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2301 Market Street
Philadelphia, Pennsylvania 19101

Facility Name: Limerick Generating Station, Unit 2

Inspection at: Bechtel Engineering Corporation Offices
San Francisco, California

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LIMERICK UNIT 2

INDEPENDENT DESIGN ASSESSMENT (IDA)
CORRECTIVE ACTION INSPECTION, APRIL 24-28, 1989

1. BACKGROUND INFORMATION

By letter dated July 28, 1988, the NRC informed the Philadelphia Electric Company (PECO) that it had accepted Revision 1 to the "Program for the Independent Design and Construction Assessment (IDCA) of Limerick Unit 2." The intent of this program was to assess the adequacy of the design and construction process used at Limerick Generating Station, Unit 2, by conducting an independent review of selected plant systems, components, and structures associated with the containment heat removal mode of operation of the residual heat removal (RHR) system. The staff viewed the scope of the program as a comprehensive review of the architect-engineer's design as well as a representative sampling of all major construction attributes, including component and system testing. PECO selected Stone and Webster Engineering Company (SWEC) of Cherry Hill, New Jersey, to conduct the independent assessment.

To monitor the proper application of the IDCA, the NRC decided to review both the independent design assessment (IDA) and the independent construction assessment (ICA) in three phases: (1) preparation of review plans by SWEC, (2) implementation of the review plans and performance of the review by SWEC, and (3) review and evaluation of the SWEC's final IDCA reports, including PECO's associated corrective actions. The NRC documented Phase 1 in Inspection Report 50-353/88-200, including recommendations for additions and clarifications to SWEC's review plans; Phase 2 was documented in Inspection Reports 50-353/88-201 and 50-353/88-203 for the IDA and in Inspection Report 50-353/88-202 for the ICA; Phase 3 is the subject of this inspection report for the IDA and Inspection Report 50-353/89-200 for the ICA.

2. INSPECTION SCOPE AND OBJECTIVE

During the week of April 24, 1989, the inspection team visited the offices of the Limerick architect-engineer, Bechtel Power Corporation, in San Francisco, California, to evaluate the final IDA report. Included in this evaluation was an assessment of the corrective actions implemented or scheduled by PECO as a consequence of the design observation reports (DORs) identified by SWEC.

3. INSPECTION DETAILS

The final IDA report prepared by SWEC resulted in 118 DORs. DORs were initiated where an action item remained unresolved after SWEC reviewed the Bechtel response. The inspection team evaluated the thoroughness of the final IDA report by reviewing Bechtel's response to selected DORs as well as the SWEC evaluation of the Bechtel response. Of the 118 DORs, the inspection team reviewed 64 DORs which were viewed to be the more significant. The inspection team was composed of two technical reviewers in the mechanical systems discipline, and one technical reviewer each in the electric power systems, instrumentation and controls, mechanical components, and civil/structural disciplines.

Before performing the inspection, the team read the IDA final report which consisted of one loose-leaf binder entitled "Volume I - Assessment Summary" and four loose-leaf binders entitled "Volume II - Design Assessment Report, Books 1, 2, 3 and 4." Based on the inspection team's review of the final IDA report, certain DORs were selected to be reviewed on the basis of their apparent safety significance. The following sections provide a summary for each discipline of this inspection.

3.1 Mechanical Systems

The IDA utilized the "vertical slice" approach focusing on the design of subsystems and components associated with the containment heat removal (CHR) mode of operation of the residual heat removal (RHR) system. In addition, the structures, subsystems, and components associated with cooling of the RHR heat exchanger by the RHR service water (RHRSW) system with heat rejection to the spray pond were included in the assessment.

The mechanical system review evaluated the sizing of the major RHR and RHRSW components and material selection to support functionality of the design, including associated specifications and calculations. In addition, the design was evaluated to determine its adequacy with respect to the lifting of heavy loads, high-energy line break (HELB) temperature/pressure profiles, fire protection analysis, moderate-energy pipe break effects, and radiation exposure mitigation to equipment and personnel. When the CHR system features review would not provide sufficient basis to draw a conclusion on the overall design and related processes, reviews of other systems/subsystems were performed. These reviews included, for example, steam piping subjected to potential water hammer, and suppression pool sparger design.

SWEC found that about 60 percent of all mechanical system DORs were a result of a review of calculations. Many calculations were found to contain unverified inputs or assumptions, undocumented engineering judgments, untraceable inputs, or inputs inconsistent with the as-built design. In general, further explanations and clarifications, sometimes including additional or revised calculations, were required to demonstrate that the calculations supported the final plant design. SWEC found, however, that the calculations were sufficiently conservative and resulted in a technically adequate design, although in some cases the calculated results overstated available design margins.

The inspection team reviewed the following 21 DORs in the mechanical systems discipline: 015, 022, 023, 029, 031, 032, 038, 043, 044, 065, 083, 084, 096, 097, 098, 099, 100, 101, 109, 110 and 112. Of these DORs, three (DORs 015, 043 and 097) were identified as open in the IDA final report because SWEC and Bechtel did not agree on the resolution. Summarized below are a few of the more significant DORs that the team reviewed in the mechanical systems discipline.

3.1.1 DOR 015-Verification of Nonstandard Computer Codes (Closed)

Bechtel Procedure EDP-4.37 required that nonstandard computer programs be verified. SWEC identified a nonstandard computer program, "QAC", that was not verified for the sample problems in the instruction manual but had been used in Calculation S102.1, Revision 0. In response to the SWEC concern, Bechtel benchmarked the calculation with the CYLSEC (NE650) standard computer code and Calculation S102.1, Revision 1, was issued.

