U.S. NUCLEAR REGULATORY COMMISSION
REGION I

Report No. 50-293/88-08

Docket No. 50-293

License No. DPR-35

Licensee: Boston Edison Company
800 Boylston Street
Boston, Massachusetts 02199

Facility Name: Pilgrim Nuclear Power Station Unit 1

Inspection At: Braintree and Plymouth, Massachusetts

Inspection Conducted: February 1-5, 1988

Inspectors: T. Koshy — 4/18/88
T. Koshy, Lead Reactor Engineer — date

C. H. Woodard — 4/15/88
C. Woodard, Reactor Engineer — date

Also participating in the inspection and contributing to the report were J.Knox, Sr. Electrical Engineer, NRR and J.T. Haller, NRC Consultant

Approved by: C J Anderson — 4/19/88
C.J. Anderson, Chief Plant Systems Section — date


Inspection Summary: Inspection on February 1-5, 1988 (Report No. 50-293/88-08)

Areas Inspected: Special announced team inspection of the electrical power systems including (1) verification of as-built drawings, (2) adequacy of breaker and fuse coordination, (3) emergency loading of the diesel generator, (4) plant modifications involving significant changes in the configuration of electric power systems, and (5) maintenance of breakers and protective relaying.

Results: The licensee review of the breaker and short circuit study was sufficiently comprehensive to establish breaker coordination and to assure adequate interrupting capacity of the breakers. The plant engineering support was sound in the electrical engineering discipline.

Two violations were identified in the electrical maintenance area. (1) Inadequate maintenance of the 125 and 250V DC batteries resulting from the lack of acceptance criteria in the procedures, for corrosion on battery terminals, gap between seismic support rails and the batteries, and the tightness of

bolted connections on battery terminals. (2) Lack of surveillance testing of DC breakers. These findings indicate a general weakness in electrical maintenance.

Three items remained unresolved at the end of the inspection (1) the corrective action resulting from the undersized contactor, (2) the corrective action for the licensee identified under voltage condition, and (3) the safety impact of the solid fuse links in the DC control circuits. See Attachment No. 7 for a Summary of Inspection Findings.

## Summary of Inspection Findings

| Violations | Section | Number |
|---|---|---|
| 1. Inadequate Battery Maintenance | 5.5.3 | 50-293/88-08-01 |
| 2. Lack of DC Breaker Surveillance | 5.5.3 | 50-293/88-08-02 |

| Unresolved Items | | |
|---|---|---|
| 1. Undersized Contactor | 5.2.1 | 50-293/88-08-03 |
| 2. Degraded Grid | 5.4.2 | 50-293/88-08-04 |
| 3. Solid Fuse Links | 5.2.3 | 50-293/88-08-05 |

## TABLE OF CONTENTS

1.0 Persons Contacted

1.1 Boston Edison Company (BECO)

R. Atkins, Sr. Electrical Engineer, Nuclear Eng. Division
* R. Banet, Plant Manager
* M. N. Brosee, Maintenance Section Magnaer
J. Caughlin, Project Electrical Engineer
J. S. Collins, Electrical Engineer, Station Operations Department
* N. Desmond, Acting QC Group Leader
R. V. Fairbank, Section Manager, Engineering
* R. E. Grazio, Field Engineering Section Manager
* D. Gerlits, Safety and Systems Analysis Engineer
* P. Hamilton, Group Leader, Compliance
* K. L. Highfill, Station Director
E. J. Janus, Engineer, Nuclear Engg. Division
J. Keiran, Electrical Maintenance
R. L. Kirven, Electrical Engineer, Nuclear Engineering Division
M. Lemieux, Electrical Maintenance
R. Levin, Electrical Engineer
J. B. McLaughlin, Engineer, Nuclear Engineering Division
J. Pawlak, Electrical Engineering Group Leader
W. Peterson, Nuclear Maintenance
N. Puekett, Electrical Maintenance
P. D. Rydman, Civil Engineer, Nuclear Engineering Division
* R. Sherry, Chief Maintenance Engineer
* N. Simpson, Principal Technical Engineer
P. Skillings, Electrical Maintenance
T. Smith, Electrical Maintenance
J. Stevenson, Electrical Maintenance
W. Swain, Engineer, Nuclear Engineering Division
R.N. Swanson, Nuclear Engineering Manager
* B. Tucker, Engineer, Nuclear Engineering Division
K.D. Ward, Safety and Systems Analysis Engineer
* R. Whetsel, Senior Compliance Engineer
* F. Webb, System Engineer
R. Winer, Electrical Maintenance
L. Young, Engineer, Nuclear Engineering Division

1.2 U.S. Nuclear Regulatory Commission (NRC)

* T.K. Kim, Resident Inspector
* J.J. Lyash, Resident Inspector

* Present at the exit meeting on February 5, 1988.

# INSPECTION OF PILGRIM ELECTRIC POWER SYSTEMS

## 2.0 Introduction and Background

The electric power systems (onsite and offsite) are important to the safety of a nuclear power plant and shall be designed and maintained accordingly. The safety function of each electrical system (assuming the redundant system is not functioning) shall be to provide sufficient capacity and capability of electric power for the safe operation of the plant under all operating modes including anticipated operational occurrences and postulated accidents. To achieve this safety function, 10 CFR 50, Appendix A, General Design Criterion 17 and 18 Electric Power Systems, specifies design requirements concerning provisions for their periodic inspection and testing.

The Final Safety Analysis Report (FSAR), Chapter 8, Electric Power Systems, describes how these design requirements are met. It also specifies the licensee's commitments with respect to the applicable Regulatory Guides (RGs) and industry standards such as the Institute of Electrical and Electronics Engineers (IEEE). The licensee's electric power systems, as originally designed were reviewed by the NRC against these requirements and commitments. This review was conducted prior to licensing the facility.

