September 11, 2001

MEMORANDUM TO: Gary M. Holahan, Director
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SUBJECT: REPORT ON RESULTS OF STAFF AUDIT CONDUCTED ON OCTOBER 4-6, 1999, OF DUANE ARNOLD ENERGY CENTER'S RESOLUTION OF ISSUES IDENTIFIED IN NUCLEAR REGULATORY COMMISSION (NRC) BULLETIN 96-03 (TAC NUMBER MA0704)

On October 4-6,1999, the staff conducted an audit of IES Utilities, (IES, the licensee) resolution for NRC Bulletin 96-03 (NRCB), "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris" (NRCB 96-03), for Duane Arnold Energy Center (DAEC). The purpose of the audit was to verify the implementation of NRCB 96-03. Specifically, the staff:

A- assessed the adequacy of the licensee's resolution; and

B- evaluated the need for additional review on a generic basis of licensees resolutions through the NRC inspection program.

On the basis of the audit team's confirmatory calculations (described below), we believe that Duane Arnold has adequately designed their emergency core cooling system (ECCS) strainers to withstand the high debris loads anticipated during a loss-of-coolant accident (LOCA). In addition, they have implemented an appropriate inspection program to ensure the operability of the ECCS (relative to strainer and suppression pool cleanliness), and they have also implemented a suppression pool cleanliness program and foreign material control procedures to limit the potential for clogging the ECCS with materials brought into the drywell or wetwell during outage operations.

This audit was seen as the starting point for the closure of hydrodynamic load open issues related to the new strainer installation. However, actual closure cannot be made until we complete our review of the GE licensing topical report (LTR). During the exit meeting, we restated that no conclusions on the hydrodynamic loads on the Duane Arnold ECCS strainers were made at the time. Our major focus of this audit was understanding the application of the GE methodology to the new ECCS strainers. Since our review of the hydrodynamic load portion of the GE LTR is currently still ongoing, we will assess the need to address any open items regarding the adequacy of the DAEC design relative to hydrodynamic loads upon the completion of our LTR review.

By letter dated November 2, 2000, DAEC identified certain information in this audit report as being proprietary. DAEC provided this information in response to a request from the NRC dated September 22, 2000. On the basis of the input provided by DAEC, two versions of this report were prepared. The first report was designated proprietary and withheld from public disclosure pursuant to 10 CFR 2.790(b)(5) and Section 103(b) of the Atomic Energy Act of 1954, as amended. This version of the report has been prepared with the designated proprietary information redacted, and will be made publicly available. Redacted information has been replaced with "**XXX**" in the body of this report, or blacked out in the audit check list tables located at the end of Appendix B of this report.

1.0 BACKGROUND

Title 10, Section 50.46 of the *Code of Federal Regulations* (10 CFR 50.46, the ECCS rule) requires that nuclear power plant utilities design their ECCS systems to meet five criteria. Criterion 5 of this rule requires the ECCS to provide long-term cooling capability following a loss-of-coolant accident (LOCA). To meet this criterion, the system should be designed to provide sufficient cooling to maintain the reactor core temperature at an acceptably low value. In addition, the ECCS should continue to remove decay heat for the extended period of time required by the long-lived radioactivity in the core. The ECCS is designed to meet this criterion, assuming the worst case single failure of any piece of equipment or system. However, experience gained from operational events and detailed analyses of Boiling Water Reactor (BWR) designs has demonstrated that excessive buildup of debris from thermal insulation, corrosion products, and other particulates on ECCS pump strainers is likely to occur during a LOCA. This creates the potential for a common-cause failure of the ECCS, which could prevent the ECCS from providing long-term cooling following a LOCA. Based on this information, the NRC decided that BWR licensees should take adequate steps to prevent strainer clogging in order to ensure that the ECCS can perform its safety function during a LOCA.

On May 6, 1996, NRCB 96-03 was issued requesting BWR licensees to implement appropriate procedural measures and plant modifications to minimize the potential for clogging of ECCS suppression pool suction strainers by debris generated during a LOCA. Regulatory Guide 1.82, Revision 2, (RG 1.82) was issued in May 1996 to provide guidance on evaluating plants for compliance with the ECCS rule. On November 20, 1996, the Boiling Water Reactor Owners Group (BWROG) submitted NEDO-32686, "Utility Resolution Guidance for ECCS Suction Strainer Blockage" (also known as the URG) to the NRC for review. The purpose of the URG is to give BWR licensees detailed guidance for complying with the requested actions of NRCB 96-03. The staff approved the URG in a safety evaluation report (SER) dated

August 20, 1998. In response to NRCB 96-03, all affected BWR licensees have installed new large-capacity passive strainers to resolve the issue. Licensees have typically concluded that installation of the new strainer designs does not create an unreviewed safety question as defined in Title 10, Section 50.59 of the *Code of Federal Regulations* (10 CFR 50.59). This means that NRC approval of the new strainers is not required. As a result, we have not performed a comprehensive formal review of licensee resolutions for this issue. Therefore, we decided to conduct 4-6 plant audits to verify adequate implementation prior to closing out this generic issue for BWRs. DAEC is the fourth of these audits. Appendix A to this report provides the staff's plan for the conduct of these audits. The audit plan also provides a more detailed description of the background on this issue.

2.0 DISCUSSION

The audit team was a four person team including Robert Elliott and Kerri Kavanagh from the Plant Systems Branch of the NRC's Office of Nuclear Reactor Regulation, and D.V. Rao and Bruce Letellier from the Los Alamos National Laboratory (LANL). The audit covered two areas involving the DAEC's resolution of issues identified in NRCB 96-03. In addition, the audit covered issues identified in NRCB 95-02, "Unexpected Clogging of Residual Heat Removal (RHR) Pump Strainer While Operating in Suppression Pool Cooling Mode," dated October 17, 1995. These three areas are:

A- DAEC's strainer modification documentation and associated 50.59 safety evaluation,

B- DAEC's analyses performed in response to NRCB 96-03, including
  1- strainer performance and design calculations
  2- hydrodynamic load calculations

C- DAEC's suppression pool cleanliness program (NRCB 95-02). While not specifically addressed in the audit plan objectives, suppression pool cleanliness and NRCB 95-02 were included in the audit scope because of the potential adverse impact that foreign debris could have on ECCS strainer operability.

As noted above, Appendix A to this audit report provides our plan for conducting plant audits of NRC Bulletins 96-03 and 95-02. For conciseness, the blank plant data spreadsheets normally attached to the audit plan have been left out of this appendix. Detailed descriptions of LANL's review related to strainer performance, associated confirmatory calculations, and the audit plan plant data spreadsheets filled in with the details of DAEC's strainer designs are provided in LANL's technical evaluation report (TER). LANL's TER is included as Appendix B to this audit report.