SWEC found that this revised calculation for a plant-specific geometry did not provide a generic verification of QAC and concluded that the validity of QAC results in other calculations in which the code may have been used should be established. During the inspection, Bechtel issued Revision 1 to DOR 015 and committed to a verification of the QAC code by performing a calculation that compared the results of the sample problems in the QAC manual with that of computer program NE650. Before the exit meeting, Bechtel provided the inspection team with Calculation S000.62, Revision 0, which confirmed the applicability of the QAC code for the types of applications described by the manual sample problems. Bechtel further noted that there are no other applications of the QAC code in Limerick calculations. The team found this corrective action acceptable as the calculation covers the areas of application of the QAC code at Limerick.

3.1.2 DOR 043 - Exponential Temperature Decay Methodology for Thermal Analysis (Closed)

SWEC's review of piping stress analysis determined that Bechtel had employed an exponential temperature decay equation for pipe near reactor pressure vessel (RPV) nozzles that reduced the temperature in the piping dead leg. This approach was apparently unconservative and lacked technical justification. In response, Bechtel provided supplemental calculations using the 1977 ASME Code, Summer 1979 Addenda, without the temperature reduction for the specific problem and indicated that the results of this alternate approach were bounded by the results of the existing calculations (using exponential temperature decay and ASME III 1974 Code). Bethtel, however, did not consider this alternative approach for other cases in which the exponential temperature decay methodology was employed. SWEC accepted the supplemented calculations for this specific case but did not close the concern raised in this DOR and requested Bechtel to apply the alternate approach using the ASME 1977 Code, Summer 1979 Addenda, for all other similar cases. Bechtel provided the revised response to DOR 043 to the NRC team and stated that the exponential temperature decay approach was employed only on two other cases; the RHR return and supply lines. Bechtel re-evaluated the stress analysis of these two lines based on the conservative approach and concluded that the original results remain valid.

The NRC team discussed this DOR with Bechtel and reviewed document SR 8031-2300-2, ASME Section III Class I Analysis of Low Pressure Coolant Injection Systems, Revision 0, dated April 3, 1989; and document SR 8301-1200-2, ASME Section III, Class I Analysis of RHR Return and Supply Systems Limerick GS Unit 2, Revision 1, dated April 24, 1989.

The inspection team noted that for RHR supply lines, as the flow originates from a high temperature of 375°F, the application of the temperature decay method provides a lower temperature at the location of concern and tends to increase the magnitude of temperature step change and hence provide conservative results.

For the RHR return lines, the flow originates from a low temperature source and the affected components were re-evaluated, based on no exponential temperature decay. The revised calculation indicated that the cumulative usage factor for the affected components was slightly lower than the original value and hence the original results remain valid. The NRC team also confirmed with Bechtel that the supplemental low-pressure coolant injection (LPCI) hand calculations as part of the response to DOR 043 have been made a permanent part of the Limerick 2 Class 1 stress report. Based on the above justifications, as they resolve all the concerns identified by SWEC, the inspection team accepted Bechtel's response and closed this DOR.

3.1.3 DOR 084 - Incorrect Nameplate for the RHR Pump Motor (Closed)

During the IDA walkdown, SWEC identified that the nameplate on the RHR pump motor referred to the original motor model rather than to the modified, current model as noted in qualification documents. This mistake could have resulted in misapplication of spare parts or incorrect maintenance. Bechtel concurred with the observation and responded that the licensee's print files were not updated when field changes were made to General Electric (GE)-supplied equipment via field deviation disposition requests (FDDRs). Also, Bechtel stated that the corrective action to revise the subject FDDR with the correct motor model number and bearing part number had been completed. SWEC accepted Bechtel's response and agreed that the incorrect nameplates were limited to the four RHR pump motors and could not have resulted in misapplication of bearing parts. Based on the response that PECO was investigating a program to update and maintain changes to vendor prints to ensure correct spare parts and maintenance service, SWEC closed this DOR.

The inspection team discussed this DOR with GE and Bechtel and reviewed FDDR No. HH2-8817, Revision 2, and confirmed that the correct motor model number had been provided. The inspection team agreed with SWEC's evaluation and recommendation that PECO implement a vendor print update program to ensure correct spare parts and maintenance service. In a letter dated May 16, 1989, PECO committed to develop an action plan by June 15, 1989, and implement it on a schedule consistent with the overall configuration management project schedule. This action was considered appropriate by the inspection team, and this item is considered closed.

3.1.4 DOR 096 - RHR Relief Valves (Closed)

SWEC identified that the RHR system steam condensing mode relief valves appeared to be undersized with regard to meeting their licensing basis and the ASME Code sizing criteria. In response to this DOR, Bechtel concurred that relief valve sizing did not meet the licensing basis in the final safety analysis report (FSAR) and that the piping pressure drop upstream of the relief valve was neglected. Bechtel clarified that the steam condensing mode was deleted as a system design basis and, therefore, the concerns relative to the relief valve sizing considering the RHR heat exchanger in the steam condensing mode were no longer applicable. Also, to provide additional confidence in the adequacy of the relief valve sizing, Bechtel agreed to review safety-related, Bechtel-procured safety and relief valves, excluding thermal relief valves.

SWEC reviewed Bechtel's response to this DOR and agreed that elimination of the steam condensing mode would invalidate the concerns that the RHR relief valve sizing calculations did not demonstrate design adequacy. SWEC closed this DOR based on the commitment from Bechtel that the review of all nuclear-class, Bechtel-procured safety and relief valves (except thermal relief valves) would be performed.

The inspection team reviewed Licensing Document Change Notice (LDCN) No. FS-1684 dated March 31, 1989, and Safety Evaluation BLP-47520 (unapproved by PECO) for Unit 1 and confirmed that the steam condensing mode had been deleted as a mode of plant operation. Also, the inspection team reviewed Bechtel document 8031-M-204B, dated April 26, 1989, covering the preliminary review of 18 Bethtel-procured safety/relief valves. This document evaluated the adequacy of the design process for safety valve sizing, code compliance, accuracy of design-basis input, consistency with licensing documents, agreement with as-built configurations, and adequacy of consideration for valve location with respect to the protected components. PECO's letter of May 16, 1989, committed that the relief valve adequacy review and corrective actions would be implemented before fuel load. Based on the above calculation and commitment, this DOR is closed.

