U.S. NUCLEAR REGULATORY COMMISSION
REGION I

Report No. 50-353/88-12

Docket No. 50-353

License No. CPPR-107 Priority - Category B

Licensee: Philadelphia Electric Company
2301 Market Street
Philadelphia, PA 19101

Facility Name: Limerick Nuclear Generating Station, Unit 2

Inspection At: Limerick, Pennsylvania

Inspection Conducted: April 25 - May 3, 1988

Inspector: c/a for C. Woodard 5/18/88
C. H. Woodard, Reactor Engineer date

Approved by: C J Anderson 5/18/88
C. J. Anderson, Chief Plant Systems Section, DRS date

Inspection Summary: Inspection on April 25 - May 3, 1988 (Report No. 50-353/88-12)

Areas Inspected: Routine, onsite unannounced inspection by one region-based inspector of activities pertaining to the safety-related electrical systems and components. Specific areas reviewed included emergency diesel generator maintenance, electrical construction inspection of wiring, cables, and components.

Results: One violation was identified, 10 CFR 50, Appendix B, Criterion V; lack of documented procedures and acceptance criteria for activities affecting quality in regards to maintenance of the emergency diesel generators.

DETAILS

1.0 Persons Contacted

1.1 Philadelphia Electric Company

*J. Corcoran, Manager Quality Assurance
J. Milito, Superintendent Start-up Support
*D. DiPalo, Superintendent, Quality Assurance
*T. Tucker, Assistant Superintendent, Quality Assurance
*K. Meck, Assistant Superintendent, Quality Assurance
*F. Valentino, Construction Branch Manager
T. Dey, Quality Assurance Engineer
L. Dyer, Quality Assurance Engineer
J. Higgins, Electrical Field Engineering
*G. Lauderback, Supervisor Start-up Quality Assurance
*M. Teller, Construction Engineer

1.2 Bechtel Construction Incorporated

H. Lilligh, Quality Assurance Manager
W. Hatton, Quality Assurance Engineer
*B. Foote, Quality Assurance Engineer
*G. Kelly, Quality Assurance Engineer
D. Jefferson, Quality Assurance Engineer
N. Roy, Electrical Engineer
J. Hanze, Quality Control Inspector
J. Smith, Electrical Superintendent
*D. Moyer, Mechanical Engineer
*K. Stout, Quality Control Engineer
*D. Yenson, Field Engineer

1.3 Colt Industries

J. Schroeder, Field Services Engineer

1.4 U.S. Nuclear Regulatory Commission

R. Gramm, Senior Resident Inspector
*R. Fuhremister, Resident Inspector

*Denotes those present during the exit meeting.

2.0 Purpose and Scope

The purpose of this inspection was to ascertain that the safety-related electrical wiring, cable, electrical components and systems that are in various stages of construction/installation completion are specified, procured, installed, maintained, tested and inspected/controlled in such a manner that they will perform their required safety functions. The scope of this inspection was limited to: the 4160 volt power cable replacement installation for the "B" emergency diesel generator; pre-operational maintenance of the emergency diesel generators; addressing a licensee identified problem in the 480V Cutler Hammer motor control centers; and the electrical construction "blue tag" completion/turn-over procedures.

3.0 Procedures

The licensee documents relating to the final construction electrical check-out (blue tagging), the emergency diesel generator installation maintenance, and electrical cable installation were reviewed. These documents included construction specifications, drawings, work and inspection procedures, and inspection/acceptance criteria.

The review was made to determine whether the technical and administrative requirements of the licensee's FSAR and the NRC requirements had been adequately translated into applicable documents to provide for adequate work performance and control.

The specific documents reviewed for this inspection are listed in Appendix A.

A deficiency was noted regarding inadequate diesel generator maintenance procedure, see section 4.1.

4.0 Electrical Systems and Components

4.1 Emergency Diesel Generators

The four Limerick Unit 2 emergency diesel generators are the twelve cylinder Colt/Fairbanks-Morse 8 1/8 opposed piston type. These units have been stored in place for several years without operation. Due to the extensive storage period, the manufacturer recommended (by letter dated February 16, 1988) twelve items of inspections, maintenance and corrective actions which should be performed prior to engine startup. These recommendations included the following:

- Due to the possibility of chemical action between the crankshafts and aluminum bearings, the main and connecting rod bearings should be replaced and the crankshaft journals relapped.