At the time of the audit, DAEC had completed the strainer hardware installation. They installed new strainers designed by the General Electric (GE) Company. The new strainers are of a stacked disk design. GE prepared a licensing topical report (LTR) on their strainers which was submitted to the NRC for review. The report is NEDC-32721P, "Application Methodology for GE Stacked Disk ECCS Suction Strainer," Revision 1, dated November 1997. The report received partial approval from the NRC in an SER dated February 3, 1999. This approval was for calculating strainer performance (i.e., the head loss across the strainer with debris on the strainer surface). However, some issues related to the calculation of hydrodynamic loads remain open for GE strainers because the hydrodynamic loads portion of the GE LTR is still undergoing staff review. As a result, these hydrodynamic load issues also remain open for DAEC, and could not be resolved at the time of the audit. When we complete our review of the GE topical report, we will assess the impact on the DAEC design and determine if further followup is required at that time. This review will be accomplished separately from this audit. For the purposes of the audit, we limited our hydrodynamic load review to assessing if DAEC's calculations were consistent with the GE methodology.

The following sections describe the reviews performed at the site and our findings for each area audited.

2.1 The Licensee's Strainer Modification Documentation and Associated Safety Evaluation (10 CFR 50.59)

In order to ensure that the implementation of the strainer resolution did not adversely impact other plant systems in such a way as to create a new or previously unidentified safety concern, we reviewed the licensee's strainer modification package and safety evaluation for the ECCS strainer modification, Modification Number ECP-1588. The documents reviewed included the Safety Evaluations SE-99-012 and SE-98-029, as well as Engineering Specification BECH-MRS-M471. We performed a technical review to ensure that DAEC adequately considered the potential impacts of the strainer modification on plant safety. In addition, we evaluated DAEC's safety evaluation to ensure that the potential impacts of the new strainers on the licensee's accident analyses were adequately considered.

The following provides a brief overview of the main design and operational considerations addressed by DAEC in the implementation of the strainer modification:

- The ECCS configuration for DAEC consists of two trains of low pressure coolant injection (LPCI) and two trains of low pressure core spray (LPCS). Each train of LPCI has two pumps that take suction off a common strainer. Each train of LPCS has one pump that takes suction from its own dedicated strainer.

- The licensee ensured that the basic ECCS functions remained unchanged by the strainer replacement. For instance, the strainers are designed to screen out objects larger than 0.125 inches in size. This requirement is the same as the old strainers.

- The new strainers were designed to have a maximum head loss equal to or less than the existing net positive suction head (NPSH) margin for the ECCS pumps (14.67 feet of water (ft H_2O) for LPCI with two pumps operating, 8 ft H_2O for LPCI with one pump operating, and 4.48 ft H_2O for LPCS when loaded with debris).

- The strainer specification limits the maximum strainer weight to less than 3000 pounds (lbs).

- All materials, design, fabrication, examination and testing for the ECCS strainers was specified to be in accordance with Section III, Subsection NC, NF, and/or NG of the 1977 edition (including Summer 1977 addenda) of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Regulatory Guide 1.82, Revision 2, and NUREG/CR-6224. The strainers were also designed, fabricated and installed as Seismic Category I, Nuclear Safety Related Equipment. All welds were

100% visually examined in accordance with the ASME Code, Section V. Structural welds requiring liquid penetrant (PT) examination were 100% PT tested in accordance with the ASME Code, Section V using the appropriate acceptance criteria specified in the ASME Code, Section III.

- The strainers were structurally analyzed to withstand the hydrodynamic and inertial loads calculated using the analysis methodologies specified in the Mark I Containment DAEC Plant Unique Analysis Report (PUAR) and Mark I Application Guides.

- The design of the strainers considers the worst case single failure. Different single failures were considered for the LPCI and the LPCS to ensure that each was design for its worst cased debris loading.

Licensee Safety Evaluation of Strainer Modification (10CFR50.59): The licensee conducted two 50.59 evaluations. The first (SE-98-029 for Mod Number ECP-1588, “ECCS Suction Strainer Replacement”) was performed before the URG and the GE topical report were reviewed by the staff. DAEC could not complete updating their licensing basis for the strainers because these two documents were still being reviewed by the NRC. So they performed their first safety evaluation for replacing the strainer with a larger stacked disk strainer design while still retaining their existing licensing basis. In this safety evaluation, they concluded that the replacement of the strainers does not constitute an unreviewed safety question because:

1) The strainer replacement does not increase the probability of occurrence of an accident evaluated previously in the Safety Analysis Report (SAR) because the design meets the design, material, and construction standards applicable to the residual heat removal (RHR) system, core spray (CS) system, and suppression chamber. No instrumentation is affected by the modification, and the modified systems will not be operated outside their design or testing limits. The modification does not affect primary containment integrity or its ability to perform its safety functions. All applicable ASME Code design requirements are met for the strainer modification design to ensure that the primary containment safety function is not inhibited.

2) The modification does not increase the consequences of an accident evaluated previously in the SAR because the new strainer design does not change, degrade or prevent any actions described or assumed in an accident analysis. No assumptions used in the evaluation of radiological consequences in the Updated Final Safety Analysis Report (UFSAR) were changed. The new strainers do not prevent the RHR or CS systems from performing their functions, and their initiation signals, system interfaces, interlocks, and flow rates are also unchanged. The modification does not affect any fission product barrier. The containment’s capability to withstand the pressures and temperatures resulting from a postulated accident is unchanged. Structural stresses are all calculated to be within ASME Code allowables.

3) The modification does not increase the probability of a malfunction of equipment important to safety previously evaluated in the SAR. The new strainers perform the same function as the old strainers, but have better head loss characteristics, and they meet or exceed the materials/construction design specifications for the original strainers. The strainer modification does not otherwise affect the operating characteristics of the supported ECCS systems. For instance, no protection feature or support system is

adversely affected by the new strainers, and there is no reduction in system or equipment redundancy/independence resulting from the modification. The frequency or severity of system test requirements are not increased by the modification. All seismic and hydrodynamic load requirements are met, and the calculated loads for the containment penetrations and piping system do not exceed ASME Code allowables (with modifications to the penetrations). The strainers, associated penetration attachments, and torus interfaces were designed to current applicable structural loads, including hydrodynamic, seismic, thermal, pressure, and deadweight. Therefore, DAEC concluded that the containment integrity and functional capability are maintained.

