Enclosure 2

INSPECTION REPORT

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
DIVISION OF REACTOR INSPECTION AND SAFEGUARDS

Report No.:	99901065/91-01
Docket No.:	99901065
Company:	NEI Peebles Limited, Peebles Electrical Machines (PEM) East Pilton Edinburgh, Scotland EH5 2XT
Industry Activity:	PEM manufactures generators and spare and replacement parts for use in emergency ac power systems supplied by its sister company, NEI Peebles - Electric Products, Inc. (P-EP)
Inspection Conducted:	September 23 through 27, 1991
Inspection Team:	Steven M. Matthews, Team Leader, NRR Stephen D. Alexander, Environmental Qualification and Test Engineer, NRR Gregory C. Cwalina, Section Chief, Special Projects Section, NRR

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Inspection Bases:	10 CFR Part 21, Appendix B to 10 CFR Part 50
Inspection Scope:	To assess PEM's compliance with regulatory requirements and licensees' procurement requirements through a performance-based evaluation of its engineering, procurement, fabrication, assembly, and tests
Plants Affected:	All licensees with P-EP power generators

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1 INSPECTION SUMMARY

1.1 Nonconformances

1.1.1 Nonconformance 99901065/91-01-01

Peebles Electrical Machines (PEM) failed to meet Criterion III, "Design Control," of Appendix B to 10 CFR Part 50;* and American National Standards Institute (ANSI) Standard N45.2, "Quality Assurance Program Requirements for Nuclear Power Plants" (1971); and ANSI N45.2.11, "Quality Assurance Requirements for the Design of Nuclear Power Plants," (1974). In Section 4, "Design Control," of "Quality Manual Volume 1," (QMV1), Issue 7, April 14, 1989, PEM failed to (1) establish adequate measures to control the design interface activities between it and its sister company, NEI Peebles - Electrical Products, Inc. (P-EP), of Cleveland, Ohio, (2) demonstrate that the results of PEM's design translation activities were equivalent to the design requirements specified by P-EP, (3) adequately document the critical requirements or acceptance criteria compared during the equivalency evaluation, and (4) adequately document the results of the equivalency evaluation or other bases to support PEM's conclusion that its drawings, procedures, and material specifications were equivalent (see Section 3.5.2 of this report).

1.1.2 Nonconformance 99901065/91-01-02

PEM failed to meet Criterion III, "Design Control," and Criterion VII, "Control of Purchased Material, Equipment, and Services," of Appendix B to 10 CFR Part 50; ANSI N45.2 (1971); and ANSI N45.2.11 (1974). In Section 4, "Design Control," and Section 7, "Purchaser Supplied Product," of the QMV1, PEM failed to (1) establish adequate measures to provide for the selection and review for and verification of suitability of application for materials, parts, equipment, and services that were procured as commercial grade items and were essential to the generator's ability to perform its intended design and safety-related function and (2) ensure the suitability of the rotor pole magnet wire, the Bakelite electrical separation ring, and certain materials, parts, and equipment that were accepted based on certificates of conformance (COC) from PEM's suppliers that were not audited to verify that their measures to control design, processes, and material changes were adequately implemented (see Section 3.6.3 of this report).

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* Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Part 50, "Domestic Licensing of Production and Utilization Facilities," of Title 10, "Energy," of the Code of Federal Regulations (Appendix B to 10 CFR Part 50).

1.2 Unresolved Item (99901065/91-01-01)

P-EP provided the material specification for the rotor pole magnet wire to PEM in purchase order (PO) 16271, which specified that magnet coil wire be provided in accordance with P-EP's material specification MW-25.3, "Magnet Wire - Round, Square, or Rectangular - Unvarnished Fused Polyester Glass Covering, With or Without Enamel Undercoat, Class F (155°C)," dated June 24, 1977. PEM procured the wire from its supplier by PO EM31035 (original), dated April 27, 1990. In its PO, PEM specified that "rotor copper-unvarnished double dacron glass insulated square magnet wire" be used. PEM also listed material specifications that corresponded to those in MW-25.3 and required certification, by a COC, of the chemical composition of copper, the conductor resistivity, and the insulation dielectric "stress" (sic) (strength). The COC, written in French, stated that the material was *Fil de cuivre guipé 2 DAGLAS Imprégné Classe F*... (which means copper wire wrapped with double dacron glass, impregnated, Class F). PEM accepted the wire and used it to wind the rotor poles. However, the team noted that the French word, *imprégné,* means impregnated and that fiber insulation material is commonly impregnated with varnish, indicating that the insulation would not have been unvarnished as specified. Accordingly, the PEM engineers confirmed that the supplied wire had been varnished. Therefore, the wire did not meet the P-EP material specification nor the PEM PO requirement for unvarnished insulation.