- Inspect cylinder liner bores.

- Replace generator end bearing.

- Flush and inspect engine jacket water, fuel intercooler, and lubricating oil systems.

- Hydrostatically test engine jacket water system.

- Clean engine lubricating oil pan, fill engine system with oil and inspect all engine lubrication pressure points.

- Inspect engine turbochargers.

- Clean preservative from fuel injection compartment.

- Remove and test all fuel injection nozzles.

- Flush engine governors.

- Check engine alignment.

- Remove and inspect tappet assemblies of cylinders positioned at high cam.

The licensee had engaged the services of the manufacturer's (Colt) field service representatives for the lead direction and supervision of the work associated with the main and connecting rod engine bearings replacement which was in progress at the time of this inspection. Personnel were provided by Bechtel to perform the work in accordance with directions, training and procedures to be supplied by Colt. Continuous QC surveillance inspection of the work was performed by Bechtel/Licensee personnel.

This inspection determined that the replacement of the EDG bearings was being performed by the licensee in accordance with the following:

- Modification Rework (MWR) packages 2AG 501-16, Revision 0 dated March 28, 1988 (This MWR is for the A EDG, the B, C, and D EDG MWR packages are the same). These MWR packages include insert sheets E14, E15, E16, E17, G3 and G4 directly from the vendors manual covering the removal, inspection, and replacement of the main and connecting rod bearings (they do not include crankshaft journal lapping procedure).

- Verbal instructions from the vendor field services representative which included the following.

    - Crankshaft main, connecting rod and thrust bearing journals lapping procedure.

- Proper abrasive lapping material (Timesaver Products Company Hard Metal Lapping Compound No. 111-Green Label).

- Proper tools and aids for use in performing the lapping and how to use them to achieve the desired bearing journal surface finish. Journal finish acceptance criteria.

- Precautions with regards to the preparation and use of the lapping abrasive.

- Precautions to prevent entry of the contaminating lapping material into other bearings, oil passageways, inverted piston skirts, and other areas adjacent to the work area.

- Procedures and materials to be used to clean the lapping abrasive from the finished crankshaft journal and adjacent areas. Cleanliness acceptance criteria (How much if any residual lapping compound is acceptable).

- Proper lubricant and procedure for application to the lapped bearing journals and new bearings prior to assembly.

- Engine oil passageways, hold-up volumes, and sumps cleaning following bearing replacements.

At the time of this inspection the licensee had completed bearings replacement in the "A" and "C" EDG units and the "B" EDG was in the process of rework/replacement. Prior to this inspection, a problem was identified relative to lapping compound-related bearing damage in these same type Fairbanks Morse EDG units at the Detroit Edison Fermi Unit 2 Plant. NRC Inspection Report No. 50-341/86046 includes a Franklin Research report of Fairbanks Morse EDG bearing failures at the Fermi Unit 2 Plant. One of the findings in this report was bearing damage from crankshaft journal lapping compound. Independent evaluation of the bearing failures at Fermi's Unit 2 was conducted by Batelle and reported to Detroit Edison on August 31, 1986. Included in this report were findings of bearing damage from journal lapping compound and a recommendation to "Improve the method used to remove lapping compound from the crankshaft journal surfaces." Failure Analysis Associates investigation of the Fairbanks Morse EDG bearing problems report was made to Detroit Edison during June 1986. It includes the following report paragraph. "The abrasive component of the bearing conditioner, the Timesaver Lapping Compound No. 111, was found to have particles up to .002 inch in diameter. The primary chemical component of the lapping compound is silica, a hard abrasive material. The presence of these hard particles in the bearing clearance will cause scratching and scoring of the bearing surfaces, friction causing excessive heat and thinning of the oil, and can contribute to breakdown of the oil film and seizure of the bearing to the crankshaft."

An initial review of the Limerick Unit 2 EDG bearing replacement was conducted with the cognizant licensee QA personnel in order to review the status of the work, the personnel involved in performing the work, the procedures under which the work was being performed, and the Quality Assurance Surveillance Inspection program for this work including the acceptance criteria for the work. Initial concern was expressed by the inspector since there were no explicit written procedures for performing the bearing journals lapping work. The operation including precautions and acceptance criteria are based upon verbal direction from the vendor field service representatives. Training of personnel in the work procedures and acceptance criteria was hands on and word of mouth type training. Initial concern was expressed by the inspector to the licensee QA representative relative to previous problems with connecting rod and main engine bearings in these same type of EDG units at other plants. The concerns included those from the Fermi Unit 2 bearing failures in identical Fairbanks Morse EDG units. Some of the causes of bearing damage were discussed including damage caused by the improper removal of lapping compound (when reworking bearings).