3.1.5 DOR 097 - Heat Load Calculations for Sizing the Control Room Cooling Coil for Emergency Conditions (Closed)

SWEC's review of Calculation M-78-2 showed that only the heat loads generated during normal operation were addressed in sizing the control room heating ventilation, and air conditioning (HVAC) cooling coil. Heat gain from the emergency fresh air supply system, which included the charcoal filter train heater and fan heat, was not addressed. In response, Bechtel explained that the heater filter was not considered because the emergency fresh air supply heater was controlled via safety-related humidistats to operate when the relative humidity was higher than 65 percent. During the emergency mode of operation, when the fresh air design temperature is 95°F DB, 78°F WB, the heater is not activated as the humidity of mixed air is less than 60 percent relative humidity. SWEC's evaluation requested Bechtel to demonstrate, based on statistical weather data, when other than design conditions exist for outside fresh air that the heater would not operate during accident conditions.

Bechtel provided the inspection team with a revised response to DOR 097 and explained that the design outside air condition of 95°F DB, 78°F WB, was selected for the Philadelphia area based on Chapter 33, Table 1 (climatic conditions for United States and Canada), of the <u>ASHRAE Handbook of Fundmentals</u> (1972). Bechtel explained that for all the outside air conditions bounded by 95°F DB and 78°F WB, the filter heater would not operate during the emergency conditions, and the cooling coil design was adequate. Bechtel stated that emergency fresh air supply fan motor heat was included for the cooling coil design. For the other outside air conditions that are not bounded by 95°F DB, 78°F WB, during the accident events, the peak air temperatures could occur for 1 percent of the summer and, during that time, the heater would operate and the control room air temperature would exceed the allowables. Bechtel stated that for this short duration during the accident conditions, there would not be any adverse effect on the control room equipment and the operator's comfort. Bechtel provided the inspection team with page 410.85-1 of the FSAR which explained that the ASHRAE Fundamentals Handbook was the basis for establishing the design conditions for outside fresh air. The inspection team also reviewed the other recent revisions of the ASHRAE Fundamentals Handbook and noted that outside fresh air design conditions considered by Bechtel encompassed the data provided in the ASHRAE Fundamentals Handbook. Based on the information provided, the inspection team concluded that Bechtel had provided adequate assurance that the cooling coil design had sufficient capacity for the normal and emergency conditions, and the inspection team agreed that the cooling coil design was adequate. This DOR was closed.

3.2 Electric Power Systems

In the electrical discipline, the SWEC review included design criteria, diagrams, drawings, specifications, calculations, test reports, and documents relating to design-changes. Engineering and design documents were compared against FSAR design basis requirements and commitments. Drawings and diagrams were reviewed for design criteria attributes such as electrical independence, including cable/raceway separation, grounding, and environmental conditions. The distribution system documents were reviewed for consistency with single-line diagrams. Overall design configuration and its impact on nearby equipment was also reviewed. Specifications were reviewed for adequate electrical and environmental requirements. Calculations were reviewed for adequacy and consistency with the design basis. The calculations included equipment sizing, voltage profile, short-circuit capacity, equipment protection, breaker coordination, and cable sizing. Vendor drawings were reviewed for consistency with specifications, drawings, and diagrams. The electrical equipment was reviewed for compliance with the guidance contained in Regulatory Guide (RG) 1.89 for environmental and seismic qualification of the equipment and according to requirements of RG 1.75 for physical independence and redundancy. Electrical interfaces between the architect-engineer and nuclear steam supply systems (NSSSs) were reviewed for compatibility and consistency of engineering and design requirements. Recent design change documents were selected and reviewed for technical adequacy. In addition to the design documents review, a site walkdown inspection was performed as part of the IDA program to verify compliance of the as-built system with the criteria for electrical independence and physical separation, grounding, environmental qualification, and consistency of the installation with the specifications.

SWEC's review resulted in 17 DORs, all of which were very comprehensive in content. For resolution of these DORs, Bechtel had to revise several calculations, several existing station procedures, and had to incorporate a hardware change that involved the procurement and installation of new sets of Class 1E undervoltage relays for the emergency buses of Limerick Units 1 and 2. Based on SWEC's technical assessment of the electrical design samples and the NRC overview, it was concluded that the station electrical system at Limerick 2 was technically acceptable and met the licensing commitments. In general, with one exception, in which a hardware change was performed, design deficiencies in the electrical system were not significant in that no operability concerns were identified, and were determined to have no impact on the technical adequacy of the design. However, the nature of the deficiencies and their number indicated that the Bechtel design process either lacked the "independent design verification" as required by ANSI N45.2.11 or it was not carried out in an effective manner.

The inspection team reviewed the following 14 DORs in the electrical power systems discipline: 018, 039, 042, 078, 079, 081, 082, 087, 088, 090, 103, 111, 113 and 115. Of these DORs, three (DORs 039, 103 and 113) were identified as open in SWEC's IDA final report because SWEC and Bechtel did not agree on the resolution. Summarized below are a few of the more significant DORs that the inspection team reviewed in the electrical power systems discipline.