PEM immediately informed P-EP of the deviation; whereupon, P-EP reportedly indicated to PEM that P-EP would perform a deviation evaluation (pursuant to 10 CFR Part 21) regarding the varnished insulation, including an evaluation of the compatibility of the varnish with, and its effects on the adhesion properties of, the other materials (such as epoxy adhesive) used in the assembly of the rotor poles. The results of P-EP's and PEM's evaluation of this deviation were not reported to the team before the exit meeting with PEM on September 27, 1991 (see Section 3.6.3 of this report).

2 STATUS OF PREVIOUS INSPECTION FINDING

The NRC's previous inspection, conducted October 6 through 8, 1986, and documented in the U.S. Nuclear Regulatory Commission's (NRC's) Inspection Report 99901065/86-01 did not result in identifying any findings to be addressed during this inspection.

3 INSPECTION FINDINGS AND OTHER COMMENTS

3.1 Entrance and Exit Meetings

During the entrance meeting on September 23, 1991, the NRC's inspection team met with PEM's staff and discussed the scope of the inspection, outlined areas of concern, and established working interfaces. The NRC inspection team explained the relationship of NRC requirements to PEM's activities associated with its manufacture of an emergency ac power generator for P-EP. The NRC quality requirements applicable to the safety-related (Class 1E) generator P-EP procured from PEM for an NRC licensee, Pacific Gas and Electric Company (PG&E), are contained in Appendix B to 10 CFR Part 50. This relationship is discussed further in Section 3.2 below.

The team observed activities, held discussions with PEM's staff, and reviewed records and procedures. The specific areas and documentation reviewed, and the team's findings are described in Sections 3.3 through 3.6 of this report. The table, "A Comparison of PG&E's Purchase Order Revisions 1 and 3 for Critical Items and Their Critical Characteristics," located at the end of Section 3.6, provides a comparison of the critical items and their critical characteristics as expressed by PG&E in Revisions 1 and 3 of its PO to P-EP. The Appendix lists the persons who participated in and who were contacted during the inspection. During the exit meeting on September 27, 1991, the team summarized the inspection findings, observations, and concerns with PEM's management.

3.2 Background

The Pilton Works of Peebles Electrical Machines (PEM) in Edinburgh, Scotland, is a sister company of, and the manufacturer for, NEI Peebles - Electric Products, Inc. (P-EP) of Cleveland, Ohio. Both companies are subsidiaries of NEI Peebles Limited. P-EP provided the sales and services office for all of the power generating equipment manufactured by NEI Peebles Limited and sold to U.S. customers. Therefore, the background of P-EP and its relationship to PEM is important to, and an integral part of, the inspection of PEM and the inspection team's use of the NRC's requirements in Appendix B to 10 CFR Part 50 and 10 CFR Part 21 as its inspection criteria.

P-EP's facility in Cleveland, Ohio, was originally known as Electric Products Incorporated (EPI) and, under various names, supplied over 120 generators to the U.S. nuclear industry. EPI was purchased by Portec, Inc., in 1969, and was known as the Electric Products Division of Portec, Inc. Portec sold the company in 1979 to Parson Peebles, a subsidiary of Northern Engineering Industries Limited (NEI) of England. NEI is a wholly owned subsidiary of the Industrial Power Group of Rolls-Royce.