4) The modification does not increase the consequences of a malfunction of equipment important to safety previously evaluated in the SAR. The modification does not change the accident response or safety function of any of the systems or components that could be affected by the change (i.e., the RHR system, the CS system, the strainers, and the torus). The new strainers meet or exceed the original design specification for the old strainers for materials and construction, and they have significantly better performance capability with debris. The strainer modification also meets all applicable ASME Code requirements, and as a result, will not adversely impact containment integrity.

5) The modification does not create the possibility of an accident of a different type than any previously evaluated in the SAR. The strainer function is unchanged. The modification only affects the size and surface area. The new strainers are passive with no active components. And for the reasons indicated above, the strainers will not adversely impact primary containment integrity or the containment's ability to perform its safety function.

6) The modification does not create the possibility of a malfunction of equipment important to safety of a different type than any evaluated previously in the SAR. The new strainers do not affect the RHR or CS systems except to increase their overall performance margin. The strainers do not introduce any new failure modes. Equipment is not being relocated and the function and operation of the equipment remains unchanged. All design requirements of the RHR, CS and suppression chamber are met. Since the strainers, their associated penetration attachments, and the torus interfaces are designed to withstand all applicable structural loads (i.e., hydrodynamic, seismic, thermal, pressure, and deadweight), the possibility of containment structural failure is not created.

7) The modification does not reduce the margin of safety as defined in the basis for any technical specification (TS). The modification does not change the required actions or surveillance requirements in the TS for the ECCS or the containment. The LPCI and CS flow rates and test frequencies are unchanged. The impact of the strainers on torus water level was reviewed and determined to have a negligible effect. The required minimum water levels for the torus and the condensate storage tank and the frequency of their verification are not changed by the modification. The modification does not change the average suppression pool temperature. The bases for the operability limits and surveillance requirements specified are not affected by the strainer design change. The net impact of the change is an increase in the margin of safety because the new strainers provide acceptable operation with significantly higher debris loadings than the old strainers.

- The second safety evaluation is SE 99-012 dated August 26, 1999. This evaluation was performed to evaluate the revision of the licensing basis for the strainers and ECCS net positive suction head (NPSH) margin. These revisions incorporated updated analyses in the licensing basis based on the new strainers, including analyses for ECCS NPSH margin, containment minimum pressure, debris generation, and strainer head loss, as well as, revisions to the UFSAR and other documentation. In this safety evaluation, they concluded that the licensing basis revision does not constitute an unreviewed safety question because:

  1) The revision to the strainer licensing basis does not increase the probability of the occurrence of an accident evaluated previously in the SAR because the licensing basis changes are related to events that happen after a LOCA has already occurred. These changes do not affect or modify operating conditions or initiators previously analyzed in the SAR. The changes are to the containment pressure/temperature analysis, debris generation calculations, debris transport calculations, strainer debris load calculations, strainer performance calculations, and NPSH analysis.

  2) The revision to the strainer licensing basis does not increase the consequences of an accident previously evaluated in the SAR because the changes do not alter or degrade any actions assumed in an accident to mitigate the event. All changes to the design inputs for the modified calculations and analyses are in accordance with methodologies previously approved by the NRC, such as the DAEC TS, the URG, and the GE LTR. No assumptions used in evaluating the radiological consequences of any accident are changed, and no fission product barriers are affected. The revision does not affect LPCI or CS system initiation signals, system interfaces/interlocks, and pump flow rates. The primary containment's ability to withstand temperatures, pressures, or hydrodynamic loads resulting from postulated accidents is unchanged. Suppression pool structural loads were evaluated in accordance with the Mark I program and the suppression pool's original design requirements. The pressure and temperature analysis changes are bounded by the design basis accident LOCA case.

  3) The revision to the strainer licensing basis does not increase the probability of a malfunction of equipment important to safety previously evaluated in the SAR. The strainer design assumptions are significantly more conservative than those used in the original SAR analysis. As a result, the ECCS suction strainer hardware will reduce the probability of a malfunction of the ECCS systems due to increased reliability in a post-LOCA environment. The methods used to size the strainer and demonstrate adequate ECCS pump NPSH margin are acceptable because they have been reviewed and approved by the NRC. Reliance on containment pressure to demonstrate adequate NPSH margin for the ECCS pumps has been reduced, increasing the margin of safety.

  4) The revision to the strainer licensing basis does not increase the consequences of a malfunction of equipment important to safety previously evaluated in the SAR. The only systems or components that could be affected by the revision are the LPCI and CS systems, the torus and the strainers. The safety functions of these systems/components are unchanged, and their capabilities to perform their safety functions have not been reduced by the revision. As noted above, the methods used to size the strainer and demonstrate adequate ECCS pump NPSH margin are acceptable because they have been reviewed and approved by the NRC.

5) The revision to the strainer licensing basis does not create the possibility of an accident of a different type than was previously evaluated in the SAR. Both the old and new strainers are passive devices that support operation of the LPCI and CS systems. Since they are passive devices, they cannot initiate an accident of a different type than previously analyzed. In addition, the changes made to analyses for debris generation, NPSH margin and containment pressure/temperature were based on existing operating conditions and TS. The operating conditions of the existing systems were not changed from the required design conditions currently listed in the UFSAR.

6) The revision to the strainer licensing basis does not create the possibility of a different type of malfunction of equipment important to safety than was previously evaluated in the SAR. No new failure modes are created since no equipment is being relocated, and system functions and operation are not changed. The new strainers perform the same function as the old, and all design requirements fo the LPCI, CS and the suppression chamber are met. The structural design margins specified in the ASME Code are maintained. As noted above, the methods used to size the strainer and demonstrate adequate ECCS pump NPSH margin are acceptable because they have been reviewed and approved by the NRC. Specific changes to containment pressure/temperature analysis inputs were evaluated by benchmarking and comparison analysis to ensure the adequacy of the new analysis.

7) The revision to the licensing basis does not reduce the margin of safety as defined in the basis for any TS. The revision does not change the required actions for the conditions specified and the ECCS surveillance requirements are not changed. The LPCI and CS pump flow rates and test frequencies were not changed, and analysis by DAEC demonstrates that the revision does not degrade their capabilities. The required water levels in the suppression pool and condensate storage tank are unchanged as are the requirements for verification of these levels. The revision does not affect average suppression pool temperature.