Following the issuance of the Operating License, plant modifications can be made which involve significant changes in the configuration of the electric power systems. These modifications may involve substantial load growth of the electric power systems. As a result, lacking adequate controls, the electrical power systems may be loaded to their rated capacity, or overloaded. This may adversely affect the functioning of the protective relays and coordination of the interrupting devices. Load growth may also create bus undervoltage conditions which may trip out or damage motors, resulting in unnecessary bus transfers, or cause other operational transients. Therefore, plant modifications should be evaluated to assure that their effect does not violate the requirements of General Design Criteria 17 and 18, and FSAR commitments, before the modifications are implemented.

Other types of significant changes in the configuration which might adversely affect the performance of electric power systems are: a transfer of a large load from one bus to another; replacement of system components such as breakers, fuses, etc. with a component having different functional characteristics; and changes in the set point of protective relays or breakers. All such changes should be reviewed in detail to assure the integrity of the electrical system.

## 3.0 Purpose and Scope

The purpose of this inspection was to ascertain that the present configuration of the offsite and onsite electric power systems is capable of sustaining and/or switching loads as required to support the safe operation of the plant. This was accomplished by verification that the physical configuration, including modifications, conforms to the current electrical drawings and that the evaluations of the configuration are current and that they support the required functioning of the power systems. This verification was accomplished by a detailed review of one electrical division.

## 4.0 Inspection Methodology

The team reviewed the adequacy of the safety related electrical distribution system with respect to the following factors affecting system availability: (1) selectivity among the various protective devices which respond to overload; (2) reasonable sensitivity and speed of response of the protective devices, considering the characteristics and criticality of the protected equipment; (3) accuracy of the coordination curves in representing the types, ratings, and settings of the devices actually present in the plant; (4) adherence to the principal that no single failure (including a failure of a circuit breaker, fuse, protective relay, instrument transformer, etc.) can disable more than one redundant safe-shutdown train; (5) assurance that faults in non-Class 1E parts of the power system cannot credibly degrade Class 1E power availability; and, (6) absence of apparent credible common-cause multi-train failure modes in those cases where complete selective coordination cannot practically be achieved.

Primary emphasis was on the safety buses and connected loads, including 4160 VAC, 480 VAC, 120V Vital AC, and 125 VDC. A selected sample of Class 1E and Non 1E buses were walked down to collect the as built data on relay set points, load configuration and equipment rating. This data was compared to electrical one line drawings, protective device setpoint calculations and load studies. The licensee analyses on selected protective relaying and breaker coordination was reviewed and field verified to determine the electrical system capability to limit the effects of electrical faults.

A sample of significant electrical modifications were reviewed in detail. The purpose of this review was to verify that appropriate controls for the assurance of quality were in effect and that adequate safety evaluations were performed by the licensee to ensure that no unreviewed safety questions (10 CFR 50.59) exist. The modification program was reviewed to verify that the appropriate maintenance attributes are transferred into the applicable procedures.

The onsite electrical power systems, emergency diesel generator and the 125V Batteries loading calculations were reviewed to verify the systems' capability to respond to design basis events. The dynamic part of the electrical system as documented in the licensee studies was verified to assess the system capability to respond to transient undervoltage, bus transfer and starting of large motors.

## 5.0 Details of Inspection of Electric Power Systems

### 5.1 General Review of Design Features

The following documents were reviewed:

- Technical Specifications.
- FSAR Section 8, Electric Power Systems.
- Electrical Single Line Diagrams. (Attachment 1)
- Calculations and Studies. (Attachment 3)

The scope of review was to ascertain that:

- The systems as designed are capable of performing their intended safety function.
- The design meets applicable requirements and commitments.

General design requirements and guidance such as Regulatory Guides and IEEE standards currently applicable for the design of electrical power systems are listed in NUREG-0800, Standard Review Plan, Revision 2 - July 1981, Section 8. However, these requirements and the guidance documents do not fully apply to older plants such as Pilgrim Nuclear Station. The applicable requirements and licensee commitments to guidance documents are specifically mentioned in various sections of the Pilgrim FSAR. This review was to ascertain that, for the current configuration of electric power systems, these specific requirements and commitments are satisfied. It should be noted that the scope of review was general in nature. Its extent was restricted to those design features selected for the inspection. Emphasis was on the capacity and capability of the current configuration of the systems under various accident modes such as Loss of Offsite Power (LOOP) and Loss of Coolant Accident (LOCA), with or without a Single Failure.

No unacceptable conditions were identified.

## 5.2 Verification of As-Built Drawings

The as-built drawings, (single line diagrams) listed in Attachment 1 were verified by the inspectors by comparing the drawings with the field configuration in a plant walk-through. The objective of the verification was to identify the differences, if any, between the as-built drawings and the field configuration. The comparison focused on items of potential safety concern and included the following:

- Additions, deletions, or transfer of loads on the buses which affect the system configuration.
- Differences in name plate data (e.g., Horsepower, kW, kVA, Thermal Overload Device, Full Load Ampere) of system components.
- Differences in continuous, momentary and interrupting rating of circuit breakers or fuses.
- Characteristics of replacement items which could potentially alter the performance of the system (e.g., make, type, model number, and design parameters of circuit breakers, fuses, transformers, relays, etc.).
- Setting of protective relays.

### 5.2.1 480V AC Motor Control Centers and Distribution Panels

The team noted in Train A 120/280V panel-board Y6 that the circuit for an air conditioning unit was wired to breaker positions #15 and #17 rather than positions #11 and #13 as shown in diagram E14, Sh. 2, Rev. 13. This diagram shows above positions #15 and #17 as spares, where as positions #11 and #13 were found to be spare. Boston Edison Company has reviewed this situation, concurs with the finding and has issued PCAQ #88-020 dated February 2, 1988 to rectify the condition. Action has been completed which involved revising diagrams E14, Sh. 2 (now Rev. 4) Single Line Diagram, 120/208/240V Vital AC Control and Power, E203, Sh. 15 (now Rev. E2) - Power Distribution Diagram, Panel Y5 (120/208V, 3 phase, 60 Hz) and E723, (now Rev. E2) - Wiring Block Diagram, Air Conditioning System and Oxygen Monitor, MCC Encl MCC B17, B18, B20, D7, D8 and D9. The condition is considered resolved.

