to H. Sumner (Southern Nuclear Operating Company, Inc.) from N. Le (NRC). We understand that the Staff is currently reviewing the LTR and associated test data for the GE strainer. Review and approval of the GE LTR is desired prior to the finalization of the DAEC modification design. In addition, NRC approval of the DAEC specific methodology for debris generation and transport is required. In order to facilitate the Staff's review, IES Utilities herewith provides a detailed description of the proposed resolution approach for the DAEC (attachment).

While the information provided in the attachment is current and not expected to change substantially as the details of the modification are developed, the information is preliminary and, as such, should not be construed as a revision to the plant's current licensing or design bases. Changes to the modification design may result from the resolution of other ongoing issues, such as Generic Letter (GL) 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps" and the proposed GL, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System After a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in the Containment." IES Utilities requests NRC Staff review and approval of the attached resolution approach and criteria by January 31, 1998. IES looks forward to the opportunity to meet with the NRC Staff to provide additional details.

Shou u have any questions regarding this matter, please contact this office.

Sincere

John Franz

John F. Franz
Vice President, Nuclear

Attachment

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Proposed Resolution Approach for the Duane Arnold Energy Center Emergency Core Cooling System Suction Strainers

Background

By letter dated November 1, 1996, IES Utilities provided an initial response to NRC Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors." IES Utilities plans to implement the necessary modifications on the Duane Arnold Energy Center (DAEC) during refueling outage (RFO) 15 which is currently scheduled to begin on April 2, 1998. IES Utilities has determined that installation of passive, large-capacity strainers on the core spray (CS) and residual heat removal (RHR) suction lines represents the most feasible option. The new suction strainers to be installed at the DAEC will be a stacked disc configuration provided by General Electric (GE).

IES Utilities will use analytical methodologies developed by the Boiling Water Reactor Owners' Group (BWROG) contained in NEDO-32686, Utility Resolution Guidance for Emergency Core Cooling System (ECCS) Suction Strainer Blockage, and supplier test data to determine the strainer size necessary to maintain the required net positive suction head (NPSH) when considering insulation debris, suppression pool sludge and other corrosion products, and operational debris. The Utility Resolution Guidance (URG) includes criteria and guidance on a number of issues which are required to address Regulatory Guide 1.82, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," Revision 2.

DAEC Strainer Configurations

The DAEC is a BWR 4 with a MARK I Containment. The existing CS and RHR suppression pool suction strainers represent four welded penetrations with an attached basket strainer. The presently installed RHR and CS strainers are 24 inches in diameter by 28 inches long, and 12 inches in diameter by 16.5 inches long, respectively. The basket portion of the strainers is fabricated from perforated stainless steel plate with 1/8 inch diameter holes.

It is proposed that the existing RHR and CS strainers be replaced with a significantly higher capacity stacked disc design provided by General Electric. The replacement strainers will be supplied in accordance with the existing DAEC system specifications.

Suppression Pool and Strainer Hardware Structural Design

The qualification of affected suppression pool structures and the strainer hardware will be consistent with the MARK I Containment DAEC Plant Unique Analysis Report (PUAR). Additional guidance will be taken from NUREG-0661, the MKI Load Definition Report and associated Application Guides, and the MKI Structural Acceptance Criteria as required. Since the various Application Guides do not accurately present certain hydrodynamic properties of the proposed strainer configuration, these hydrodynamic properties were defined empirically by detailed strainer testing. In addition, guidance has been taken from the appropriate Application Guide for the fluid structure interaction techniques used in the analysis.

To accomplish the required evaluations, detailed piping, strainer and torus penetration finite element models will be subjected to loads and load combinations developed using the original load generation software and methodologies as specified in the DAEC PUAR, and MKI Application Guides. The resulting stresses will be reviewed for compliance with the DAEC PUAR.

Net Positive Suction Head

The original design provides a credit for containment pressure in establishing adequate net positive suction head. Regarding NPSH for ECCS pumps, the original Safety Evaluation for the DAEC dated January 23, 1973, states that "The most limiting case occurs during the long term transient following the design basis LOCA [Loss-of-Coolant-Accident] when one core spray and one RHR pump will be running continuously. In this operating condition, the NPSH requirement for the spray pump is the limiting parameter. The analysis shows that a containment pressure margin of about 1.5 psi will be available throughout the long-term post-LOCA period to assure adequate NPSH for the core spray pumps for the above cited conditions. Although the design does not fully meet the provisions of the safety guide, we have concluded that the applicant's analysis is conservative and that there should be adequate NPSH to the ECCS pumps, in the unlikely event of a LOCA."

Updated Final Safety Analysis Report (UFSAR) Section 1.8.1, "Safety Guide 1 (Regulatory Guide 1), Net Positive Suction Head For Emergency Core Cooling And Containment Heat Removal System Pumps" allows the use of containment overpressure. "Although the safety guide requirement of no increase in containment pressure is not met exactly, the use of the pressure within the drywell to provide additional suction head to the pumps is not unreasonable. This factor would exist in reality and would be greater than calculated due to the conservatism of the analysis. There is no credible situation that would cause the core standby cooling system pumps to lose suction."