The Cleveland facility was known at that time as Parson Peebles Electric Products, Inc. (also EPI). Subsequent to Parson Peebles' purchase of the Cleveland facility, NEI reorganized its Parson Peebles operations under the name of NEI Peebles Limited and the Cleveland facility became NEI Peebles - Electric Products, Inc. P-EP's Cleveland manufacturing facility was closed in September 1984 and moved to PEM's Pilton Works in Edinburgh, Scotland. The organizational structure of NEI Peebles Limited at the time of this inspection was such that the Vice President and General Manager of P-EP reported directly to the Manager of PEM.

Since 1984, PEM has manufactured the generators and many of the spare and replacement parts that P-EP supplied to the U.S. nuclear industry. PEM recently completed the fabrication, assembly, and testing of a safety-related (Class 1E) emergency ac power generator for PG&E's new sixth (no. 2-3) emergency diesel generator (EDG) set for its Diablo Canyon Nuclear Power Plant Unit 2 (DCNPP2). At the time of this inspection, PEM was fabricating a safety-related emergency ac power generator for Washington Public Power Supply System's Nuclear Project 2 (WNP2). The generator for WNP2 was procured by PO C-30464, dated November 29, 1990 (P-EP shop order no. S-1141, serial no. 260505/1). Although the team focused its inspection activities on the completed generator for PG&E's DCNPP2, the concerns discussed in this report may have generic implications for WNP2's generator and any similar generators, or spare and replacement parts, built by PEM and supplied to P-EP to other licensees.

The NRC quality requirements applicable to PG&E's procurement of this generator for DCNPP2 are contained in Appendix B to 10 CFR Part 50. Other NRC requirements applicable to PG&E's procurement of this generator are contained in 10 CFR Part 21, "Reporting of Defects and Noncompliance," because this procurement constituted procurement of a basic component as defined in 10 CFR Part 21. General NRC technical requirements for this generator to be used as an "alternate ac power source," as defined in 10 CFR 50.2, are contained in 10 CFR 50.2, 10 CFR 50.63 (station blackout), and Criterion 17, "Electric Power Systems," and Criterion 18, "Inspection and Testing of Electric Power Systems," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50. Applicable NRC requirements related to identified licensing and design basis events (DBE), specifically, seismic qualification, are contained in Criterion 4, "Environmental and Dynamic Effects Design Bases," of Appendix A to 10 CFR Part 50.

DCNPP's five existing emergency ac power generators (serial nos. 16908022 through 16908026) installed on EDG nos. 1-1, 1-2, 1-3, 2-1, and 2-2, were procured in 1969 from the Electric Products Division of Portec, Inc., and manufactured in the Cleveland facility, described above. PG&E procured a spare generator

(serial no. 38604851) in 1986 from P-EP, specifying that it be identical (i.e., like for like) to DCNPP's five 1969 generators. PEM manufactured the 1986 spare generator in its Pilton Works in Edinburgh, Scotland.

The generator for DCNPP's new 2-3 EDG was procured by PO ZS-1539-AB-9, Revision 0, dated January 16, 1990, in which PG&E requested P-EP to supply one 4.16-kV, 2600-kW, 60-Hz, 3-phase, 8-pole, 900-rpm, single-bearing, engine-driven, ac synchronous generator. The generator was to be supplied as a design Class 1E basic component in accordance with PG&E's Engineers Material Memorandum (EMM) DC2-3322-BRH-E, Revision 0, dated January 5, 1990. In the EMM, PG&E required that the generator be identical to PG&E's 1986 spare generator and DCNPP's five 1969 generators on the basis that the previously supplied generators had already been determined to have met all applicable requirements including the NRC's quality and technical (including seismic DBE) requirements. PG&E's apparent strategy to demonstrate compliance with the requirements for safety-related equipment suitability, including DBE (seismic) and any environmental qualification requirements, was to procure the generator on the basis of a like-for-like comparison with the 1969 generators, which were presumably fully qualified.