The team observed that the contactor installed in unit B1735 is actually NEMA size 1 whereas the E10, Rev. 12 indicated a NEMA size 2. The load served by this unit is a 20 HP motor for drywell unit cooler V-AC-206A1. According to NEMA standards, size 1 contactors can be used with 460 volt motors having ratings not exceeding 10 HP and size 2 contactors with 460V motors having ratings not exceeding 25HP. This contactor misapplication is an Unresolved Item pending NRC review of the licensee action to review other potential misapplications of contactors and the cause of this misapplication (50-293/88-08-03).

5.2.2 250/125V DC System

The 250V DC Battery D3 Circuit/Fuse Panel D31 provides circuit breaker disconnect/connect and fuse protection for the battery feed to power distribution panel D10. Neither the panel, circuit breaker or fuse will provide the operators of indication if the fuse has blown or if this circuit opens. An open power circuit anywhere from battery D3 to power cubicle D10 would go undetected initially, since the battery charger D13 would supply the loads and provide indication on the ammeter and voltmeter. However, it is understood from the licensee that an open circuit from the battery to the charger will cause the battery charger regulating circuit to fail very quickly thereby causing a complete loss of 250V DC. The inspector raised a concern that if the back-up 250V DC battery charger were switched on without closing the battery open circuit, it could also fail for the same reason.

The inspector noted that the 125V DC battery charger circuits are also subject to failure on open circuit. The licensee was aware of this potential problem and had recognized its short term single channel failure potential. Failure of any one of the 125 or 250V DC channels to supply DC power to its loads is immediately evident in the control room as DC power failure which can lead to prompt corrective action. The inspector had no further questions regarding this issue.

The 125V DC Distribution Panel D37 was installed by the licensee under PDCR 79-25. It is fed from distribution panel D5 and provides power to circuits including those for the ATWS modification. Drawing E13 shows that circuit breaker No. 1 feeds "Load Shedding Control at C5." This breaker had no feeder identification label installed. Even though there are no specific labeling requirements, the load was verified by the licensee, the breaker was appropriately labelled temporarily and permanent labeling was ordered. The 125V DC Distribution Panel D6, feeder circuit breaker No. 22 was shown on Drawing E13 feeding Distribution Panel D19; however, this breaker was not labelled. The licensee confirmed the distribution, installed a temporary label and ordered permanent labeling. The inspector had no further questions. These two findings appeared to be an isolated instance of incorrect labeling.

5.2.3 Solid Fuse Links

A review of the 125 volt DC distribution system below the feeder circuit breaker level showed that the emergency diesel generator field flashing circuits are solidly wired through solid copper fuse links rather than through properly sized fuses. Solid fuse links are also used in auto trip circuits on switchgear. A potential short circuit in any one of the solid-link wired circuits could cause an upstream feeder circuit breaker to trip with a consequent loss of control power to all of the other loads on that circuit breaker which usually serves a full switchgear. Metal links were used in these circuits initially by the licensee because it was thought to be safer than fuses due to the importance of the particular circuits. The licensee has recently completed an analysis and made changes to replace all of the metal links in the 125V DC control circuits for the 480V motor control centers. The licensee agreed to conduct a similar evaluation to determine if the 125V DC EDG field flashing and 4160 volt breaker auto trip circuits can be properly fused to replace the solid metal links. This is an unresolved item pending NRC review of the licensee study on the use of solid links in the 125 volt DC circuits (50-293/88-08-04).

5.3 Electrical Configuration Control and Plant Modifications

5.3.1 Administrative Controls

The team reviewed the licensee program for electrical modifications. Nuclear Engineering deparment procedure 3.02 Revision 22, "Preparation, Review, Verification. Approval and Revision of Design Documents For Plant Design Changes," provides the work instructions for performing Plant Design Changes (PDC) that deal with electrical equipment. A power systems cognizant engineer has the responsibility to assure that the PDC complies with this procedure. This work instruction provides guidelines for assuring the required quality, seismic and equipment qualification requirements. This procedure also contains the protection criteria for electrical motors and transformers. Design criteria specifications, an attachment to the procedure, contains a mandatory check list of 30 line items which include the electrical loading, coordination of fuses, breakers and voltage availability. An independent review process further assures the adequacy of the PDC before it is issued. This procedure currently controls the load growth on AC and DC buses. The licensee's load studies and calculations reflected the current configuration of the electrical system. No deficiencies were identified with the above procedures.

In order to preserve the fuse coordination, the licensee has issued Nuclear Operations Department Procedure 3.M.3-44 Revision 0, Control of Fuses. The team reviewed this procedure and discussed the value of including a reference to the fuse type into Section VII of the procedure. The fuse type information is needed to preserve the required trip characteristics that are established in the design calculations. The licensee management agreed to make this change.

No other deficiencies were observed.

New Computer Program for Load Studies

The licensee is in the process of developing a computer based in-house capability for the analysis of the electric power systems, based on a commercially available program called Distribution Analysis for Power Planning, Evaluations and Reporting (DAPPER). The new program is intended to generate load list (static loading of the buses) and to analyse the system for short circuit and voltage profile considerations when major modifications are performed. The results of the program can be used for evaluating the adequacy of the breaker interrupting capacities and the relay coordination. The licensee is currently in the process of transferring the electrical data from a main frame computer to the personal computer based DAPPER program. This data will be maintained as a quality document. The licensee intends to add a data sheet for use with the DAPPER program containing the necessary revised electrical data to all the applicable electrical modifications. The licensee expects the new program to be in place within three months. The licensee expects that use of the DAPPER program will significantly enhance their in-house capability to analyze the system when modifications are performed.

5.3.2 Review of Modification Packages

A sample of modifications involving significant changes in the configuration of electric power systems was selected for detailed review. These are listed in Attachment 2. the review focussed on the change control aspect of the modifications and adherance to the administrative controls discussed in Section 5.3.1 of this report. The scope of review included a verification that:

- The Quality Assurance Controls and Administrative Controls were effectively used during the implementation of the modifications.