3.2.1 DOR 039 - Sizing Thermal Overload Relay Heaters (Open)

SWEC issued this DOR to address a concern that the methodology used for selection of heaters for thermal overload (TOL) relays of continuously running 480-volt motors could result in a spurious tripping of these motors. Spurious tripping could be a result of the terminal voltage being lower than 90 percent of the rated value, the ambient temperature being higher than 30 degrees centigrade, the negative tolerance associated with these TOL relays, or any combination of these factors. Bechtel's response indicated that automatic load tap changers would prevent the voltage at the motor terminals from being less than 90 percent, that the actual ambient temperatures were usually below design ambient temperatures, and in some cases that the motor sizing was very conservative. Based on these assumptions, Bechtel concluded that no corrective action was needed. SWEC did not agree with Bechtel's response and during a telephone conference call including the inspection team, Bechtel, SWEC and the licensee, SWEC informed the team that in a few cases spurious tripping may occur at terminal voltages as high as 97 percent of the rated voltage. SWEC insisted that a case-by-case evaluation of TOL relay heater selection should be performed to ensure that spurious tripping does not occur. The inspection team concluded that an evaluation of the sizing of TOL relay heaters was needed, including the effects of low voltage, high ambient temperature, and negative tolerances for all continuously running nonMOV, 480-volt motors required for safe shutdown. PECO's letter of May 16, 1989, committed to perform this evaluation before exceeding 5 percent power. The results of the evaluation are to be transmitted to the NRC (NRR).

3.2.2 DOR 087 - End of Life Voltage for the Vital Batteries (Open)

SWEC issued this DOR to address a concern that the calculation for control circuit maximum cable length for switchgear and dc motor control centers (MCCs) concluded that the minimum end-of-life (EOL) voltage of the batteries should have been 108 volts instead of 105 volts. Bechtel's response confirmed that although the batteries were sized using an EOL voltage of 105 volts, a separate evaluation performed by the manufacturer of the batteries indicated that enough margin existed such that 108 volts could be used as the EOL voltage. SWEC accepted this response. However, the inspection team identified that the manufacturer's evaluation did not confirm that this margin was sufficient to demonstrate that the batteries were capable of handling the design load in conjunction with an undetected high impedance fault on the load side of the inverters. PECO committed in their letter of May 16, 1989, to the NRC to perform the associated evaluation of battery capacity considering 105-percent inverter loading and 108-volt EOL voltage. The results of this evaluation are to be transmitted to the NRC (NRR).

3.2.3 DOR 103 - Evaluation of Safety-Related Bus Separation from Grid (Open)

This DOR was issued because the calculation for voltage regulation contained incorrect information relating to inputs, assumptions, methodology, computations, and conclusions. In their response to these concerns, Bechtel provided many clarifications that were acceptable to SWEC. However, SWEC's concern relating to worst-case voltage was not resolved. SWEC described a possible worst-case voltage scenario as follows: the system was lightly loaded before a LOCA [thus the transformer load tap changer (LTC) was in an unfavorable position] and a load swing occurred as a result of a LOCA concurrent with a voltage swing of the offsite power source. In response to this concern, PECO informed the inspection team that their review of the history of grid performance revealed that it did not experience swings such as those suggested by SWEC. Also, Bechtel stated that enough margin existed to mitigate a voltage dip caused by any postulated event. To prove that enough margin existed and that spurious separation of onsite buses from grid would not occur as a result of a grid voltage swing when engineering safety feature (ESF) loads were sequenced following a LOCA, the inspection team requested that an analysis be performed assuming a single offsite power source, a LOCA in one unit and shutdown of the other unit, the LTC in a most unfavorable position before this event, and a dip in the grid voltage as a result of the plant trip when voltage on the grid was at minimum as a result of a regular voltage swing. Also, if during the above-described scenario, separation between onsite system and grid occurred, a cause and effect analysis would be performed assessing the capability of the ESF systems to mitigate the event without encroaching on the design safety limits, including the effect of tripping the ESF loads and resequencing on the diesel generator. Initially, PECO objected to maintaining the status of the LTC tap in its pre-LOCA position, but later agreed as the LTC has a high response time (30 seconds for initial move and 3 seconds for each subsequent step). PECO's letter of May 16, 1989, committed to revise the voltage regulation study, including the grid voltage swing before exceeding 5 percent power. The results of this study are to be transmitted to the NRC (NRR).

3.2.4 DOR 113 - Diesel Generator (DG) Ground Fault Protection (Closed)

SWEC identified that during a LOCA the existing diesel generator (DG) grounding and associated protection schemes could allow a ground fault of 18 amperes or less to flow anywhere in the Class 1E 4kV system (including motor feeds) without causing a trip to isolate the fault. The existing scheme allows a current of 40 amperes for a line-to-ground fault at the 4kV bus without causing a trip to isolate the fault for a LOCA condition concurrent with a loss of offsite power. Also, the existing scheme allows approximately 40 percent of DG winding (DG differential relay trip setting of 16 amps/40 amps maximum fault current = 40 percent) to be shorted to ground without being isolated or tripped. The effects of such faults on the DG capability and the effect of DG output voltage distortion on acceleration of ESF loads have not been analyzed. Ground fault annunciation was provided in the control room. In the absence of a ground fault trip, fault currents of 4 amperes (current transformer ratio is 10:1) would flow continuously through the relay which had been qualified for 2.6 amperes continuous rating for 8 minutes. In this situation, the relay would be destroyed in 8 minutes or less and if the annunciation was reset, fault currents of 40 amps would continue to flow, thus posing an undetected fire threat. Also a smoking relay in Class 1E switchgear may affect proper operation of nearby Class 1E circuits. Bechtel responded that all of these scenarios were bounded by the single failure criteria, and therefore no design change was required.

The inspection team agreed that credit for a single failure may be taken but believed the existing DG grounding scheme and associated protection circuits to be examples of poor design practice. Existing guidelines, standards, and technical papers dealing with this subject state that the allowable value of groun. fault current should be limited below 10 amperes. Therefore, PECO should re-evaluate the sizing of the DG ground fault resistor in light of currently accepted good engineering practice.