In performing these safety evaluations, the licensee considered a number of different documents to ensure that they fully captured the potential impacts of the modification in their safety evaluations. For instance, DAEC considered relevant background information provided in various generic communications such as NRCBs 95-02 and 96-03, as well as DAEC's responses to those generic communications. Relevant requirements of the DAEC licensing basis as defined in their UFSAR were considered for the residual heat removal (RHR), LPCI, primary containment, suppression pool, suppression pool cooling, containment spray, CS, and high pressure coolant injection systems. The impact of the strainer modification on these systems under different plant operating modes was considered based on the plant's Nuclear Safety Operational Analysis (NSOA) to ensure that the new strainers did not adversely impact the capabilities of these systems under the various required operating conditions for these systems. The NSOA defines the operating modes or states that these systems are expected to be capable of performing their functions. DAEC also evaluated the requirements for the LPCI, CS, and primary containment specified in the design basis documents (DBDs) for these systems. The DBDs for the LPCI and CS were updated to reflect the new strainer criteria relative to the overall size; however, other criteria such as strainer hole size was maintained to ensure that the new strainers did not adversely impact system performance.

DAEC also performed an evaluation of the HPCI and reactor core isolation cooling (RCIC) systems to determine if there would be a significant safety benefit to installing new strainers for these systems. The results of DAEC's "Risk-informed Evaluation of Torus Suction Strainers for HPCI and RCIC" was transmitted in IES memo NG-99-0443 to the DAEC Project Manager for NRCB 96-03 on March 24, 1999. In this memo, DAEC concluded that there would be negligible safety benefit to installing new strainers on these systems. For a large break LOCA, the LPCI and CS systems would provide core cooling. For medium and small breaks, if clogging of the high pressure system strainers were to occur, the reactor vessel could be depressurized via the safety relief valves (either automatically or manually) so that cooling could be provided by the low pressure systems which have the new improved strainers. They also note that the smaller breaks would generate less debris making it less likely that the strainers would be clogged. They further stated that the "combined core damage frequency (CDF) for large, medium, and small break LOCAs is 4.1% of the CDF for all internal events, and damage cutsets involving torus strainer clogging comprise only 3% of this 4.1%. As such, the contribution to core damage of LOCA induced torus strainer clogging as currently modeled in the DAEC PSA is relatively small." Although not stated in the DAEC evaluation, we noted in reviewing the UFSAR that both the HPCI and RCIC systems preferentially draw suction from the CST before before switching to the suppression pool. For medium and small break LOCAs, this would allow more time for debris to settle before the HPCI or RCIC would switch over to the suppression pool, thereby further minimizing the potential for clogging the suction strainers for these systems.

Staff Evaluation: We reviewed DAEC's engineering packages described above to determine if DAEC had fully considered the systems potentially affected by the strainer modification. In addition, we evaluated these packages to ensure that DAEC made appropriate engineering, procedural, or documentation changes to ensure that plant safety is adequately maintained during the installation of the new strainers and in normal operation with the new strainers. Based on our review, we concluded that DAEC's engineering package and associated safety evaluation were adequate in scope, evaluating the potential impacts of the strainer replacement. We did not identify any systems or components that would be impacted by the strainer replacement that were not addressed by the licensee. Therefore, we conclude that appropriate steps were taken by DAEC to safely install the new strainers and to ensure that the installation improved overall plant safety.

We also reviewed DAEC's evaluation of the HPCI and RCIC systems to determine if there would be a significant safety benefit to installing new strainers for these systems. We agree with DAEC's conclusion that there would be a negligible safety benefit to upgrading the strainers for these systems.

2.2 Plant-specific Analyses, Strainer Performance and Design Calculations, and Hydrodynamic Loads

Strainer Performance and Design Calculations: We evaluated DAEC's strainer analyses and design calculations through a series of confirmatory calculations. These calculations were performed by LANL. LANL's confirmatory analyses focused on two objectives:

1) Confirm DAEC's estimated debris loadings for the new strainers.

2) Confirm the performance of the strainer design based on the strainer design criteria and DAEC's calculated accident conditions.

These calculations are designed to confirm that the strainers will function as intended during a LOCA. LANL conducted two sets of calculations to achieve these objectives. First, they independently estimated the debris loadings for the strainers using the methods approved by the NRC. Second, they estimated the head loss across the strainers using (a) the debris loadings calculated by DAEC in their analyses, and (b) the debris loadings independently estimated by LANL. LANL's report is included in Appendix B of this report. Their report includes a description of their analyses, their analyses results, and calculation summary tables. LANL's overall conclusion in their report is that the "DAEC strainer replacement strategy is sound and their analyses provide reasonable assurance that the ECCS strainers are adequately sized to support long-term ECCS operation following a LOCA." LANL further states that any uncertainties in DAEC's analyses are compensated for by conservative assumptions factored into the analysis.

Staff Evaluation: We have reviewed LANL's findings relative to the performance of the DAEC strainer design and agree with their results. The audit's confirmatory analyses demonstrate that the DAEC's strainers are adequately sized. We did not identify any weaknesses in DAEC's analyses and documentation that we believe need to be addressed.

Hydrodynamic Loads: We met with members of the DAEC's staff to discuss their evaluation of the submerged loads on the strainer. In preparation for the audit, we reviewed the GE LTR. Our review of the hydrodynamic loads portion of this topical report was not complete at the time of the DAEC audit. Open issues still remained with the GE LTR on hydrodynamic loads. As such, no conclusions on the adequacy of the hydrodynamic loads on the DAEC's strainer were made during the audit or in this report. The review of the hydrodynamic load portion of the GE LTR is currently still ongoing. We will assess the need to address any open items regarding the adequacy of the DAEC design relative to hydrodynamic loads upon the completion of our review of the LTR.

The data from tests conducted by GE was available at the time of the audit. The detailed methodology of how the submerged structure hydrodynamic masses and acceleration drag volumes were calculated was provided in the GE LTR.

GE provided the values of the hydrodynamic masses and the acceleration drag volumes (ADV) for the GE stacked disk suction strainers installed at Duane Arnold. According to the GE LTR, the procedure for calculating the design acceleration drag volume for the GE strainers consists of:

(1) determining the geometry factor and the hole factor, and
(2) calculating the acceleration drag volume for the crossflow and longitudinal directions.

The geometry factor can be determined using Table 2 in Appendix C of the LTR. Table 2 presents the predictions for the proprietary fast-panel analysis. The GE methodology uses the fast panel analysis to predict the hydrodynamic mass coefficients of three GE stacked disk strainer designs (i.e., three different ratios of diameter to length, referred to as D/L) placed in an inviscid flow field. These results are then used to compare the predicted mass coefficients for solid surfaced cylinders of the same corresponding dimensions. According to the LTR, Table 2 can be used to determine the longitudinal and crossflow geometry factors for any given GE strainer with a specified D/L. However, the fast panel analysis cannot directly model the complex configuration of the stacked disk geometry with perforated plates. As such, a hole reduction factor was required.