The replacement strainers will be designed for the following flow rates:

Maximum RHR Flow Rate per Strainer Assembly 13,000 gpm
Maximum CS Flow Rate per Strainer Assembly 4,500 gpm
Rated Flow Rate through the RHR Strainer Assemblies long term 9,600 gpm
Rated Flow Rate through the CS Strainer Assemblies long term 3,100 gpm
(The RHR system has 2 pumps per penetration and the CS system has 1 pump per penetration.)

The new strainers will be designed to the appropriate flow rate versus suppression pool temperature to identify the limiting case for NPSH margin. This design will consider the higher flow rates of 6500 gpm per RHR pump and 4500 gpm per CS pump which occur during the initial vessel reflood (within the first 10 minutes post-accident). Following the initial 10 minutes, the ECCS pump flow will be reduced to rated output based on the DAEC analytical and licensing design basis, reactor vessel level recovery and operating instructions. During this time, the suppression pool temperature increases until the heat removal systems capability exceeds the decay heat removed from the vessel. Consequently, the NPSH analysis considers the expected suppression pool temperature at different points in the accident progression with the NPSH calculated for the flow conditions and pool temperatures expected at that point.

The existing basis relative to NPSH assumes that 50% of the strainer is clogged. The new design will evaluate the system for NPSH with a debris bed developed in accordance with Regulatory Guide 1.82, Revision 2 and URG requirements. The required NPSH will be retained for all operating conditions.

The original NPSH calculations will be revised to incorporate the new strainer head loss characteristics, as well as other information identified in the URG.

In addition, IES intends to have GE re-perform the containment pressure-temperature analysis. This will enable IES to resolve several discrepancies identified within the design basis and will provide both a short term and long term minimum pressure curve for NPSH calculations (inside 10 minutes). GE will use the current version of their SHEX and M3CIP codes for the long term and short term analysis respectively. GE will perform appropriate benchmarking of the computer codes.

Plant-Specific Method for Sizing New Strainers

The DAEC is a 100 % NUKON fiberglass insulation plant, with small amounts of reflective metal insulation (RMI) within the bioshield and on some piping, as well as small amounts of calcium silicate, urethane, and fiberglass anti-sweat insulation. The RMI and other types of debris were included in the evaluation of strainer blockage; it was found that these additional debris sources did not significantly affect the strainer design since most of these materials are outside the worst-case break zone of influence.

Pipe Break Locations

Potential pipe break locations were examined to ensure the largest amount of debris generation was identified. The bounding estimate of insulation debris generated consists of approximately 136 ft^3 of fiber. This worst-case break for debris generation is located on the 20 inch "A" recirculation suction line piping at an elevation of approximately 774 feet. No calcium silicate is identified within the zone of influence from this worst-case break. Other postulated breaks that include calcium silicate within the zone of influence result in the generation of much less NUKON insulation debris. Urethane is not included in the debris loading, since it represents a type of material that is light and will float on the surface of the suppression pool should it be transported. The debris generation analysis is consistent with the guidance in the BWROG URG document.

Debris generation from breaks at the piping nozzle connection to the reactor pressure vessel near the bioshield wall was also evaluated and was determined to be bounded by the worst-case recirculation line break. The reactor pressure vessel insulation inside the bioshield wall is RMI. Because the bottom of the pedestal is closed, the only potential release path is through the bioshield door openings, thus limiting the quantity of debris released to the drywell. The spray from the break would force the insulation away from the bioshield door opening rather than through the opening. These doors remain closed during operation and the only openings consist of a gap between the door and the piping and a gap between the door and the door frame.

The head loss is maximized based on the following:

1. The amount of insulation generated was determined non-mechanistically. A break location was chosen that maximized the fiber insulation debris without determining, mechanistically, whether the particular pipe break location had a high probability of occurring. In other words, the criteria applicable to high energy line breaks (HELBs) were not used.

2. Conservative values were used for the generation of sludge, dust and dirt, rust, and paint chips. A value of 500 lb. of sludge was chosen for the purpose of strainer design. This value is conservative with respect to the 95 lb. of sludge/cycle which was measured at the end of cycle 14. Other values were identified in the URG as referenced in Table 1 on page 5 of this attachment.

Debris Generation

IES Utilities will use Method 2, Target Based Analysis using Limiting Size Zones of Influence, described in URG Section 3.2.1.2.3.2, to determine the zone of influence.

The quantities for drywell dust, dirt, rust from unpainted surfaces, paint, coating, and transportable foreign materials will follow the URG recommendations as supplemented by plant-specific data. Table 1 provides the amounts.