The license stated that the procedure in use for removing the lapping compound is to wipe the journal clean with a rag soaked with varsol. A visual observation and/or rag wipe by the QA inspector is made to verify proper removal.

An inspection of the "D" diesel bearings replacement was made of the removed bearings including the Number 3 connecting rod bearing. A substantial quantity of the lapping compound (approximately one teaspoon full) was observed on the face of this bearing. Since this bearing had not been reworked, investigation was made by the licensee to determine the source of the contaminating lapping compound. Determination was made that the lapping compound had either flowed through the oil-passage from the adjacent Number 3 main bearing which had been recently lapped or it had been accidentally dropped onto the bearing after removal. This finding raised questions relative to reworked/new bearings possibly having substantial quantities of lapping compound in them from adjacent bearings through the connecting oil passageways. Several upper crankshaft main and connecting rod bearings were disassembled and all were found to have small quantities of the lapping compound in them. However the new number 10 upper main bearing was found with a substantial amount of lapping material in it. The entire surface of this bearing was scratched by the lapping compound. Apparently the small amount of manual barring (turning) of the engine while lapping other bearings had been sufficient to cause damage to this bearing because of the contaminating lapping compound left in it. It was at the point that all bearings in the engine became suspect for contamination.

As a consequence of these findings, the licensee took immediate actions including the following:

- The bearing journal lapping operation was stopped.

- The proper procedures for lapping and cleaning the bearing journals were discussed by the licensee with the Fairbanks Morse field service representative. It included a proper sequence of work, plugging of oil passageways and acceptance criteria. Craft and quality assurance personnel were instructed by the Fairbanks Morse and licensee personnel.

- Borescope inspections were made of several upper connecting rod lubrication passages from the crankshaft journal bearing area down to the piston wrist pin bearing ("D" EDG unit). No contamination was observed.

- All "D" EDG unit crankshaft main and connecting rod bearings were disassembled. All bearing surfaces were cleaned with fuel oil, inspected to the new zero-residual-lapping compound criteria, and the bearings were then re-assembled. The damaged new Number 10 main bearing was replaced with another new bearing.

There are twenty four connecting rod and twenty six main bearings in each EDG engine. Sample inspections of two bearings in each engine were made for residual lapping compound contamination in the reworked "A" and "C" EDG units to establish a basis to either accept "As-Is," to expand the inspection scope for a greater confidence level, or to remove all bearings and clean (the same as EDG "D"). Lower main bearings number 8 and 10 on the "A" unit and numbers 5 and 9 on the "C" unit were inspected. The selection of these particular bearings was made because it allowed inspection of work by both shifts of craftsmen and Q-C inspectors under the direction of the two different Fairbanks Morse field service representative. Based upon these inspections, the licensee decided to accept the "A" and "C" EDG units "As-Is."

Interviews were conducted with several of the crafts and Q-C personnel directly involved in the performance of this bearing replacement work. The bearings replacement work is being performed by journeyman millwrights. Lapping of shafts and journals, while not a frequent activity, is considered a standard job function for the millwrights and is a standard job skill. Two of the millwrights interviewed expressed considerable knowledge and experience in the lapping of bearing journals. However they did not have previous experience with the Fairbanks Morse journal special finishing requirements nor were they familiar with the type of lapping compound being used.

The inspector expressed further concern beyond the immediate EDG bearing rework/replacement problems. This concern regards the lack of written procedures for performing the crankshaft lapping work which could accompany bearings inspection/replacement at any time during the life of the EDG units. These bearings are routinely inspected as a part of the

18 month and 5 year surveillances which could involve resurfacing crankshaft journals. Without detailed written procedures to assure proper performance of this effort, including the removal of lapping abrasive contamination, the EDG bearings and other engine oil lubricated components are again subject to abrasive damage and possible failure. Further concern was also expressed for the adequate procedures and controls for the remaining eleven items of work covered by the Fairbanks Morse, February 16, 1988 letter.