The values to be used for the hole factors were provided in Appendix I of the LTR. According to Appendix I, the acceleration drag volume values were determined from the fast panel analysis and the test results of GE's prototype strainer. Since the strainer perforated plate (or holes) was the only difference between the analytical model and the tested strainer, the ratio of these ADV values represented the hole reduction factor to be applied to the hydrodynamic mass coefficient for the GE strainers. The hole factor was determined to be **XXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXX**.

The acceleration drag volume is the volume of the strainer straps added to the product of the geometry factor, hole factor, and the circumscribed cylinder volume of the stacked disk strainer. Based on the procedure described in the GE LTR, GE provided the crossflow and axial direction acceleration drag volumes for the Duane Arnold LPCI and CS system suction strainers. The acceleration drag volumes were then used as an input to the calculation of the submerged structure loads and their effect on the containment penetrations. DAEC documented the their efforts to address the requirements originally defined by NUREG-0661, "Safety Evaluation Report MARK I Containment Long-Term Program Resolution of Generic Technical Activity A-7," for the strainer modification in ECP-1588 and in DDC-3741, "DAEC, Plant Unique Analysis Report, Volume 7 - Residual Heat Removal and Core Spray Strainer Modifications for NRC Bulletin 96-03." We reviewed these documents as part of our audit.

While our main concern was centered on the methodology used to calculate the acceleration drag coefficient (C_m), we were also interested in the value of the standard drag coefficient, C_d. Standard drag is generally considered to be small in comparison with C_m but it can represent about 10 percent of the combined load, C_m and C_d. Similar to C_m, GE felt that it could be demonstrated by analysis and test that the original value of 1.2 for C_d was too conservative for the new strainer application. The LTR recommended values of **XXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX** for C_d be used in the analysis. However, during our review we noted that some of the Duane Arnold calculations use a value of **XXXXX** for C_d.

Although the audit was not focused on the structural aspects of the new strainer design, we were able to obtain a brief summary of the criteria used in the design. As expected, the loads associated with the new strainer design did increase the penetration loads. The increased penetration loads required modifications to the LPCI and CS containment penetrations. The modifications are described in Volume 7 of the DAEC PUAR. With these modifications and the supporting re-analysis, the design was able to meet all ASME code requirements.

<u>Staff Evaluation</u>: The staff performed confirmatory calculations of the acceleration drag volumes and hydrodynamic masses for the Duane Arnold suction strainers. Our calculation followed the procedure described above. Our confirmatory calculations demonstrated that values provided by GE were consistent with the values that would be calculated using procedure in the GE LTR. However, since the review of the GE LTR is not complete, we cannot provide an evaluation of the adequacy of the design acceleration drag volumes and

hydrodynamic masses used in the calculation of the submerged structure loads. For the standard drag coefficient, C_d, we believe that the standard drag is not a significant contributor to the overall hydrodynamic load on the strainer. Therefore, we have concluded that the recommended values in the LTR for the standard drag coefficient are reasonable for load recalculation purposes.

2.3 Suppression Pool/Strainer Cleanliness

Consistent with the requested actions of NRCB 95-02, DAEC has established a suppression pool cleaning program to ensure operability of the ECCS and to prevent the design basis for the new strainers from being exceeded. The program consists of a combination of foreign material control procedures and cleaning activities. We reviewed DAEC's suppression pool/strainer cleanliness program to ensure that the program is adequate to maintain ECCS operability during normal operation. Specifically, we interviewed the station personnel regarding the suppression pool cleanliness and reviewed selected procedures and work orders from the program including:

- Surveillance Test Procedure (STP) 3.6.1.1-01, "Suppression Chamber and Drywell Visual Inspection."
- Administrative Control Procedure (ACP) 1408.20, "Foreign Material Control."
- Integrated Plant Operating Instruction (IPOI) 7, "Special Operations."
- Pre-planned Maintenance Action Request (PMAR) 99-0285, dated April 6, 1999.

Foreign Material Control: ACP 1408.20 provides guidelines for implementing foreign material control. As a minimum, foreign material exclusion areas (FMEAs) or system closure shall be required on all work activities requiring foreign material exclusion (FME). Formal accountability of the entry and exit of tools, parts, grinding particles, and other items that could affect the intended operation of a system or component is maintained in FMEAs using material accountability logs (MALs). An FMEA is established when a system closure inspection to verify removal of all foreign material is not feasible. Guidance to the work planner provided in this procedure states that FME control requirements should be defined based on work activity considerations such as the size of the system opening, the potential effects of foreign material on system reliability, the effects of restricting access to the work zone, the ease with which tools dropped into the system can be readily retrieved, the cleanliness of adjacent areas, the potential detrimental effects of work activities in adjacent areas, the potential for introduction of foreign material via the ventilation system, the ease of cleaning and inspecting the system or component upon completion of the work, and the need for quality control inspections. The work planner must also balance the need for FME barriers with ease of retrieval. If an FMEA is implemented, then the following is implemented:

1- A custodian is assigned to control and account for tools and materials, and a MAL is implemented.

2- All personal objects are removed prior to entering the FMEA, or they are taped inside clothing pockets. In addition, badges, dosimetry, and glasses shall be taped or otherwise secured.

3- Lanyards shall be used to ensure the ability to retrieve objects, if dropped.

ACP 1408.20 provides guidance on many other potential methods the work planner can use to control foreign material. Examples include roping off the work area, temporary ventilation filters, temporary coverings for areas where recovery of dropped items would be difficult, cleaning adjacent areas, rescheduling work to avoid overlap with potentially detrimental activities in adjacent work areas, vacuuming the open system or component prior to closure, or flushing the system upon completion of the work.

ACP 1408.20 also describes the responsibilities of the worker and the Custodian. Prior to beginning work, the worker shall review, understand and adhere to the FME requirements. He shall also inspect the work area for loose tools, parts and materials. If an FMEA is established, he will verify that materials smaller than the planned system opening are formally accounted for or removed from the FMEA. The worker shall perform the work activities in a manner that reduces the possibility of introducing foreign material into the system (e.g., remove foreign material following maintenance, ensure components removed from the field are sealed to prevent foreign material intrusion, prevent metal shavings from entering electrical components, etc.). The worker is also responsible to notify supervision if FME control is lost and to balance the MAL before the system closure inspection is completed. Custodian responsibilities are also defined in ACP 1408.20. The Custodian controls the access to the FMEA and maintains the records for material accountability using the MAL.

The procedure defines the actions necessary when tools, parts or materials are lost. If they cannot be accounted for, a Supervisor is notified promptly and an Action Request initiated. If a loose parts analysis is preferable to physical recovery, the necessary evaluations/actions shall be completed and documented in the AR system prior to the system closure inspection.