TABLE 1

Type	Quantity	
Fiber	150 ft^3	URG Section 3.2.1.2.3.2 (136 ft^3 calculated value)
Sludge	500 lbs	The quantity of sludge is based upon conservative evaluations involving measurements of the wet weight of filter with and without the sludge and extrapolating to a dry weight. The DAEC has been proactively cleaning the suppression pool on a regular basis which has allowed the determination of an actual sludge generation rate. The 500 lb. quantity of sludge conservatively bounds several operating cycles between cleanings.
Dirt/Dust	150 lbs	URG Section 3.2.2.2.1
Rust	50 lbs	URG Section 3.2.2.2.2
Paint Chips -- qualified	71 lbs	URG Section 3.2.2.2.2.1.1
Paint Chips -- unqualified	71 lbs	URG Section 3.2.2.3.3
Zinc	47 lbs	
Equipment tag (2.5" X 4.5") and tape pieces	50 ea.	
RMI	308 ft^2	RMI encased between outer reactor and bioshield wall is ignored. The identified RMI is located on a 4" Reactor Core Isolation Cooling (RCIC) line in the zone of influence.

Transport and Destruction

IES will use the combined drywell to suppression pool transport and destruction factors contained in URG Section 3.2.3.2.5, Tables 5 and 6. Twenty-eight (28) percent will be used for debris generated above the lowest grating level in the drywell. None of the insulation in the worst case break is below the lowest grating.

Strainer Design

The new strainers are the stacked-disc design supplied by GE. The strainers utilize disks whose internal radius and thickness vary over the length of the strainer. The variation in these parameters achieves an increased surface area compared to conventional strainers of comparable size. Information pertaining to these strainers has been submitted to the NRC Staff for approval in Licensing Topical Report NEDC-32721P.

GE will employ the head loss correlation documented in NEDC-32721P to design the plant specific strainers. The strainer head loss will consider the maximum expected quantity of debris combined with the maximum expected amount of sludge and other debris. Consistency with the inputs and assumptions used in the evaluation model required by 10 CFR 50.46 to calculate ECCS cooling performance will be assured.

IES intends to design the new strainers (except welds) using ASME Code Section III, Class 2-NC allowable stresses. Welds and weld acceptance criteria will be in accordance with ASME Code Section III, Subsection NG. The strainers, the associated penetration attachments, and the torus interfaces will be designed to current applicable structural loads, including hydrodynamic, seismic, thermal, pressure, and deadweight. IES does not plan to change the licensing basis of the applicable loadings at this time.

Determination of the final strainer sizing for the DAEC is still in progress, thus a final size for fabrication has not been established. The preliminary strainer size for each RHR pump is approximately 45 inches in diameter by 53 inches in length and for core spray approximately 45 inches in diameter by 41 inches total length. The maximum diameter is limited to approximately 45 inches due to the inside diameter of the access hatch to the torus (48 inches) and anticipated installation interferences.

The actual size of the strainers used in GE's testing is provided below. (Reference GE Licensing Topical Report NEDC-32721P for further details.) The stacked-disc strainer No. 2 described in the URG document and the GE-supplied disk strainer have identical measurements.

Flange size	24 inch nominal
Outer diameter	42 inch
Active strainer length	48 inch

Accident Analysis Inputs

The ECCS suction strainers will be designed based on the following assumptions in order to maximize the loading on the strainers.

<u>Design Condition to Maximize RHR Strainer Debris Loading</u>

The first design condition is a loss-of-offsite-power (LOOP) loss-of-coolant accident (LOCA) in combination with the failure of one battery division resulting in the loss of one division of ECCS. As a result, the debris will be distributed on one (1) RHR strainer and one (1) core spray strainer. There will be two RHR pumps and one Core Spray pump available.

<u>Design Condition to Maximize CS Strainer Debris Loading</u>

The second design condition is a LOOP-LOCA in combination with a failure of the Low Pressure Coolant Injection (LPCI) system injection valve on the unbroken loop. This results in the loss of all RHR injection capability. The remaining systems result in the availability of two core spray strainers and two RHR strainers. Since the RHR system will operate in a minimum flow condition until operators take action to spray containment or use torus cooling, this design condition places the largest debris burden on the core spray strainers.

The total debris loading for each of the strainers is determined by assuming 100% of the debris present in the suppression pool is accumulated on the functioning strainers in amounts proportional to the flow rate through each strainer. The strainers are assumed to be loaded through multiple "pool turnovers."

Surveillance Requirements

IES Utilities submitted a conversion of the DAEC Technical Specifications (TS) to the Improved Technical Specifications (ITS) by letter dated October 30, 1996. The ITS submittal is currently undergoing review by the NRC, with implementation planned prior to RFO 15. The ITS removed many of the previously included inspection surveillances and placed them into plant programs and procedures. Consequently, IES does not plan to propose a change to the TS incorporating a surveillance requirement for the strainers. Periodic inspection of the new strainers will be included in plant procedures. However, the modification may result in changes to the required torus water level (due to changes in the amount of water displaced by the strainers). A revision to TS will be submitted if required due to changes in torus water level.