In its acceptance of the PO from PG&E, P-EP accepted the responsibility to assure overall compliance with all the applicable provisions of Appendix B to 10 CFR Part 50 and the reporting requirements of 10 CFR Part 21. PG&E's EMM, Attachment A, "Specification for Supplier's Quality Assurance Program," Specification SP-D-Peebles (SP-D-Peebles), Revision 3, dated October 11, 1989, required in Section 1.0, "General," that the supplier's quality assurance (QA) program for supplying equipment and components comply with British Standards Institution's British Standard (BS) 5750, Part 1, "Specification for Design/Development, Production, Installation, and Servicing" (ISO 9001-1987, Quality systems - Model for quality assurance in design/development, production, installation, and servicing), Part 2, and Part 3, and that the supplier's QA program for supplying engineering services comply with Appendix B to 10 CFR Part 50 and ANSI N45.2-1971. In Section 3.0, "Quality Assurance Program (Edinburgh, Scotland)," SP-D-Peebles required that the supplier's QA program detail the procedures and methods used to ensure that all supplier's (PEM) activities satisfy the requirements of BS 5750, Part 1 (ISO 9001-1987), and Parts 2 and 3. In Section 4.0, "Quality Assurance Program (Cleveland Facility)," SP-D-Peebles required that the supplier (P-EP) ensure compliance with the applicable requirements of Appendix B to 10 CFR Part 50, ANSI N45.2-1971, and all other codes or standards

referenced in the PO. SP-D-Peebles also imposed the requirements of numerous other ANSI nuclear standards, including ANSI N45.2.11-1974. Additionally, PG&E's PO for this safety-related generator, defined as a basic component in 10 CFR 21.3, invoked the reporting requirements of 10 CFR Part 21.

P-EP adapted PG&E's technical and quality procurement specifications into its own procurement specifications, including drawings, bills of material, and material specifications. P-EP then either included or referenced its own documents in its procurement documents to PEM. P-EP audited PEM's quality program and determined that, although it was not based on Appendix B to 10 CFR Part 50, PEM's program nevertheless met the applicable requirements of Appendix B to 10 CFR Part 50. Therefore, P-EP believed that it could impose PG&E's requirements on PEM by invoking PEM's quality program. With the notable exception of 10 CFR Part 21, no other NRC requirements or PG&E requirements were formally imposed on PEM, although PG&E's list of critical items and characteristics was informally transmitted to PEM by P-EP.

PEM completed and tested PG&E's generator during January and February 1991. PEM issued a COC to PE-P on February 27, 1991, which certified that the generator (serial no. 260274/1) was designed, manufactured, inspected, and tested in accordance with its quality program and the requirements of PE-P's PO 16271. On March 1, 1991, PEM shipped the completed generator to PG&E's contractor, GEC Alsthom of Toronto, Canada, for the final assembly and skid-mounting of the EDG set and the combined testing of the diesel engine, the generator, and the EDG's auxiliary systems. As required by PG&E's PO, when the DCNPP2's generator was delivered, P-EP provided PG&E with a COC that certified that the generator was produced in compliance with Appendix B to 10 CFR Part 50 and the reporting requirements of 10 CFR Part 21. This certification was based largely on P-EP's audit and determination regarding the equivalence of PEM's quality program to Appendix B of 10 CFR Part 50. In its COC to PG&E dated March 27, 1991, P-EP certified that the generator complied with the provisions of PG&E's PO ZS-1539-AB-9 and added that the generator was the same in form, fit, and function, as the original generators supplied in 1969 (serial nos. 16908022 through 16908026).

The last NRC inspection of PEM was conducted on October 6 through 8, 1986; P-EP, however, was last inspected by the NRC on August 5 through 9, 1991. The inspection of P-EP was conducted primarily to evaluate P-EP's QA program and its implementation as it was applied to the safety-related generator supplied to PG&E. For the purposes of clarity and understanding, this report of the

inspection of PEM contains references to certain activities that were performed by P-EP or to certain concerns that were identified during the inspection of P-EP. In either case, the NRC report of the inspection of P-EP, Inspection Report 99900772/91-01, describes all references to P-EP contained herein.