3.3 Instrumentation and Controls

The SWEC IDA review in the instrumentation and control (I&C) discipline covered a comprehensive range of design topics, including FSAR/licensing commitments; setpoint calculations and flow element sizing; instrument location drawings, instrument installation details, and instrument tubing isometric drawings; piping and instrumentation diagrams (P&IDs), logic, loop, and elementary/schematic diagrams; procurement and installation specifications; vendor drawings and installation/maintenance instructions; discipline/group interfaces among I&C and Mechanical, Materials, Engineering Mechanics, and Electrical Departments; design change documents; nonconformance reports, and as-built verification of select I&C drawings. In addition, environmental and seismic qualification for a sample of instrumentation was assessed. As the Unit 2 environmental and seismic qualification programs were extensions and modifications to the existing programs for Unit 1, but were not completed for Unit 2, some of the basis for the assessment was necessarily supported by documentation for Unit 1 equipment and by commitments to completion of the Unit 2 program.

SWEC identified 22 DORs in the I&C discipline. Of the 22 DORs, 9 pertained to seismic qualification concerns, 5 to environmental qualification concerns, 2 to concerns about tubing supports, 2 to apparent FSAR commitment discrepancies, and singular concerns pertained to instrument location drawing discrepancies, nameplate discrepancies, a vendor site procedure weakness, and weaknesses in the establishment and control of balance-of-plant (BOP) Q-functional setpoints in the Bechtel/PECO scope.

SWEC concluded that, with the exception of the BOP Q-functional setpoints issue, the concerns identified were generally minor. SWEC also concluded from the IDA that the corrective actions committed to by the Limerick project were acceptable, that there was no impact on technical adequacy, that the Limerick project had satisfactorily resolved all concerns, and that the extent of the concerns beyond the immediate sample had been adequately addressed.

No major safety significant findings were identified in the IDA, and no hardware changes resulted from the DORs (a commitment to provide environmental seals for certain temperature elements was reported to have resulted from planned EQ walkdown inspection activities independent of the IDA). Some comparatively minor FSAR inconsistencies were identified, and commitments were made during the action item resolution to revise the FSAR accordingly. Several calculations and drawings required revision as a result of the IDA. Some new setpoint calculations and seismic analyses were performed to resolve concerns in these areas.

To assess the adequacy of SWEC's review and Bechtel's corrective actions in this concluding phase of the IDA, the inspection team reviewed the disposition of the following 12 DORs: 006, 021, 041, 047, 049, 051, 056, 072, 086, 094, 102, and 105. Summarized in the sections below are a few of the more significant I&C findings that the inspection team reviewed.

In addition to the DOR review, the inspection team tracked the resolution of two remaining potential concerns identified by the inspection team in earlier inspections [Inspection Report 50-353/88-200 of September 29, 1988, Addendum I, Item 1.3.2; and Inspection Report 50-353/88-201 of November 29, 1988, Item 3.1.3.2 (2)]. The first concern about wiring installation in control room panels was addressed in the SWEC IDA report, wherein several instances of separation violations were noted for Panel 20C601; however, the IDA report stated that this panel had not been accepted by Quality Control and was scheduled for rework for divisional separation. Assuming correct implementation of this scheduled rework before fuel loading, the team found this resolution acceptable.

The second concern about undetected diode failures in circuit breaker control circuits was resolved by retrieval of surveillance test procedures indicating that all circuits using this diode application were covered by an 18-month surveillance that would detect an open diode. The team found it necessary to expand the sample to assure that all safety-related circuits using this diode application were covered by an appropriate surveillance. For the expanded sample, the surveillance cited by SWEC/Bechtel in the IDA report (a pump/valve interlock surveillance) did not apply, but another more general surveillance (test of the loss of safeguard buses) would detect the diode failure in all applications. On that basis, the team agreed to the closure of this concern. Throughout the IDA, the inspection team was generally impressed with SWEC's technical efforts and the Limerick Project's depth of responses to potential concerns identified by SWEC. Although weaknesses were found in the Bechtel BOP Q-functional setpoint/instrument tolerance program, supplemental calculations and data provided by Bechtel appeared to substantiate the sample of existing setpoints; moreover, the confirmatory letter requested before fuel load, followed by a timely implementation of the applicant's commitment to reconstitute the basis for all safety-related setpoints, provided reasonable assurance that this weakness would not have a short-term safety impact and would be eliminated as a longer-term concern.

The number and nature of DORs and corrective actions examined did not appear to indicate any obvious or significant weaknesses in the design process. Based on the earlier inspections cited herein, the review of the resolution and corrective actions for the DORs sampled, the review of the resolution of the additional potential concerns identified by the inspection team early in the IDA (discussed in this and other inspection reports), and based on completion of the applicant's committed actions and confirmatory items cited herein, the inspection team agreed with SWEC's determination that the overall instrumentation and controls design for Limerick Unit 2 met the licensing commitments and was technically adequate.

3.3.1 DOR 021 - Establishment of Bechtel BOP Q-Functional Instrument Setpoints and Control of Instrument Tolerances (Closed)

SWEC identified discrepancies in setpoint calculations within the IDA sample. As one example, a setpoint tolerance calculation for a pressure switch assumed a calibration period of 1 year in determining drift error, whereas PECO's preventive maintenance program indicated a recalibration period of 7 years. This and other inconsistencies led to a concern that an effective, consistent, proceduralized, and well-documented program to establish BOP Q-functional instrument setpoints and tolerances had not been established by Bechtel. The potential safety significance of this situation was that inappropriate setpoints could have been established for BOP safety functions in Bechtel's scope.