The final parts of ACP 1408.20 include system cleanliness classifications and the definitions of the acceptance criteria for cleanliness. Reactor core isolation cooling and ECCS systems are class B. The acceptance criteria states that metal chips, filings, and grindings are unacceptable. Small particles and atmospheric dust that will be removed during flushing is acceptable.

Suppression Pool Cleaning: PMAR 99-0285 establishes a schedule of every other refueling outage for desludging the suppression pool to ensure that sludge quantities are maintained below the analyzed value of 500 lbs.

Suppression pool cleaning is accomplished through the work order system. The suppression pool cleaning is tracked as a Pre-planned Work Order (PWO). These work orders are in the computer with a defined schedule. Prior to the refueling outage, the PWO's are printed out and integrated into the outage work schedule.

Surveillances: STP 3.6.1.1-01 requires visual inspection of the interior and exterior of the suppression chamber, vent lines, vent header and downcomers, and the interior surface of the drywell for evidence of deterioration. This procedure also includes the inspection of the ECCS strainers and the suppression pool coatings. This procedure is primarily structural inspection, but includes an inspection of the ECCS strainers for debris. It provides a comment space in the procedure checklist, but no success criteria. This surveillance is typically performed every outage. The surveillance schedule is not to exceed 24 months.

IPOI 7 provides procedures for primary containment entry and closeout, as well as torus closeout. The procedure provides instructions to ensure that the drywell and torus are free of debris although some engineering judgement is allowed in assessing the need to remove materials from the drywell. In cases where the suppression pool has been drained, the strainers are inspected and verified free of debris as part of the torus closeout.

Maintenance Rule: We reviewed IES Maintenance Rule Memorandum NG-98-2021, "Core Spray and RHR Strainer Monitoring." This memorandum provides a discussion on the new ECCS strainers and their relationship to the DAEC Maintenance Rule Program. Specifically, the strainers are included in the licensee's maintenance rule activities because they are captured as an integral component of the ECCS systems to which they are attached. DAEC maintains programs for component-specific predictive maintenance, preventive maintenance, surveillance and inspection activities separate from the Maintenance Rule Program. DAEC's Maintenance Rule Program provides the performance-based mechanism for tracking the effectiveness of these programs in maintaining the reliability and availability of key plant functions. Using their Maintenance Rule Program, DAEC tracks the ability of the Containment Spray, LPCI and CS systems to deliver rated flow. They are tracked both on failure rate and unavailability. If the strainer related problem caused a failure of these systems, then it would be captured in the reliability and unavailability criteria. The Maintenance Rule Program also captures past unavailability identified at a later date. For instance, if, based on an inspection of the strainers or the torus, the inspector concludes that an ECCS system or train would not have been able to perform its function after a certain period of time, then the past unavailability would be applied to the system/train in the Maintenance Rule database. In addition, DAEC also has a Structure Monitoring Program within their Maintenance Rule program which has performance criteria regarding discovery of structural conditions, which without repair, could reasonably be expected to cause a system/train failure prior to the next scheduled assessment of the structure. The memorandum further notes that the NRC's baseline Maintenance Rule inspection conducted at DAEC in October 1997 concluded that DAEC's program acceptably monitored equipment performance and met the requirements of the Maintenance Rule.

Staff Evaluation: DAEC has implemented a program of suppression pool cleaning every other refueling outage. We conclude that this cleaning interval is appropriate based on the conservative assumptions in DAEC's strainer analysis relative to the amount of sludge in the suppression pool, and on the foreign material controls utilized in the torus and drywell to prevent foreign material from being inadvertently dropped in the suppression pool. Cleaning the suppression pool every other refueling outage means that the torus will be desludged approximately every three to four years. In addition, STP 3.6.1.1-01 requires strainer visual inspections as part of the Primary Containment Leakage Rate Testing Program required visual examinations. As part of this program, the strainers are visually examined and verified free of debris every refueling outage. Inspection of the strainers every outage minimizes the potential for unrecognized buildup of debris on the strainer surface. Similarly, cleaning the suppression pool every other refueling outage ensures that debris buildup in the suppression pool beyond the strainer design basis will not occur. The level of inspection and cleaning performed by DAEC is a conservative approach to ensuring adequate strainer availability; therefore, we conclude that DAEC's cleaning and surveillance intervals are acceptable.

We reviewed several work orders from previous refueling outages involving work in an around the torus. These work orders included activities such as coating inspections, torus cleaning (desludging), and containment leak rate testing. Our review determined that the work orders included appropriate foreign material controls that was consistent with the guidance in ACP 1408.20. For instance, for local leak rate testing of the torus hatch, the torus was declared an FMEA and a MAL was established. A Quality Control (QC) hold point was included for verification of compliance with ACP 1408.20 and the establishment of the MAL. A second QC verification was included for verifying that the MAL was balanced at the conclusion of the work. Based on our review, we conclude that DAEC's foreign material exclusion procedures provide an appropriate level of protection from foreign material for the ECCS strainers.

We agree with DAEC's assessment that their Maintenance Rule Program would capture ECCS performance problems (both reliability and unavailability) related to the ECCS strainers. The Maintenance Rule performance data should ensure that DAEC would address strainer issues appropriately with their preventative or predictive maintenance programs, as required.

Overall, our review and interviews with Duane Arnold's staff have shown that DAEC has a good focus on maintaining adequate cleanliness in the suppression pool, the drywell, and on the strainer surfaces. We also conclude that they have implemented appropriate programs and procedures to ensure operability of the ECCS strainers and availability of suppression pool water for ECCS injection during a LOCA. Therefore, we conclude that Duane Arnold has adequately addressed the issues raised in NRCB 95-02.

3.0 CONCLUSIONS

As shown by the audit team's confirmatory calculations, we believe that Duane Arnold has adequately designed their ECCS strainers to withstand the high debris loads anticipated during a LOCA. In addition, they have implemented an appropriate inspection program to ensure the operability of the ECCS (relative to strainer and suppression pool cleanliness), and they have also implemented a suppression pool cleanliness program and foreign material control procedures to limit the potential for clogging the ECCS with materials brought into the drywell or wetwell during outage operations. The licensee was well prepared for the audit. All requests for additional information were addressed quickly and efficiently. As a whole, it was a successful site visit.