3.3 P-EP's Procurement Documents Issued to PEM

P-EP issued PO 16271 (shop order no. S-1128) to PEM on January 29, 1990, for PG&E's generator. The PO specified that the generator be identical to the generator previously ordered by P-EP's PO 14673, dated February 25, 1986 (shop order no. S-1076, and job no. 259132), with some exceptions. The most significant exceptions were (1) the phase rotation was changed per Drawing C-08991U, (2) the pole insulation specification was changed from polyester resin to epoxy resin MV-20.9 per Specification EI-1.5.1, and (3) the rotor pole assembly was changed per Drawing A-66843-7, Revision 2. P-EP's PO also imposed the reporting requirements of 10 CFR Part 21 on PEM. P-EP required that NEI Peebles Limited's QA program comply with Attachment A (SP-D-Peebles) of PG&E's EMM, and provide the generator's specifications for (1) the tests to be witnessed, (2) the applicable material specifications, (3) the applicable manufacturing specifications, and (4) the documentation requirements. P-EP's PO further required PEM to provide certification that PEM's manufacturing process complied with P-EP's and PEM's drawings and PEM's QA program, Issue 5, dated December 18, 1986, which was imposed because it was applicable to PG&E's 1986 spare generator. P-EP stated that PEM's QA program was equivalent to the requirements in Appendix B to 10 CFR Part 50, as discussed above and in Section 3.4 of this report.

The original issue of P-EP's PO did not identify the generator's critical items. Although P-EP issued several change orders to its PO during the fabrication, assembly, and test of PG&E's generator, it still failed to identify the items of the generator specified as critical by PG&E. This issue is discussed further in Section 3.6.1 of this report.

3.4 PEM's Quality Assurance Program

NEI Peebles Limited's Quality Manual Volume 1, Issue 7, dated April 14, 1989 (known in this report as PEM's QMV1), delineated the QA program applicable to the overall operations of PEM and Peebles Power Transformers. The QMV1 was developed by NEI Peebles Limited to comply with the requirements of BS 5750, "Quality Systems," Part 1 (ISO 9001-1987). However, Attachment A (SP-D-Peebles) of PG&E's EMM required that the QA program for equipment and components comply with BS 5750, Part 1 (ISO-9001-1987), Parts 2 and 3.

P-EP's audits of PEM, dated September 30, 1985, and August 7 through 9, 1989, were conducted to qualify PEM as a supplier of safety-related components and parts. According to P-EP, these audits qualified PEM to supply components and parts to P-EP in accordance with PEM's QMV1, which met the applicable requirements of Appendix B to 10 CFR Part 50 as well as the reporting requirements of 10 CFR Part 21. P-EP developed an equivalency evaluation of PEM's QMV1 and concluded that the QMV1 met the requirements of Appendix B to 10 CFR Part 50. Since the requirements of Appendix B to 10 CFR Part 50 are the basis for acceptance of safety-related components supplied to the U.S. nuclear industry, the team's evaluation of PEM's QA program and its implementation was based on those requirements.

However, P-EP's reports of the 1985 and 1989 audits did not document objective evidence to substantiate that PEM's QMV1 established adequate measures to provide control over certain activities affecting the quality of safety-related components. Specifically, P-EP failed to show that PEM had measures (1) for the control of design interface activities with P-EP; (2) for the selection and review for suitability of application of material, parts, equipment, and processes; and (3) for the commercial grade dedication of items essential to the safety-related function of the generator. P-EP also failed to demonstrate that PEM's dedication activities, for critical parts procured by PEM as commercial grade, resulted in establishing reasonable assurance that the parts and the completed generator will perform their respective design and safety-related functions. This concern is discussed further in Section 3.6.3 of this report.

3.5 Design Control

Criterion III, "Design Control," of Appendix B to 10 CFR Part 50, and ANSI N45.2.11-1974, require that measures be established to ensure that applicable regulatory requirements and the design bases are correctly translated into specifications, drawings, procedures, and instructions and that design changes be subject to design control measures commensurate with those applied to the original design. Measures also shall be established for the identification and control of design interfaces and for coordination among participating design organizations including procedures for the review, approval, release, distribution, and revision of documents involving design interfaces and for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of the component.