- Adequate safety evaluations were performed to ensure that no unreviewed safety question (10 CFR 50.59) exists.

- Independent design verifications were performed as required.

- Adequate post-modification tests were performed and the test results met the acceptance criteria.

- The modifications involving a major change in the configuration of the electrical power systems were further reviewed in detail. The scope of the review was to determine the extent of the change, its potential effect on the safety functions of the electrical power systems and to confirm that the current load analysis accounted for the present load configuration.

No unacceptable conditions were identified.

## 5.4 Review of Protection and Coordination System

### 5.4.1 4.16kV Electrical System

The onsite power distribution supplies the ac power required to safely shutdown the reactor and maintain it in the shutdown condition. The distribution system also provides power to operate all auxiliaries necessary for safe startup, operation, and shutdown of the station. The six 4.16kV buses (A1 through A6) comprise both the safety related and normal (non-safety) service portions of the distribution system. The safety related buses (A5 and A6) supply power to the station auxiliaries requiring AC power during plant operation.

The power supply to the six 4.16kV buses during normal operation is either from the unit auxiliary transformer or from the startup transformer. Additionally, Safety buses A5 and A6 may also be supplied power from the standby onsite power source (diesel generators), the shutdown transformer, or the black out diesel generator when its installation is completed. See Attachment 6 for a single line diagram.

The phase time overcurrent protective relay settings identified on Drawing E5-200 sheet 1 and 2 for 4.16kV switchgear (Bus A5) for circuit breakers 152-507 (core spray pump), 152-508 (line feed to transformer X-21 and 480V bus B1), and 152-609 (diesel generator A) were compared with the as-found relay settings. No unacceptable conditions were found.

Coordination between 4.16kV breaker 152-509 (supply to bus A5 from diesel generator A) and breakers 152-507 (supply to the core spray pump) and 152-508 (supply to 480V bus B1) as shown on page 22 of Calculation PS-30 were reviewed. The protective relays were fully coordinated. No unacceptable conditions were found.

5.4.2 480V Electrical System

The eight 480V buses (B1 through B8), like the 4.16kV buses, are divided into safety related and normal (non-safety) service buses. Safety related auxiliary equipment required during operational transients and accidents are all supplied from safety buses B1, B2, and B6.

Bus B1 is supplied from 4.16kV Bus A5 through 4.16kV to 480V stepdown transformer X-21. Bus B2 is supplied from 4.16kV to 480V stepdown transformer X-22. Bus B6 is supplied normally from 4.16kV Bus A5 through 480V bus B2. On loss of AC power on buses A5 and B1, the power supply to bus B6 is automatically transferred to 4.16kV bus A6 through 480V bus B1. The five normal service buses (B3, B4, B5, and B8) supply power to other 480V AC auxiliary equipment required during plant operation.

DC control power for buses A5 and B1 is supplied from safety related 125VDC control battery A. DC control power for buses A6 and B2 is supplied from safety related 125 VDC control battery B. DC control power for 480V bus B6, breaker 52-102 on bus B1, and breaker 52-202 on bus B2 is normally supplied from safety related 125VDC control battery A. On loss of power from battery A and its associated battery charger, control power is transferred automatically to 125VDC control battery B.

Protection and Coordination

The 480V load center protective relay settings as identified on drawing E7-133 sheet 1 for circuit breakers 52-101 (supply from transformer X21 to bus B1), 52-102 (tie between bus B1 and bus B6), 52-104 (supply from bus B1 to bus B6), and 52-501 (tie between B6 and B1) were compared with the as-found relay settings. The breakers were fully coordinated with adequate margin. No unacceptable conditions were found.

Coordination between 480 volt breakers 52-101 and 52-601 to bus B6 as shown on page 21 of Calculation PS-30 and between 480 volt breakers 55-101 and 52-104 to bus B17 as shown on page 24 of Calculation PS-30 were reviewed. No unacceptable conditions were found.

The 480V swing bus design for automatically transferring the AC supply power to bus B6 from B1 to B2 and the design for automatic transfer of dc control power to B6 from battery A to battery B were reviewed for compliance with the single failure criterion. Drawings E13 and E534 were reviewed and no discrepancies were observed.

The molded case breakers used in motor control centers are Westinghouse type HFA, HFB and HKA. Types HFA and HFB have a manufacturer's published interrupting capability of 25KA symmetrical (sym) and the type HKA has a capability of 35KA (sym). These interrupting ratings are in excess of the calculated fault duty on the motor control centers' supply 480V Bus B1 and are therefore acceptable. Boston Edison Company calculation of PS-26, Rev. 0, dated October 9, 1986 - indicates the short circuit current on 480V Bus B1 as 22.4KA (sym). The anticipated fault level on the motor control centers served by this bus would be less due to cable impedance. The motor control center bus bracing is reported to have a withstand capability of 25KA (sym). No deficiencies were identified.

The coordination of protection for the 480V system was reviewed by the team as documented by Boston Edison Company calculations PS-30, Rev. 0, dated April 25, 1987 480 Volt Breaker Coordination/ Protection Setting and PS-24, Rev. 0, dated September 11, 1986, - Coordination Study - Safety Related 480V system. The team found these calculations to be acceptable and coordination of the 480V system, including the 120/208/240 panelboard, was demonstrated by the calculations. Coordination had been enhanced by BECo with the modification of the 480 volt switchgear breakers using the General Electric Company type "MicroVersa Trip" solid state trip units. No unacceptable conditions were found.

The thermal overload relays used with the various contactors were identified during the walkdown. These agreed with the listing shown on a preliminary copy of the BECo drawing E8-13-8, Rev. 3, Arrangement Drawing Motor Control Center B17. A copy of calculation PS-49, Rev. 0, dated February 1, 1988, "Overload Heater Selection - Safety Related Motors," was obtained and reviewed. The results of the calculation indicate overload relay heater elements with slightly higher trip current ratings should be used due to considerations of margin including degraded voltage and ambient temperature. The calculation notes that revision to design documents should be made to indicate the need for overload heaters with higher rating. The licensee issued Field Revision Notice 87-80-19 dated February 2, 1988 to correct this problem. This activity is scheduled to be complete before restart. The inspector had no further questions.