This audit was seen as the starting point for the closure of hydrodynamic load open issues related to the new strainer installation. However, actual closure cannot be made until we complete our review of the GE LTR. During the exit meeting, we restated that no conclusions on the hydrodynamic loads on the Duane Arnold ECCS strainers were made at the time. Our major focus of this audit was understanding the application of the GE methodology to the new ECCS strainers. Since our review of the hydrodynamic load portion of the GE LTR is currently still ongoing, we will assess the need to address any open items regarding the adequacy of the DAEC design relative to hydrodynamic loads upon the completion of our LTR review.
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Appendix A

AUDIT PLAN

Implementation of NRC Bulletin 96-03 Resolutions

Applicability: The staff plans to audit the following sites:

1- Duane Arnold (Mark I, GE Bolt-on, NUKON Fibrous Insulation)
2- Dresden (Mark I, PCI Bolt-on, RMI Insulation)
3- Limerick (Mark II, ABB, NUKON Fibrous Insulation)
4- Grand Gulf (Mark III, Enercon, Calcium Silicate and Kaowool Insulation)

After performing the above audits, the staff will evaluate the need for additional audits. If additional audits are needed, the staff would most likely select from the following plants:

- Susquehanna (Mark II, GE Bolt-on, RMI)
- Fitzpatrick (Mark I, PCI Ring Girder, Various Fibrous Insulations)
- Peach Bottom (Mark I, ABB, NUKON Fibrous Insulation)
- Perry (Mark III, Enercon, NUKON Fibrous Insulations)

The choice of any additional plants to be audited will be assessed by the staff based on findings from the initial four audits. If the initial audits identify any safety issues, then additional sites may be selected to determine if the issues are vendor-specific, plant-specific, or generic in nature.

Objective: To verify the implementation of NRC Bulletin 96-03 (NRCB 96-03), "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris." Specifically, the staff will:

1) assess the adequacy of licensee resolutions;

2) identify if additional evaluation of licensee resolutions through the NRC inspection program is necessary; and

3) if additional inspection effort is needed, identify areas to be inspected and guidance needed to support inspection effort (i.e., a Temporary Instruction).

Background: On July 28, 1992, an event occurred at Barsebäck Unit 2, a Swedish boiling-water reactor (BWR), which involved the plugging of two containment vessel spray system (CVSS) suction strainers. The strainers were plugged by mineral wool insulation that had been dislodged by steam from a pilot-operated relief valve that spuriously opened while the reactor was at 435 psig. Two of the three strainers on the suction side of the CVSS pumps that were in service became partially plugged with mineral wool. Following an indication of high differential pressure across both suction strainers 70 minutes into the event, the operators shut down the CVSS pumps and backflushed the strainers. The Barsebäck event demonstrated that the potential exists for a pipe break to generate insulation debris and transport a sufficient amount of the debris to the suppression pool to clog the ECCS strainers.

Similarly, on January 16 and April 14, 1993, two events involving the clogging of emergency core cooling system (ECCS) strainers occurred at the Perry Nuclear Power Plant, a domestic BWR. In the first Perry event, the suction strainers for the residual heat removal (RHR) pumps became clogged by debris in the suppression pool. The second Perry event involved the deposition of filter fibers on these strainers. The debris consisted of glass fibers from temporary drywell cooling unit filters that had been inadvertently dropped into the suppression pool, and corrosion products that had been filtered from the pool by the glass fibers which accumulated on the surfaces of the strainers. The Perry events demonstrated the deleterious effects on strainer pressure drop caused by the filtering of suppression pool particulates (corrosion products or “sludge") by fibrous materials adhering to the ECCS strainer surfaces. This sludge is typically present in varying quantities in domestic BWRs, since it is generated during normal operation. The amount of sludge present in the pool depends on the frequency of pool cleaning/desludging conducted by the licensee.

On September 11, 1995, Limerick Unit 1 was being operated at 100-percent power when control room personnel observed alarms and other indications that one safety relief valve (SRV) was open. The licensee implemented emergency procedures. Attempts by the reactor operators to close the valve were unsuccessful, and a manual reactor scram was initiated. Prior to the opening of the SRV, the licensee had been running the "A" loop of suppression pool cooling to remove heat being released into the pool by leaking SRVs. Shortly after the manual scram, and with the SRV still open, the "B" loop of suppression pool cooling was started. The reactor operators continued their attempts to close the SRV and reduce the cooldown rate of the reactor vessel. Approximately 30 minutes later, operators observed fluctuating motor current and flow on the "A" loop of suppression pool cooling. Cavitation was believed to be the cause, and the loop was secured. After it was checked, the "A" pump was successfully restarted and no further problems were observed. After the cooldown following the blowdown event, the licensee sent a diver into the Unit 1 suppression pool to inspect the condition of the strainers and the general cleanliness of the pool. The diver found that both suction strainers in the "A" loop of suppression pool cooling were found to be almost entirely covered with a thin "mat" of material, consisting mostly of fibers and sludge. The "B" loop suction strainers had a similar covering, but less of it. Analysis showed that the sludge primarily consisted of iron oxides and the fibers were polymeric in nature. The source of the fibers was not positively identified, but the licensee has determined that the fibers did not originate within the suppression pool, and contained no trace of either fiberglass or asbestos. This event at Limerick demonstrated the need to ensure adequate suppression pool cleanliness. In addition, it re-emphasized that materials other than fibrous insulation could clog strainers.

In response to the Limerick event, the staff issued NRCB 95-02, "Unexpected Clogging of Residual Heat Removal (RHR) Pump Strainer While Operating in Suppression Pool Cooling Mode," on October 17, 1995. The bulletin requested that licensees (1) assess the operability of their ECCS on the basis of the cleanliness of their suppression pool and ECCS strainers, (2) verify the operability of the ECCS through an appropriate pump test and strainer inspection within 120 days from the date of the bulletin, (3) establish a pool cleaning program, (4) review their foreign material exclusion (FME) practices and correct any identified weaknesses, and (5) implement any additional appropriate measures for ensuring the availability of the ECCS.

Title 10, Section 50.46 of the *Code of Federal Regulations* (10 CFR 50.46) requires that licensees design their ECCS systems to meet five criteria, one of which is to provide long-term cooling capability following a successful system initiation for a sufficient duration so that the core temperature is maintained at an acceptably low value and decay heat is removed for the extended period of time required by the long-lived radioactivity remaining in the core. The ECCS is designed to meet this criterion, assuming the worst single failure. However, experience gained from operating events and detailed analyses has demonstrated that excessive buildup of debris from thermal insulation, corrosion products, and other particulates on ECCS pump strainers is highly likely to occur. This creates the potential for a common-cause failure of the ECCS, which could prevent the ECCS from providing long-term cooling following a LOCA. The staff has concluded, therefore, that licensees must take adequate steps to prevent strainer clogging in order to ensure compliance with the regulations.