P-EP maintained the overall engineering and design control responsibility, in addition to providing sales and services support, for the generators and other power generating equipment

procured by the U.S. nuclear industry. However, PEM's engineering and design organization performed independent design activities. The team evaluated PEM's design activities in the areas described separately below.

3.5.1 Design Basis Documentation

In its PO, PG&E required that the generator be like-for-like to its 1986 spare generator and DCNPP's five 1969 generators. The team reviewed P-EP's and PEM's control of the generator's engineering design basis that would be necessary to establish the like-for-like relationship of the new generator to the design basis of the generators previously supplied. Specifically, the team reviewed the synergistic effect of the changes that were made to the original engineering design bases since 1969 to determine what, if any, effect those changes had on PG&E's like-for-like procurement requirement.

P-EP's design basis reconciliation to the original 1969 design consisted of a drawing change review dated June 24, 1991. P-EP's review encompassed the drawings associated with PG&E's generator since 1984, including all revisions. However, P-EP's reconciliation of design changes for the generator was documented and verified only to 1984 when the manufacturing facility closed in Cleveland, Ohio. Therefore, neither P-EP nor PEM could substantiate that the new generator was like-for-like to PG&E's five existing 1969 generators.

3.5.2 Design Interface

A significant design interface existed between P-EP and PEM. Although P-EP maintained the overall responsibility for the generator's engineering and design control, PEM's engineering and design organization functioned completely independent of P-EP's organization and it performed certain independent design activities. P-EP provided its design drawings, procedures, and material specifications to PEM, and PEM's engineering organization translated them into PEM specifications, drawings, procedures, and instructions to fabricate and assemble PG&E's generator. This process also included converting dimensions and tolerances from English values to their metric equivalents.

PEM-produced documents were not reviewed or approved by P-EP before use, and PEM-initiated engineering changes were not controlled by documented procedures until December 1990. The measures established in Section 4, "Design Control," of PEM's QMV1 did not provide for adequate procedures between PEM and P-EP for the review, approval, release, distribution, and revision of documents involving their respective design interface. This deficiency appeared to have resulted from the "sister company" relationship of PEM and P-EP and the daily interface of their respective staffs. Although PEM issued

Departmental Procedure 03A004, "Processing of Engineering Change," Revision 0, dated December 17, 1990, it did not affect PEM's design interface activities during most of the fabrication and assembly of PG&E's generator.

PEM performed equivalency evaluations of its drawings, procedures, and material specifications to P-EP's drawings, procedures, and material specifications and initiated design changes, as required. The equivalency evaluations were not auditable because (1) P-EP's drawings, procedures, or material specifications were not always available for comparison to PEM's documents and (2) the documentation of the evaluations consisted of only a brief summary of the drawing, procedure, or material specifications. In its equivalency evaluations, PEM failed to adequately document (1) the critical requirements or acceptance criteria compared during the evaluation and (2) the results of the evaluation or basis that supported PEM's conclusion that the documents were equivalent to P-EP's.

Therefore, PEM failed to establish adequate measures to control its design interface activities and to demonstrate adequate design equivalency evaluations. This is Nonconformance 99901065/91-01-01.

3.6 Dedication Process

Dedication is the selection and review for and verification of suitability of application to ensure the adequacy of critical parameters (characteristics) of commercial grade items that are to be used in safety-related applications. PG&E's generator is a complex component composed of several critical parts that directly affect the ability of the generator to perform its design and safety-related functions. The credible failure mechanism or long-term degradation of the part could adversely affect the generator's ability to perform its safety-related function. PG&E was aware that its generator was actually to be manufactured by P-EP's sister company, PEM, and became involved in the dedication of certain commercial grade parts by selecting the critical parts of the generator and specifying their critical characteristics.

3.6.1 Selection of Critical Items

PG&E's PO ZS-1539-AB-9 (described in Section 3.2 of this report) was modified by Revision 1, February 2, 1990, to add Attachment F, "Critical Items Listing & Dedication Testing," to its EMM. Attachment F listed 14 critical items and their associated critical characteristics and required P-EP to verify the PG&E-identified critical characteristics for each of the 14 critical items by performing tests. PG&E further required that P-EP's verification tests and their respective acceptance criteria be furnished to PG&E for approval before the materials and parts

were installed or used. P-EP subsequently passed to PEM the responsibility for procuring seven of the items and verifying their critical characteristics. However, P-EP did this indirectly by identifying only those items it would procure and supply to PEM as safety-related items. P-EP transmitted PG&E's list of items and their critical characteristics to PEM without making it a part of or referencing it in P-EP's PO.