5.4.3 250/125V DC System

The DC system is comprised of two 125V DC batteries (D1, D2) and one 250V DC battery (D3), three 125V DC chargers (one back-up) and two 250V DC chargers (one backup). 125V DC power is supplied through two separate distribution panels and through one common distribution panel through an electrically isolated automatic transfer switch. 250V DC is supplied directly to Power bus D10 for distribution to major dc motor loads including the vital services MG-set and also to MCC D9 for distribution to some of the smaller pumps and motor operated valves.

Protection and Coordination

BECo DC System Overcurrent Protection Coordination Study PS-31 dated May 7, 1987 was reviewed to assess the protection and coordination of the related dc distribution systems. These studies cover the overall 125V and 250V DC systems as described by Drawing E-13, Single Line Relay & Meter Diagram, 125 and 250V DC system.

The coordination curves were reviewed for the complete 250V DC distribution (D3-1 and D3-2 of PS-31) and for both of the 125V DC supplies (D1-1, D1-2, D1-3, D1-4, D1-4A, D1-5, D1-5A, D1-6, D2-1, and D2-1A). All curves show proper circuit breaker coordination within their portions of the DC system.

To further verify the coordination, all of the circuit breakers in the 250V DC distribution system in MCC D9 and D10 were field verified and found to be of the proper type and have overcurrent trip elements as analysed in the PS-31 study.

The licensee has made several changes within the DC electrical systems since licensing which have affected the connected loads and load demands. The inspector confirmed that the licensee has factored these changes into load analyses to assure that the system is capable of meeting its design bases requirements. Current licensee static and dynamic analysis of the loads on these DC systems were reviewed and presented in DC System Loading Voltage Profile Calculation PS-47. This study presented a projected worst case loading profile which covered an eight hour accident scenario which included loss of offsite power, loss of all battery chargers, and a small break LOCA. The dynamic and steady state loading voltage profiles of these dc systems during this eight hour accident scenario demonstrates the battery capability to power all of these loads and maintain adequate terminal voltage.

Battery tests conducted (during the last test cycle in 1986) in accordance with Procedure 8.9.8 Battery Rated Load Discharge Tests were reviewed for both 125V and the 250V DC battery. Test data taken during the batteries discharge and charging periods provided evidence of satisfactory performance of the batteries and the battery chargers. The licensee plans to conduct tests for all of the safety related batteries prior to start-up.

5.5 Undervoltage study

As a result of a degraded grid voltage condition at Millstone Nuclear Power Station Unit 1 in July 1976, the NRC staff, by letter dated August 13, 1976, requested Boston Edison Company to conduct a thorough evaluation of the degraded grid problem and to submit a report. The staff required the licensee to evaluate the design of the Pilgrim Station's Class 1E electrical distribution system to determine if the operability of safety related equipment, including associated control circuitry or instrumentation, can be adversely affected by short or long term degradation in the grid system voltage within the range where the offsite power is counted on to supply important equipment. The licensee performed a voltage study, titled "Evaluation of Grid System Voltage Degradation on Pilgrim Unit #1," dated November 15, 1976. This study was submitted to the NRC Office of Nuclear Reactor Regulation (NRR) for review.

As a result of a September 1978 event at Arkansas Nuclear One, the NRC, by letter dated August 8, 1979, provided additional guidelines to be considered when performing voltage studies. As part of these guidelines, the NRC staff indicated that the voltage study should include documentation for each condition analyzed, of the voltage at the input and output of each transformer and at each intermediate bus between the connection to the offsite circuit and the terminals of each safety load. The licensee in response to these guidelines advised the NRC, by letter dated October 16, 1979, that voltage studies had already been completed for the Pilgrim station as part of their November 15, 1976 voltage study that had been submitted for NRC review.

During the review of the licensee's voltage study, the NRC staff expressed the concern that in the event of an accident (LOCA) or anticipated transient (unit trip), the onsite distribution system in conjunction with the offsite power sources must have sufficient capacity and capability to automatically start and operate all required Class 1E loads within the equipment's voltage ratings. In response to this concern, (i.e., the maximum voltage rating of equipment must not be exceeded) the licensee, by letter dated November 5, 1980, stated that voltage profiles of the safety related buses were analyzed as part of their November 15, 1976 voltage study for operating ranges of Pilgrim's grid system voltage i.e., ±5% of "nominal voltage"

(328kV to 362kV) and based on past experiences and system stability studies it was determined that the voltage of the safety related buses will not exceed the maximum voltage rating of the Class 1E equipment.

Also, as part of the NRC review of the licensee's voltage study, the staff specifically requested that voltage drops be provided from the Class 1E buses to the terminals of all Class 1E loads for all cases analyzed. The licensee by letter dated June 16, 1981, provided these voltage drops and indicated that voltages at the terminals of safety-related loads are within the operating ranges of the equipment.

The NRC reviewed the licensee submittals and issued safety evaluations (amendments 42 and 61) to the licensee by letters dated May 12, 1980 and May 28, 1982. As a result of the degraded grid problem, the licensee made a design change to provide automatic protection against degraded grid voltages when the startup transformer is supplying power, and to provide an alarm with operator action to restore the bus voltage when the unit auxiliary transformer is supplying power. For transmission system voltages of less than 328kV, the degraded grid voltage protection will trip and cause a transfer of Class 1E loads from the offsite system to the onsite diesel generators.

The licensee recently notified the NRC on January 30, 1988 that the degraded grid voltage protection at Pilgrim was set too low to ensure manufacturer recommended voltage at some Class 1E electrical equipment for certain operating scenarios. The licensee performed a self-initiated plant voltage study of the electrical distribution system and determined that, for a plant turbine trip combined with offsite transmission voltage of less than 344 KV, the terminal voltage at some Class 1E electrical equipment would be less than the manufacturer's rated voltage. For voltages greater than 344 KV, the plant electrical system voltages will ensure device terminal voltages consistent with manufacturer recommendations.