As a result, NRCB 96-03 was issued on May 6, 1996, requesting BWR licensees to implement appropriate procedural measures and plant modifications to minimize the potential for clogging of ECCS suppression pool suction strainers by debris generated during a LOCA. Regulatory Guide 1.82, Revision 2, (RG 1.82) was issued in May 1996 to provide non-prescriptive guidance on performing plant-specific analyses to evaluate compliance with 10CFR50.46. On November 20, 1996, the Boiling Water Reactor Owners Group (BWROG) submitted NEDO-32686, "Utility Resolution Guidance for ECCS Suction Strainer Blockage" (also known as the URG) to the staff for review. The purpose of the URG is to give boiling-water reactor (BWR) licensees guidance for complying with the requested actions of NRCB 96-03. The staff approved the URG in an safety evaluation report (SER) dated August 20, 1998. In response to NRCB 96-03, all affected BWR licensees have installed (or will install during their next refueling outage) new large-capacity passive strainers to resolve the issue. These installations have typically been conducted under 10 CFR 50.59 with the licensees concluding that no unreviewed safety question exists due to the installation of the new strainer designs. As a result, no detailed review of licensee resolutions for this issue has been performed by the staff. Therefore, the staff will conduct 4-6 plant audits to verify implementation prior to closing out the generic issue for BWRs.

Audit Requirements: The following analyses and programs will be included in the audit scope:

1) the licensee’s 50.59 safety evaluation,
2) the licensee’s plant-specific analyses performed in response to NRCB 96-03,
3) the licensee’s strainer performance and design calculations, and
4) the licensee’s ongoing suppression pool cleanliness program (NRCB 95-02).

Audit Guidance

1) Licensee’s 50.59 safety evaluation

Purpose: to perform a technical review to ensure that implementation of the strainer resolution did not create new safety concerns (e.g., hydrodynamic loads), as well as to ensure that the licensee’s safety evaluation is sufficiently comprehensive to ensure that no additional safety concerns were caused by the strainer resolution.

Specifically, the auditor will review the licensee's 10 CFR 50.59 safety evaluation performed in response to its NRCB 96-03 resolution to assess the:

- affect of any changes to strainer hydrodynamic load calculations on plant safety
- affect of the increased strainer size (and associated supporting structure) on suppression pool inventory/accident analyses
- adequacy of scope of resolution (e.g., is change only required to low pressure ECCS pumps)
- potential for new failures not previously evaluated being created by the resolution
- potential for an increase in the probability of a failure previously evaluated

The staff will perform a technical review of the 10 CFR 50.59 safety evaluation to confirm that the licensee's resolution adequately addressed the potential impacts of the new strainer design on plant safety.

2) Plant-specific analyses performed in response to NRCB 96-03

Purpose: Evaluate plant-specific application of the URG in plant analyses to determine if the calculated strainer debris loadings are appropriate.

Specifically, the auditor will review the licensee's plant-specific strainer analyses:

- to assess the overall application of the URG to the plant
- to confirm consistent interpretation of the URG and the staff's SER
- to evaluate licensee analyses of areas where the URG did not provide detailed guidance (e.g., evaluation of debris generation and transport inside the bio-shield wall)

Limited confirmatory calculations will be performed, as necessary, to confirm consistency in the application of the URG methodologies.

3) Strainer performance and design calculations

Purpose: To confirm that the strainer has been adequately designed and constructed to meet its safety function.

Specifically, the auditor will review the licensee's strainer design calculations to confirm:

- the adequacy of the licensee's basis for determining their strainer head loss
- the adequacy of the licensee's basis for calculation of their NPSH margin

- the adequacy of the strainer structural design and construction (e.g., ASME code requirements)

In addition, the auditor will compare calculated clean strainer head losses with results of post-implementation testing performed by the licensee.

4) Ongoing suppression pool cleanliness program (NRCB 95-02)

Purpose: To confirm that the licensee's program to ensure appropriate levels of suppression pool and ECCS suction strainer cleanliness is adequate to ensure operability of the ECCS.

Specifically, the auditor will review the licensee's suppression pool cleanliness program to confirm:

- the licensee has established an adequate suppression pool cleaning program including:
  1) procedures to evaluate pool cleanliness
  2) criteria for cleaning pool/strainers
  3) frequency of pool evaluation and cleaning
  4) basis for cleaning frequency and criteria

- the licensee has established adequate administrative controls on the program (e.g., included in the plant maintenance program)

The appendices to this audit plan (not included herein) provide spreadsheets detailing the specific information which will be evaluated by the auditors. The auditors will review plant drawings, calculations, strainer specification and other design documentation, as appropriate. The licensee's documentation will be used to fill in the attached spreadsheets. Confirmatory calculations will be performed by the team as shown on the spreadsheets. The completed spreadsheets will be included in the trip report for each plant.

Reporting Requirements: The results of this audit will be documented in a routine trip report. The trip report will be addressed to the Director, Division of Systems Safety and Analysis, NRR (mail stop O-8E2). A copy of the trip report will be forwarded to the Project Manager for the audited plant. A summary report of the staff's findings on all the audits will be published following completion of the audits.

Completion Schedule: These audits should be completed by May 31, 1999.

Contact: Questions regarding this audit plan should be directed to Rob Elliott at 301-415-1397.

Statistical Data Reporting: Hours expended for this audit, including preparation time, should be reported under TAC number MA0704.

Originating Organization Information

Organization Responsibility: This audit plan was initiated by the Containment Systems and Severe Accident Branch (SCSB).

Resource Estimate: It is estimated that each audit will require approximately 240 hours per audit (120 hours per auditor, with two NRR representatives on each audit). The staff estimates approximately 40 hours at each audit site.

Other: It is anticipated that each audit team will consist of two members of SCSB and two contractor personnel.

Training: No specific training is associated with this audit.

References:

NRC Bulletin 93-02, “Debris Plugging of Emergency Core cooling Suction Strainers,” dated May 11, 1993.

NRC Bulletin 93-02, Supplement 1, “Debris Plugging of Emergency Core cooling Suction Strainers,” dated February 18, 1994.

NUREG/CR-6224, “Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris,” dated October 1995.

NRC Bulletin 95-02, "Unexpected Clogging of Residual Heat Removal (RHR) Pump Strainer While Operating in Suppression Pool Cooling Mode," dated October 17, 1995.

NRC Bulletin 96-03, “Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors,” dated May 6, 1996.

Regulatory Guide 1.82, Revision 2, “Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident,” dated May 1996.

GL 97-04, “Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps,” dated October 7, 1997.

APPENDIX B

Los Alamos

Technical Evaluation Report

LA-CP-99-346

ON-SITE AUDIT OF DUANE ARNOLD ENERGY CENTER'S EMERGENCY CORE COOLING SYSTEM STRAINER BLOCKAGE RESOLUTION