In its PO to PEM, P-EP identified the material specifications applicable to certain parts of the generator and required PEM to supply certificates of analysis, test reports, or certificates of conformance for those materials and parts. The material specifications specified such items as materials, identification, ordering information, approved suppliers, and storage requirements. In many cases, the material specification contained an approved suppliers list that included specific products, listed by trade name, that P-EP had approved as meeting the material specification.

The team immediately identified three concerns with these actions that were distinct from other procurement and technical issues discussed in Section 3.6.3 of this report. First, PG&E's selected critical items were not made a formal part of P-EP's PO for procurement of the generator from PEM. Second, the listed critical items (including their critical characteristics) did not correspond to P-EP's material specifications and other requirements specified in the PO. Third, P-EP did not amend its PO to PEM to address the revisions to PG&E's PO.

Revision 2 to PG&E's PO, dated February 22, 1990, addressed specific data that P-EP was to provide to enable PG&E to perform the seismic analysis of the generator.

Revision 3 to PG&E's PO, dated February 6, 1991, included significant revisions to EMM Attachment A (SP-D-Peebles), and the critical items list of Attachment F. In Attachment A, Revision 5, dated November 15, 1990, PG&E imposed numerous requirements on P-EP that were not previously imposed in Revision 3, which was included in PG&E's original PO. The most significant additions are listed below.

- Section 4.2.6(1), requirements for critical material, parts, or components procured as commercial grade items
- Section 4.2.8, requirements for the identification and control of materials and items
- Section 4.2.9, requirements for a test program to identify and document all testing required to demonstrate that items will perform satisfactorily in service

- Section 4.2.10, requirements for the control of measuring and test equipment

In EMM Attachment F, PG&E changed the list of critical items from 14 (shown in Revision 1) to 27 (in Revision 3). Several of the critical characteristics for those items that were to be verified also changed. In addition, certain subassemblies that were previously identified as critical items were divided into individual parts of the subassembly and listed separately. For example, the brushes and brush holder were listed as item 7 in Revision 1 and the critical characteristics were identified as size and shape and final generator test for resistance, material, and contact pressure. However, Revision 3 listed the brushes and the brush holder separately as items 20 and 19, respectively, and identified configuration as the only critical characteristic for both items. A comparison of the critical items and their critical characteristics, as expressed by PG&E in Revisions 1 and 3 of its PO, is provided in the table located at the end of Section 3.6.3.

P-EP's generic failure modes and effects analysis (FMEA) was applicable to all rotating electrical machinery produced and was part of P-EP's technical documentation that demonstrated a generator's compliance with the requirements of the Institute of Electrical and Electronics Engineers (IEEE) Standard 323, "Qualifying Class 1E Equipment for Nuclear Power Generating Stations," and IEEE Standard 344, "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations." The FMEA included the credible failure mode for each individual part of the generator assembly and a criticality level (see definitions below) was assigned to the part on the basis of the effect of the part's credible failure mode on the ability of the generator to perform its safety-related function.

<u>Level 1</u> - catastrophic failure (i.e., will not operate at all, extensive repair needed)

<u>Level 2</u> - severely degraded (i.e., operates far off-normal giving warning that a failure will soon occur, extensive repairs needed)

<u>Level 3</u> - degraded (i.e., operates off-normal but with adequate warning of an impending failure, repairs simple if done promptly).