The licensee has analyzed the cause of the problem and determined that the current degraded grid voltage setpoint (328kV) was based on a 1976 voltage analysis that used, as a basis, the assumption that if the 480V bus voltage was maintained within its design operation range of $\pm 10\%$ nominal, then terminal voltage at the safety related electrical equipment would be acceptable. A more comprehensive analysis that is finalized indicates the assumption to be invalid for some equipment. This potential undervoltage conditions for safety related equipment was reported to NRC on January 30, 1988.

The license has initiated pre-restart corrective action with a commitment to complete the ongoing study and evaluate whether longer term improvements are appropriate. The pre-start actions include finalizing the voltage study and obtaining additional information on grid voltage fluctuations to revise the degraded grid voltage protection setpoints to more conservative values (both alarm and trip functions); implement a plant modification to initiate the load shedding scheme (now used specifically for a LOCA signal with loss of offsite power) for any LOCA signal; formally notify the NRC; and submit technical specification changes, if necessary. The licensee is continuing its detailed analyses and will evaluate whether longer term improvements to the electrical distribution system are appropriate. This is an unresolved item pending NRC review of the licensee actions to rectify the undervoltage problem (50-293/88-08-05).

## 5.6 Maintenance

The team reviewed the critical electrical components requiring testing and/or maintenance. The details are as follows.

### 5.6.1 4.16KV and 480V AC System

The following procedures were reviewed along with the test records for the current year.

3.M.3-2 480V Load Center Breaker trip device calibration test and Annunciator Verification

3.M.3-1 A5/A6 Buses 4kV Protective Relay Calibration/Functional Test and Annunciator Verification

8.M.3-27 480V Bus B6 Automatic Transfer Test, UV and Timing Relays Calibration and Annunciator Verification.

The objective of this review was to ascertain that the trip characteristics of the relays are maintained adequately to limit the effects of a potential fault. During the walkdown the as left settings of the protective relays were collected and compared with the required acceptance values established in the calculations. No unacceptable conditions were found.

The team was informed that when type HFA Breakers used in motor control centers did not meet performance criteria they were replaced with type HFB, since the manufacturer has discontinued building the former. The plant maintenance people stated that they had experienced a very high rejection rate (possible 90%) when type HFA breakers are tested. The team discussed this concern with Boston Edison Company's Nuclear Engineering Division (at Braintree) and were advised the high failure rate could be attributed to the following causes:

- Contact resistance acceptance criteria was based on factory test values not achievable in the field.
- Misinterpretation of time-current values based on factory testing rather than field testing.
- Aging of HFA Breakers

The breaker trip characteristics (amperes and time) were obtained from documented plant maintenance and testing records. A plant procedure, 8.0.3-3-1, Rev. 9, dated December,29, 1987, "480 VAC Motor Control Center Testing and Maintenance," was used by plant maintenance to obtain acceptable trip characteristics for the various molded case breakers. The team reviewed the calibration data for breakers in Motor Control Center 17. No discrepancies were observed.

5.6.2 <u>Diesel Generator Testing and Loading</u>

Calculation number 003, "Emergency Diesel Generator Steady State Loading - Pilgrim Power Station," and procedure number 8.M.3-1, "Automatic ECCS Load Sequencing of Diesels and Shutdown Transformer with Simulated Loss of Offsite Power" were reviewed.

The results of the diesel generator load calculation demonstrates that the maximum steady state kW loading for which the diesel generator would be subjected to during a Loss of Coolant accident with loss of offsite power and during a loss of offsite power without an accident, will not exceed the 2600kW continuous design rating of the diesel generators. No unacceptable conditions were found.

The capability of the diesel generator to accept actual design loads (to the extent practical) is tested on a once per refueling cycle basis. During this test, the RHR and core spray pump loads (connected to mini flow lines) and the other loads are sequenced onto the diesel generator. 4.16kV bus voltage and diesel generator load current versus time is recorded. Test results, during preoperational testing (prior to Pilgrim Station commercial operation) and recent testing were reviewed and found to demonstrate the continued capability of the diesel generators to accept actual safety loads with margin.

An analysis, based on the results of the above testing, to demonstrate diesel generator capability to accept and carry the greater current demand of RHR and Core Spray pumps operating at full flow was unavailable. The team concluded that, based on testing that has been performed and the loading calculation, that there is reasonable assurance that sufficient capacity margin is available in the Pilgrim diesel generators to meet the greater demand of the RHR and Core Spray pumps when they would be required to operate at full flow during accident conditions. However, we recommend that a computer analysis be performed to confirm DG loading capability for the worst case design basis load and verify the data using the test results, i.e., the dynamic loading of a large pump load as compared to the computer simulation of a large load.

### 5.6.3 250/125 DC System

Pilgrim Station has undergone several loss of AC power events. This places additional emphasis on the reliability of the DC systems since they are relied upon to provide uninterruptible sources of power during such times and for safe shutdown of the reactor following abnormal operation transients and postulated accident conditions.

Inspection of DC circuit breakers in 250V DC power bus switchgear D10 and MCC D9 and 125V DC circuit breakers in power bus switchgear B7 and MCCs D5 and D37 revealed properly sized breakers for the loads which are equipped with magnetic overcurrent trip devices. However, there was no evidence of calibration of these breakers for maintaining proper electrical coordination. Discussions with maintenance, engineering, and management personnel indicate that these circuit breakers were not calibrated for assuring trip characteristics during initial installation or since. The consequences of improper coordination would be the loss of a DC Bus if a downstream breaker does not trip at the required time and current to clear a fault. If the faulted circuit is not isolated by a properly set magnetic protection, the cable in the faulted circuit could overheat and create a potential fire hazard. However, such postulated failures would be limited to one train of DC system. A properly coordinated electrical system with a well maintained breakers will substantially improve the system reliability.