Bechtel acknowledged absence of a formal program for documenting the basis for BOP setpoints, stating that an ad hoc process using engineering judgment and project source documentation was used in determining BOP setpoints. Instrument setpoint data sheets and loop tolerance sheets documented the results, but not necessarily the input sources, assumptions, and calculations. Bechtel performed additional calculations to resolve this DOR; these calculations were reviewed by SWEC, and the process tolerances adequately encompassed the instrument loop tolerances. Bechtel stated that the methodology for determining total channel error in these calculations was similar to the GE methodology of NEDC-31336 submitted by the Boiling Water Reactor Owners Group (BWROG) to the staff (e.g., the basis for independent error sources). The team noted that all error contributors were assumed independent in this approach, which was less conservative than other vendor methodologies; however, on the basis of prior NRC staff acceptance of NEDC-31336, the Bechtel approach was accepted. For the discrepancies in drift intervals, PECO agreed to evaluate any effects of extending the drift/calibration basis to 18 months, and to address any instances in which loop tolerance exceeded process tolerance, before fuel load. The results of PECO's review were documented in a letter dated May 25, 1989, to the NRC and were reviewed and determined to be acceptable. Effective in 1989, changes to setpoints for safety-related instruments, technical specification and FSAR setpoints, and selected existing nonQ setpoints considered important to safety and reliable operation were to be performed using formal calculations. By June 30, 1989, a formal setpoint determination procedure was to be developed, and a 3-year to 5-year program to formally reconstitute all such instrument setpoint calculations would be undertaken, with priority placed on those calculations important to safety.

Based on the sample calculations reviewed, acceptance of NEDC-31336, consideration of the comparatively limited scope of Bechtel BOP setpoints, and discussions with PECO, the inspection team generally agreed with SWEC's conclusion that the current setpoints were acceptable and that the corrective actions were appropriate. However, the inspection team requested that the following issues be clarified in a confirmatory letter before fuel load:

(1) Confirm that all Bechtel-established Q-functional BOP instrument and channel tolerances that support the operating basis surveillance/calibration

frequencies have been reviewed and properly taken into account. This is apparently the PECO position, but it was not obvious to the team from the DOR.

(2) In light of the weaknesses identified in the setpoint program regarding identification of instrument tolerances, confirm that these types of weaknesses did not unduly affect the accounting for critical instrument tolerances required to support preoperational acceptance testing of safety-related BOP equipment within Bechtel's score of supply.

The results of PECO's review were documented in a letter dated May 25, 1989, to the NRC that adequately addressed these aforementioned issues. This DOR is closed.

3.3.2 DOR 047 - Basis for Using Transmitter Conduit Connections That Were Not Totally Sealed (Closed)

SWEC had reviewed an environmental qualification (EQ) package for Rosemount 1153 Series B transmitters, and it had been determined from walkdowns that a totally sealed conduit installation had not been used for these transmitters. Bechtel responded to this concern by demonstrating that the transmitters of interest were not required to function under high energy line break (HELB) conditions in the area in which they were located. SWEC expressed further concern that moisture accumulation and entry into the terminal block cavity of the transmitter might occur under normal fluctuating conditions of humidity and temperature, and that the effects of moderate-energy line breaks (MELBs) should also be addressed. The qualifying test report did not establish threshold environmental conditions beyond which a totally sealed conduit installation was required.

In response, Bechtel indicated that no credit was taken for conduit seals for these transmitters and obtained a commitment from Rosemount that the transmitter performance would not be affected at the design-basis maximum normal humidity conditions. Bechtel also indicated that there was a low probability of significant condensation; that walkdowns indicated that all conduit entered from below the transmitter; that the likelihood of a MELB causing an instrument failure was low, based on an assessment of the pathways available for low-energy intrusive liquid; that functionality of the instrument during a MELB was not as important, and that the MELB would not affect more than one redundant instrument. Bechtel also stated that seven temperature sensors used to detect steam flooding were identified during EQ walkdowns as requiring conduit seals, and that installation of the seals was in progress and would be completed before fuel load.

The team discussed this DOR with Bechtel and reviewed a sample of the photographs taken during the walkdown confirmed that conduit entry was from below. On that basis, the inspection team agreed with SWEC's acceptance of this DOR resolution.

3.3.3 DOR 105 - Use of NonClass 1E Fuses in Circuits for Essential Safeguards System Functions (Closed)

SWEC identified that fuses used for distribution of power for the trip units on a GE elementary diagram were classified as nonsafety-related by GE. The trip units performed a safety function. SWEC discussions with GE had indicated that GE quality assurance (QA) records should provide appropriate documentation regarding functional testing of nonClass 1E devices following the seismic testing of the panel; however, SWEC could not find evidence of such functional testing of the fuses/circuits in the documents originally provided by GE. Supplemental documentation provided by GE confirmed that the fuses of interest were installed and the circuits monitored during and after the seismic test, and the results were used to qualify the panel, its circuits, and its devices. SWEC then reviewed and accepted the supplemental documentation.

The inspection team reviewed part of the supplemental documentation wherein the acceptance criteria for the seismic test state, in part, that no measurable power interruption (in the millisecond range) shall occur during or after the test. On that basis, the inspection team agreed that the seismic tests of the panels qualify the fuses for this application and concurred with the DOR closure.

3.4 Mechanical Components

In the mechanical components discipline, the scope of the IDA review included piping stress analysis, supports, hazards analysis, and seismic qualification of equipment. The piping stress analysis review consisted of ASME Class 1, 2, and 3 piping; consideration of equipment nozzle loadings; hydrodynamic loads; large temperature changes; seismic anchor movements; expansion joints, and penetration design. The support review included all types of piping, ducting, and electrical raceway supports including anchors, restraints, and hangers, as well as a review of snubbers, struts, rigid frames, spring hangers, integral welded pipe attachments, baseplates with concrete anchor bolts, attachments to embedded plates, and attachments to structural steel. The hazards review consisted of high-energy line break analyses, internally generated missiles, and Seismic II over I. As Bechtel had not completed the system walkdown inspections associated with the hazards review at the time of issuance of the final IDA report, SWEC subsequently reviewed this area and issued a supplemental IDA hazards report. This supplemental report was not included in the inspection team's scope of review, but was later reviewed by the NRC staff and found acceptable.

Generally, the issues identified were minor and had no impact on the technical adequacy of the design. To resolve the issues that were identified, Bechtel performed additional reviews, revised the associated calculation, or revised the design criteria to avoid future problems. Also, Bechtel initiated the appropriate actions necessary to demonstrate that the issue was bounded when it was determined not to be an isolated case. The inspection team found no problems with the IDA review in the mechanical components discipline and was satisfied with the level of effort shown.