The lack/absence of these procedures both for the current bearing replacement as well as for bearing work during the life of the EDG units is a violation of Code of Federal Regulations 10 CFR 50, Appendix B Criterion V. This portion of the regulations requires the following: "Activities affecting quality shall be prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings. Instructions procedures, or drawings shall include appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished." (50-353/88-12-01)

4.2 Motor Control Centers (MCC) Supplied by Cutler Hammer (CH)

4.2.1 Bus Overheating

On April 15, 1988 the licensee reported that the potential exists for Cutler Hammer supplied MCC aluminum vertical bus bar sections to overheat thereby causing copper spring-loaded stab connections to the bus to deteriorate. The licensee report was based upon experience with similar CH supplied MCC units at the Eddystone Generating Station (non-nuclear) and upon information provided by CH. CH reported to the licensee that "the problem seems to be heat build-up over a long time span which deteriorates the connection point between the copper stab and the vertical aluminum bus. The heat build-up seems to be caused by the aluminum bus not being a good enough heat sink to draw the heat away from these connection points. Aluminum will not disperse a concentrated heat point as rapidly as copper will due to the density differential in the two metals. This problem has occurred before and the solution has been to change the aluminum bus to copper bus in those sections containing size 4 starters only."

The licensee performed a visual inspection of all of the CH MCC Units in Unit 1 during the recent mini-outage. No evidence of contact burning or degradation was observed. Licensee engineering is currently conducting a study of all of the CH MCC Units and their loads in order to make an evaluation and establish recommendations for any actions required to resolve this potential problem.

4.2.2 Defective Bellville Washers

On April 15, 1988 the licensee reported finding multiple instances of defective conical spring (Bellville) washers during BOP inspection of CH MCC horizontal copper to vertical aluminum bus bar bolted connections. The Belleville washers are used to maintain proper bolted mating pressure between the main horizontal copper bus and the individual vertical aluminum bus sections. The failures observed consists of the washer becoming segmented by cracking from the outer to the inner edges. A washer in this condition could fail to properly maintain contact pressure between the two bus bars, allowing higher than designed resistance and eventual failure due to overheating. Licensee metallurgical examinations of the failed washers indicate that improper process control during the plating led to hydrogen embrittlement and failure of the washers during or shortly after tigntening. Both PECO and CH are conducting further evaluations to conclude root causes of the defects and failures and to assess their reportability. Disposition of this item to resolve the problem is dependant upon the licensees actions taken with regards to the aluminum bus bar heating problem discussed in paragraph 5.2.1. If the aluminum bus bar is replaced with copper, Belleville washers will not be used. However if the bus bar is not replaced, the licensee is committed to take actions with regards to replacement of the washers.

Licensee's actions for the foregoing items appear to be adequate. The inspector had no further questions at this time.

4.3 Electrical Power Cable

On September 9, 1988 the licensee reported that the "B" Diesel Generator Power Cable had failed due to damage incurred while installing/pulling the cable. The damaged cable did not pass the installation megger test and requires replacement. The licensee reported that the cable was damaged while pulling out of one concrete sleeve and into another because of the sharp bending radius and the sharp/abrasive edges on the concrete sleeves.

The licensee has re-evaluated the cable pull and has chipped away some of the outer edge of the concrete sleeves to permit easier transition of the cable out of/into the sleeves. Based upon the licensees cable pulling tension calculation E-622, Revision 0 dated April 26, 1988, it appeared that the pull can be made without exceeding the maximun pull tension and side wall pressure permitted for the types of cable. An independent NRC calculation was made of the first segment of the pull in order to verify the licensee's calculation E-622.

The pulling route and pulling procedures were thoroughly reviewed with the licensee both in the office and along the pulling route. (Procedures

and calculations reviewed are listed in the Appendix to this report.) On May 3, 1988 the inspector witnessed the successfull pull of the first segment of the replacement cable and monitored the pulling tension during the pull. The maximum tension measured was 1050 pounds. This compared favorably with the maximum calculated expected tension of 2141 pounds and the maximum allowable tension of 3604 pounds. Inspection was made of the pulling devices including the tuggers, the mares tail cable attachment, proper minimum bend radius templates and the current calibration of the tension meter. No discrepancies were observed in either the cable pulling procedures, calculations, or in the actual cable pull.