BECO technical specification section 6.8A requires that written procedures be established implemented and maintained that meet or exceed the requirements of ANSI N18.7-1972 and Appendix A of NRC Regulatory Guide (RG) 1.33. ANSI N18.7-1972 Section 5.3.6 requires that procedures be provided for the periodic calibration and testing of safety related protective circuits. RG 1.33 Section 8(2)(q) requires calibration for emergency power tests. Failure to perform DC breaker calibration/test constitutes a violation from the technical specification requirements.

This is a violation (50-293-88-08-01).

Review was made of the licensee's battery surveillance procedures 8.C.14, Revision 20 dated September 16, 1987 "Weekly Pilot Cell and Overall Battery Check" and 8.C.16, "Quarterly Battery Surveillance" and the battery manufacturer's instruction manual 12-800 "C&D Power Systems Stationary Battery Installation and Operating Instructions". This review revealed that the licensee's surveillance procedure did not include appropriate qualitative and quantitative criteria in accordance with the manufacturer's instruction in Section 9.3 for checking the battery connections at least four times yearly, for corrosion, bolting torque values to 125 inch pounds and intercell and intertier connection resistance to 20-25 and 70-80 millivolts, respectively. The licensees procedure also did not include the manufacturer's criteria for maintaining the proper spacing of the batteries within the battery rack to ensure continued operational capability during and after seismic events. C&D instruction manual section 3.2.3 requires the seismic support side rails to be very close to the battery with just enough clearance (gap) to permit an index card to be inserted. Inspection of the batteries revealed excessive corrosion at the terminal connections of battery cells 31 through 60 and cell 3 on battery D2, cell 31 on battery D2, cell 43 on Battery D1 and an excessive gap (½") between the seismic support rail and cell 91 of Battery D3.

These findings constitute a violation of 10 CFR 50 Appendix B, Criterion V which requires that activities affecting quality shall be prescribed in documented procedures which include acceptance criteria for determining that important activities have been satisfactorily accomplished. (50-293/88-08-02)

### 5.7 Independent Calculations

The team performed independent calculations to verify the technical adequacy and accuracy of the licensee calculations associated with the protection and coordination. As these calculations are quite involved, only portions of the calculations were verified. The portions of the calculations verified by the team included the voltage study, short circuit studies, coordination study, and the emergency diesel generator loading study. No deficiencies were identified.

## 6.0 Conclusions

Two violations involving inadequate maintenance of safety related batteries and lack of surveillance on safety related DC breakers were identified. Three items remained unresolved at the end of the inspection.

The above finding along with licensee actions and commitments are discussed in detail in Section 5.0. Based on the teams review and inspection, it was concluded that there is reasonable assurance that the present configuration of Electric Power System is capable of supporting the safe operation of the plant.

7.0 Unresolved Items

Unresolved items are matters for which more information is required in order ascertain whether they are acceptable, violations, or deviations. Three unresolved items are discussed in sections 5.2.1, 5.2.3 and 5.5 of this report.

8.0 Exit Interview

At the conclusion of the inspection on February 5, 1988, the inspection team met with the licensee representatives, denoted in section 1.0. The team leader summarized the scope and findings of the inspection at that time.

The team leader and the licensee discussed the contents of this inspection report to ascertain that it did not contain any proprietary information.

No written material was provided to the licensee by the team.

ATTACHMENT 1

DRAWINGS REVIEWED

| Drawing No. | Rev. | Title |
|---|---|---|
| SE155 (Sh.1) | E21 | Station Electrical Diagram 4.16kV & 480V-AC Systems |
| E13<br>FSAR Fig. 8.6.1 | E16 | Single Line Relay and Meter Diagram 125V and 250V DC Systems |
| E1 (Sh.1)<br>(FSAR Fig. 8.2-1) | E10 | Single Line Diagram Station |
| E537 | E0 | Schematic/Connection Diagram 125V D.C. Auto Transfer Scheme |
| E10 | E12 | Single Line Diagram MCCs B14, B15, B17, B18, B28 and B29 |
| E14 (Sh.1) | E11 | Single Line Diagram 120V AC Vital and Reactor Protection System |
| E14 (Sh.2) | E3 | Single Line Diagram 120/208/240V AC Control and Power |
| E203 (Sh.1A) | E4 | Power Distribution Diagram Panel D4, 125V DC |
| E203 (Sh.2C) | E3 | Power Distribution Diagram Panel D5, 125 DC |
| E203 (Sh.2B) | E5 | Power Distribution Diagram Panel D6, 125 DC |

ATTACHMENT 2

Modifications Reviewed

| Modification Package Number | Title |
| --- | --- |
| PDC #80-49 | TMI Safeguard Power Distribution |
| PDC #86-56B | Blackout Diesel Generator Set |
| PDC #84-18 | MCC Enclosures |
| PDC #79-16 | Installation of Atlas Copeo Air Compressor |
| PDC #85-42 | Transformer Replacement |

ATTACHMENT 3

Calculations Reviewed

| | | |
|---|---|---|
| PS-12 | 4kV Switchgear - High Momentary | 11-7-83 Rev. 0 |
| PS-19 | Harsh Environment Breaker Coordination Study | 10-9-86 Rev.0 |
| PS-23 | DC Short Circuit Currents | 8-5-85 Rev.0 |
| PS-24 | Coordination Study Safety Related 480V System | 8-11-86 Rev. 0 |
| PS-26 | Short Circuit Currents At 4.16kV and 480V Load Center Buses | 09-9-86 Rev.0 |
| PS-30 | 480V Breaker Coordination/Protection Settings | 4-13-87 Rev.0 |
| PS-31 | DC System Overcurrent Protection Coordination Study | 4-20-87 Rev.0 |
| PS-42 | 250V Battery Discharge Calculation | 12-7-88 Rev.0 |
| PS-43 | 125V Battery Discharge Calculation | 12-7-88 Rev.0 |
| PS-47 | DC System Loading Profile | 1-28-88 Rev.0 |
| PS-48 | DC System MOV Voltage Analysis | 1-28-88 Rev.0 |
| PS-49 | Overload Heater Selection for Safety Related Motors | 2-1-88 Rev.0 |