The inspection team reviewed the following six DORs in the mechanical components discipline: 001, 003, 019, 028, 089 and 099. Summarized below are two of these DORs that the team reviewed.

3.4.1 DOR 089 - Local Stresses for Welded Attachment (Closed)

SWEC identified that the local stress evaluations for trunnions/stanchions performed using the "Stanchion" computer program may have not adequately addressed the appropriate ASME III Code requirements. Also, SWEC stated that Bechtel had not demonstrated that the conservatism in the program was adequate for all utilized cases and consideration of pressure stresses was inappropriately omitted.

Bechtel's approach to integral attachment stress analysis was to first use its standard method detailed in Specification 8031-P-403, Appendix L, "Local Stress Analysis Criteria." If that approach showed that local stresses exceeded the acceptance criteria, a more detailed approach was taken using Bechtel's ME-210 program to verify the structural integrity of both the integral attachment and local stress induced into the pressure boundary. The ME-210 computer program utilized a Bijlaard approach in evaluating the local stresses in the process pipe pressure boundary as a result of integral attachments. Bechtel's response concurred with the finding and included identifying all calculations for Limerick Unit 2 that utilized the "Stanchion" program (a total of 12) and reanalyzing them using the ME-210 program. The inspection team independently reviewed 9 of the 12 calculations and concluded that the criteria existing in Specification 8031-P-403 was conservative and agreed with the resolution of this DOR.

3.4.2 DOR 093 - Seismic Qualification of Panel (Closed)

SWEC identified that the as-built mounting of Limerick Panel H12-P618 was different from the documented test panel mounting, and GE's qualification document did not provide a similarity analysis between the test configuration mounting and the as-built mounting.

Bechtel concurred with the observation, but indicated that the use of engineering judgment in establishing similarity between the test panels was deliberate and appropriate. In order to resolve the issue, however, Bechtel performed a similarity analysis utilizing finite element analysis techniques. The results varied by only 2 to 5 percent from the GE finite element analysis for natural frequency. The inspection team concurred with SWEC's evaluation and concluded that both the bolting configuration and testing requirements were satisfactory.

3.5 Civil/Structural

In the civil/structural discipline the IDA reviewed the structural design of selected buildings, as well as the structural elements within the building, including blockwalls, structural concrete and steel, floors, walls, and equipment supports. Included in this review were assessments of the associated seismic and hydrodynamic analyses.

As a result of the IDA, SWEC identified instances in which licensing commitments were not met but the associated technical approach was adequate and FSAR changes were issued, design criteria documents were changed to remedy discrepancies, and calculations had to be revised to correct errors or to substantiate engineering judgments. However, even though the aforementioned actions were required to resolve observation reports, the design was proven repeatedly to be adequate. Also, all undocumented engineering judgments were proved to be correct. SWEC ultimately concluded that the design of structures and structural components had been completed in a technically adequate manner.

The inspection team reviewed the following 11 DORs in the civil/structural discipline: 002, 009, 010, 011, 012, 013, 017, 024, 037, 058, and 061. Summarized below are two of these DORs that the team reviewed.

3.5.1 DOR 002 - Reactor Building Mat Design Calculations (Closed)

SWEC's review of the reactor building mat calculations resulted in the following concerns: (1) not all loading combinations were evaluated; (2) an approximate method of analysis was used; (3) there were discrepancies between design calculations and drawings; and (4) the footing design of Column E-29 might not be adequate.

Bechtel agreed with SWEC that there were some inconsistencies. Bechtel also admitted that undocumented engineering judgments were made in the design calculations. The following summarizes the Bechtel response and corrective action, as well as the inspection team's evaluation:

(1) Bechtel acknowledged that not all loading combinations were evaluated, that the reactor building mat design did not evaluate hydrostatic pressure as a result of ground water levels, and that footings were not evaluated for loading combinations containing safe-shutdown earthquake (SSE) loads.

    Bechtel performed Revision 6 of Calculation 23.4, "Reactor/Control Building Foundation Design," dated October 27, 1988, and demonstrated that the hydrostatic pressure as a result of ground water levels did not govern the mat design. In its response, Bechtel also demonstrated that the loading combination involving operating-basis earthquake (OBE) controlled design of the footings.

    The inspection team reviewed Calculation 23.4, Revision 6, and confirmed that hydrostatic pressure from ground water did not control the design of the reactor building mat. Also, the inspection team reviewed other Seismic Category I building calculations for mat design and similarly verified that hydrostatic loadings were not controlling the design and agreed with SWEC's closure of this issue.

(2) Bechtel agreed that the approximate analytical method did result in a rock-bearing pressure slightly exceeding the allowables used in the calculation. However, the FSAR provided higher allowables after the rock foundation was excavated and the calculated bearing pressure was lower than the allowables provided in the FSAR. The team reviewed Table 2.5-3A of the FSAR and agreed that it provided higher allowables than those used in the calculation. The team also reviewed a report on "Treatment of Fracture Zones at Limerick," Revision 0, July 22, 1974, which described the method used to treat the fractured rocks and clay seams. This treatment justified use of a higher rock-bearing pressure allowable, and the team agreed with closure of this issue.

(3) One discrepancy involved the calculation using an effective footing width of 11 feet. Although this was inconsistent with the Bechtel drawing, even

if the drawing footing width was used in the calculation, the bearing pressure would have increased only an insignificant amount. The other discrepancy involved a change in wall thickness as a result of field change request (FCR) C-93. This FCR was dispositioned and approved in accordance with project design control procedures, and a decision was made that a calculation change was not warranted. The inspection team determined that revisions to drawings were adequately controlled by project procedures and agreed with closure of these discrepancies.