4.4 Electrical Construction Final Inspection for Turn-Over to Start-Up

A review inspection was made of the licensee's program for "Blue Tagging" electrical components, sub-systems and systems for construction completion/verification and turn-over to start-up for pre-operational tests. The inspection consisted of a review of licensee's procedures, personnel qualification, and field verification of the implementation of the procedures. Procedures and documents reviewed are listed in the Appendix to this report.

An inspection was made of the licensee's blue tag verifications which were in progress for the emergency diesel generator engine starting controls in panel 2ETB-AG-501. The drawings in use were verified as the latest issue in effect of Colt Industries drawing 11870038 sheets 1-6. Two inspectors were observed in the process of performing verification of some of the alarm and annunicator circuits in an alarm and annunicator panel. The inspectors were observed physically tracing each wire within the panel to and through each connection and component. The wiring was verified as to type, size, identifications, terminations and routing. Each component (relay, switch, terminal block, transformer, etc.) was also verified. Each wiring circuit was meggered to ensure wiring integrity. As each wire and component were verified they were yellowed out on the drawing. Inspector responses to questions indicated a good understanding and knowledge of the work being performed. Their qualifications were found to be current in accordance with Licensee Qualification Procedure EE 2.1.

A review was made of completed and partially completed blue tag inspection drawings and records. Each of the drawings and records examined were found to be in order with appropriate sign-offs and approvals.

The blue tag inspection/verifications are not normally witnessed by Q-C personnel. However periodic audits are performed to verify that the inspections are conducted and documented in accordance with the latest approved procedures and drawings. A review was made of PECO Audit Reports AR-2E-227 dated May 5, 1986 and AR-2S-074 dated March 7, 1988. Except for minor documentation problems, there was no adverse audit findings.

5.0 Exit Interview

An exit interview was held on May 3, 1988 with members of the licensee staff, denoted in paragraph 1, at the conclusion of the inspection. The inspector summarized the scope and findings of the inspection at that time.

No written material was provided to the licensee.

Appendix A

Documents Reviewed

1.0 Final Safety Analysis Report Chapter 8, Electric Power

2.0 Construction Procedures

E-2	Permanent Plant Cable Installation and Termination
G-3	Long Term Storage/Maintenance/Lubrication of Permanent Plant Equipment and Material Prior to Turnover
E-622	Cable Pulling Calculation for Repull of Cable 2B6501A
E-1412	Wire and Cable, Notes and Details
M-1	Modification/Rework Package MRP 2A6501-1C to Replace the Diesel Generator Bearings

3.0 Field Engineering Procedures (Blue Tag)

FE-34	Procedure to Inspect and Test 480 VAC Load Center Breakers
FE-40	Procedure to Inspect and Test Medium Voltage Circuit Breakers
EE-11.11	Inspection and Testing Procedure Implementation
EE 2.1	Procedure for the Qualification of Field Engineers Assigned to Nuclear Power Plants
EE2 1-I	Personnel Qualification Records of Field Engineers Assigned to a Nuclear Power Plant (Including Unit 2 List of Personnel and their Qualification).
EE6.3	Procedure to Control Design Documents used for Inspection and Test Activities

4.0 Quality Assurance

2E-213	Quality Assurance Surveillance Check Report Verification of Cable Pulling Tension Calculation
2S-074	Audit Report of PECo Electric Field Engineering Blue Tag Testing of Safeguard 440 Volt Load Centers
2E-227	Audit Report Inspection of Cutler Hammer Motor Control Center 20B224

5.0 NRC Reports

50-341/85-046 Inspection Report of the Detroit Edison Fermi Nuclear Power Plant Plant, Unit 2 Emergency Diesel Generator Bearing Failures, July 3, 1986.

6.0 Consultants Reports

Franklin Research Center Report to USNRC - Evaluation of Bearing Failures in Fairbanks Morse Diesel Engines at the Enrico Fermi Unit 2 Reactor, March 3, 1986.

Battelle Final Report to Detroit Edison - A Metallurgical Investigation of Various Defect on the Surfaces of Diesel Engine Aluminium-Tin Bearings, August 31, 1986.

Failure Analysis Associates Report to Detroit Edison - Investigation of Surface Scoring of Main Bearings: Fairbanks Morse 38TD8-1/8 Diesels at Fermi II Power Plant, June 1986. Report FAA-DC-R-86-06-03.