ATTACHMENT 4

Boston Edison Procedures Reviewed

| | |
|---|---|
| 3.M.3-25 | Cleaning and Agitation of Station Batteries<br>Revision 0, February 20, 1984 |
| 3.M.3-42 | Battery Charger Maintenance and Calibration<br>Revision 0, February 19, 1987 |
| 8.C.14 | Weekly Pilot Cell and Overall Battery Check and Weekly Battery Charger Test,<br>Revision 21, December 23, 1987 |
| 3.M.1-11 | Routine Maintenance<br>Revision 5, March 12, 1987 |
| 8.9.3-3-1 | 480V AC Motor Control Center Testing and Maintenance<br>Revision 9, December 29, 1987 |
| 8.9.8 | Battery Rated Load Discharge Test<br>Revision 14, October 15, 1987 |
| 8.C.16 | Quarterly Battery Cell Surveillance<br>Revision 14, October 5, 1987 |
| 3.02 | Preparation Review Verification Approval and Revision of Design Documents for Plant Design Changes<br>Revision 22, January 22, 1988 |
| 3.M.3-44 | Control of Fuses<br>Revision 0, March 4, 1987 |

# ATTACHMENT 5

## REFERENCE MATERIAL

IEEE-STD-308 - IEEE Standard Criteriea for Class 1E Power Systems for Nuclear Power Systems for Nuclear Power Generating Stations

IEEE-STD-450 - IEEE Recommended Practice for Maintenance, Testing, and Replacment of Large Lead Storage Batteries for Generating Stations and Substations

NRC Regulatory Guides

1.33 Quality Assurance Program Requirements (Operation)

ATTACHMENT 6

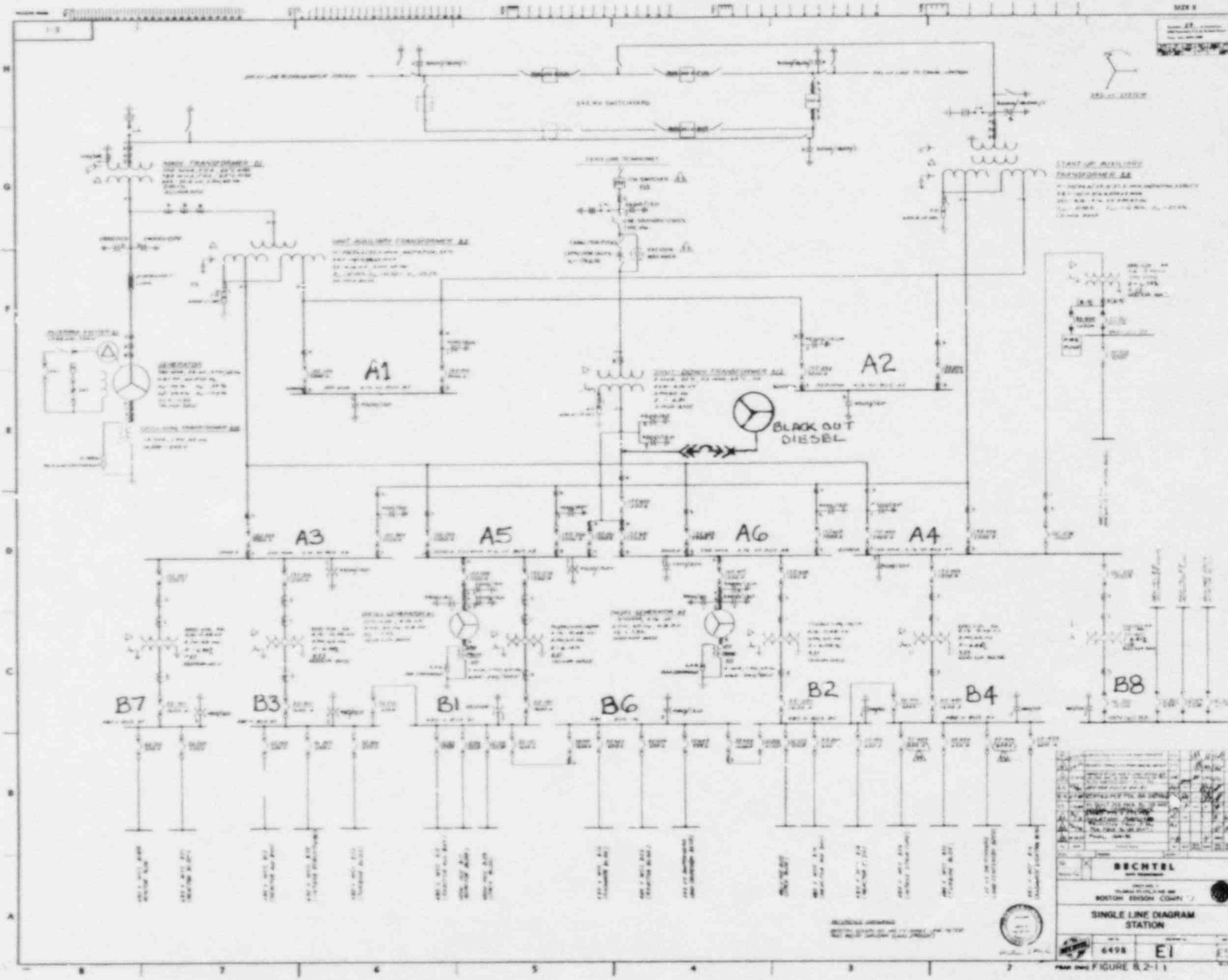

FIGURE 8.2-1 1

ATTACHMENT 7

SUMMARY OF INSPECTION FINDINGS

| Violations | Section | Number |
|---|---|---|
| 1. Lack of DC Breaker Surveillance | 5.6.3 | 50-293/88-08-01 |
| 2. Inadequate Battery Maintenance | 5.6.3 | 50-293/88-08-02 |

| Unresolved Items | | |
|---|---|---|
| 1. Undersized Contactor | 5.2.1 | 50-293/88-08-03 |
| 2. Solid Fuse Links | 5.2.3 | 50-293/88-08-04 |
| 3. Degraded Grid | 5.5 | 50-293/88-08-05 |