SWEC was concerned that the footing for Column E-29 was sized in accordance with the similar footing of Unit 1 without verifying that the design parameters were the same. The allowable rock-bearing pressure was less for Column E-29 than the similar column footing in Unit 1. Therefore, SWEC reasoned that the footing for Column E-29 might not be adequately designed. Bechtel's response indicated that after the foundation was excavated it was determined that the allowable rock-bearing pressures were the same for both units. These were treated as indicated in the FSAR. After treatment, the allowable rock-bearing pressure was higher, as listed in Table 2.5-3A of the FSAR. The team reviewed the Section 2.5.4.12 of the FSAR and the report on "Treatment of Fracture Zones at Limerick" and agreed with closure of this issue.

3.5.2 DOR 009 - Seismic Load on Block Walls (Closed)

In reviewing seismic accelerations used to analyze block walls, SWEC was concerned that horizontal frequencies were used for calculating vertical seismic acceleration, and that scaling factors based on the peak of the response spectrum curve were used in transforming accelerations for 0.5 percent damping to 2 percent.

The Bechtel response indicated that engineering judgments were made regarding the conservativeness of the analytical approach and the occasional use of scaling factors at regions of the spectra other than at the peaks. Bechtel performed a comprehensive review of all safety-related block wall calculations and found that most safety-related block wall design calculations used this approach. However, revised calculations performed by Bechtel indicated that (1) the use of horizontal wall frequencies instead of vertical wall frequencies to calculate vertical responses conservatively overestimated the vertical accelerations, and (2) use of a time history method to calculate the responses of increased damping showed that there were no changes for the most highly loaded block walls as the adjusted peak did not change.

The inspection team reviewed Calculation 22.2L66, "Re-evaluation of Block Wall 756.57," Revision 5, December 20, 1988, and found that use of the horizontal frequencies to calculate vertical responses was conservative. Also, the overall spectral curves showed that seismic load changes as a result of increased damping were in the rigid range which did not affect the wall design. The inspection team agreed with SWEC's closure of this item.

4. CONCLUSION

The inspection team was satisfied with the level of effort and thoroughness of the IDA. This program coupled with the PECO commitments documented in letters to the NRC dated May 16, 1987 and May 25, 1989, provides the necessary additional design assurance that Limerick Unit 2 has met its licensing commitments and is adequately designed.

APPENDIX A

PERSONNEL CONTACTED DURING INSPECTION

Name	Title	Affiliation
B. Acosta	Senior Engineer	Bechtel
*V. Aggarwal	Civil Engineering Group Supervisor	Bechtel
A. Arastu	Lead Mechanical Analysis Group Engineer	Bechtel
G. Ashley, III	Lead Engineer for Mechanical/Nuclear Staff	Bechtel
*W. Baronowski	Assistant Project Manager, IDCA	SWEC
M. Bhatia	Lead Civil Engineer for IDCA	Bechtel
J. Bisti	IDA I&C Discipline Lead	SWEC
*W. Brady	Mechanical Engineer	PECO
S. Brahma	IDA I&C Engineer	SWEC
R. Bulchis	IDCA Coordinator	Bechtel
*P. Chang-Lo	Chief Civil Structural Engineer	Bechtel
C. Chern	Piping Engineer	Bechtel
K. Clough	Civil Engineer - Pottstown	Bechtel
*J. Coughlin	-	Bechtel
D. Dexheimer	Lead Staff Radiation Shielding Engineer	Bechtel
I. Doncow	Engineering Supervisor - Electrical	Bechtel
*J. Edlinger	Chief Engineer, Control Systems	Bechtel
E. Fabri	Electrical Engineer	Bechtel
W. Feir	Mechanical Engineer	Bechtel
S. Giusti	Chief Engineer, Electrical	Bechtel
*E. Goldenberg	EQ Engineer	Bechtel
A. Go	HVAC Engineer	Bechtel
*C. Haynes	Project Manager	Bechtel
*D. Helwig	Assistant to Executive Vice President	PECO
*R. Henderson	-	Bechtel
*H. Hollinghaus	Vice President - Manager of Engineering	Bechtel
*E. Hughes	IDA Lead Manager	Bechtel
D. Hsu	Piping Engineer	Bechtel
*M. Iyer	Project Engineer	Bechtel
*W. Jony	Quality Assurance	Bechtel
A. Kar	Group Leader - Electrical	Bechtel
*M. Khlafallah	Project Engineer	Bechtel
*D. Klein	IDCA Systems Lead	Bechtel
P. Kuhn	Electrical Engineer	Bechtel
L. Kuo	HVAC Engineer	Bechtel
K. Lee	Mechanical Systems BOP Engineer	Bechtel
S. Loo	Lead Civil Engineer	Bechtel
*W. Lui	Group Supervisor, Electrical & Control Systems	Bechtel
W. McCullough	Limerick 2 Startup Director	Bechtel
T. McDonald	Staff Engineer	Bechtel
E. Mercurio	EQ Engineer - Seismic	Bechtel
*W. Mindick	Senior Engineer	PECO
H. Minkonski	Civil Engineer	Bechtel
V. Nercessian	HVAC Engineer	Bechtel

*R. Nossardi	Mechanical Supervisor	Bechtel
M. O'Conner	Sr. Engineer - Mechanical Systems	Bechtel
R. Pence	Limerick Project Engineer	GE
E. Purcell	Mechanical Systems Engineering Specialist	Bechtel
U. Reider	EQ Engineer - Environmental	Bechtel
A. Rifai	Electrical Engineer	Bechtel
M. Schletd	Piping Engineer	Bechtel
J. Schott	Deputy Group Supervisor, Control Systems	Bechtel
R. Senior	Controls Engineer	Bechtel
S. Sharma	EQ Engineer	Bechtel
D. Strassman	HVAC Engineer	Bechtel
J. Strohm	EQ Engineer - Environmental	Bechtel
*T. Tam	Assistant Chief Electrical Engineer	Bechtel
S. Yim	Supervisor - Mechanical Systems	Bechtel

*Attended Exit Meeting