<u>Level 4</u> - minor degradation (i.e., operates near-normal but gives a warning of eventual failure, situation deteriorates very slowly; repairs are simple)

<u>Level 5</u> - no effect (i.e., part does not affect operation, repairs are part of maintenance)

According to P-EP, PG&E's PO did not impose qualification of the generator to the requirements of IEEE Standards 323 or 344 and PG&E did not procure P-EP's FMEA documentation for use in the selection of critical items or their critical characteristics. P-EP also stated that the extent of its involvement in PG&E's selection of critical items and their critical characteristics was limited to only an agreement with PG&E to perform testing necessary to verify the critical characteristics of the critical items identified by PG&E in Attachment F of Revision 1 to its PO.

Both P-EP and PEM reported that they had not been involved in PG&E's selection of the critical items or their critical characteristics listed in Revision 3 of PG&E's PO. Furthermore, PG&E's generator was completed when Revision 3 was issued; therefore, neither P-EP nor PEM considered Revision 3 during its design, procurement, and manufacturing activities.

Because of the minimal involvement of P-EP's engineering organization in PG&E's selection of critical items and their critical characteristics listed in Revision 1, the team was concerned that PG&E's selected list of critical items may not have been sufficiently comprehensive to ensure that all items were included, specifically, those items with a credible failure mode or that, in a degraded condition, could adversely affect the generator's ability to perform its design and safety-related function. The team reviewed P-EP's generic FMEA and discussed the technical bases for the critical items and their critical characteristics with the engineering staffs of both P-EP and PEM to determine whether PG&E's Revision 1 list of 14 critical items, or its Revision 3 list of 27 critical items, included <u>all</u> parts that are critical to the generator's ability to perform its design and safety-related function.

According to P-EP's FMEA, the generator's two major design parameters with regard to the effects of long-term degradation and cyclic fatigue were its operating temperatures and cyclic loading or high vibration forces. On the basis of these design parameters, criticality levels 1 or 2 were assigned in the FMEA to critical items such as the stator windings, leads and their connections, rotor pole windings, roller bearings, rotor shaft, coil supports, and slip rings. From its review of P-EP's generic FMEA documentation, the team determined that PG&E's lists of critical items did not adequately envelope all of the generator's critical parts having a design or safety-related function (i.e., the slip-ring mounting sleeve insulator and the temperature and vibration indicating devices, as discussed in Section 3.5.3 of NRC's Inspection Report 99900772/91-01).

For a complex assembly such as a generator, the selection of critical items and the determination of their critical characteristics would require the involvement of both the licensee's and supplier's engineering staffs. Although in

Revision 3 of its PO, PG&E revised the introductory statement of Attachment F, in part, to state that this listing was based on discussions between the staffs of PG&E and NEI-Peebles at QA audit meetings held in Cleveland, Ohio, during December 1989 and in Edinburgh, Scotland, during October 1990, PEM and P-EP considered this interface activity to be limited to those critical items identified in Revision 1 to PG&E's PO, and they believed the interface activity was nonexistent for the critical items identified in Revision 3 of the PO. Furthermore, PEM and P-EP had completed PG&E's generator when Revision 3 was issued; therefore, Revision 3 was not considered during the design, procurement, and manufacturing activities of the generator.

Although P-EP agreed to perform the testing necessary to verify the critical characteristics of the items identified in Revision 1 of PG&E's PO as critical, P-EP did not (1) identify the items critical to the generator's ability to perform its intended safety-related function or (2) perform a technical evaluation of the items identified in Revision 1 of PG&E's PO to determine the adequacy of PG&E's list of critical characteristics. For the critical characteristics selected by PG&E, P-EP failed to demonstrate their relevance (1) to the properties or attributes of the item necessary to withstand the effects of long-term degradation, (2) to the credible failure mode of the item, and (3) to the ability of the item to perform its safety-related function. P-EP failed to substantiate that the PG&E-identified critical items included <u>all</u> parts that were required for the generator to perform its safety-related function and that the PG&E-identified critical characteristics were adequate to ensure that the part will perform its safety-related function. Consequently, an evaluation of P-EP's generic FMEA identified additional critical characteristics for certain items that were not identified or verified by PEM during its commercial grade dedication activities and were not identified by PG&E in its Revision 1 to the PO.

3.6.2 Review for Suitability

PEM and P-EP procured the critical items identified in Attachment F of Revisions 1 and 3 of PG&E's PO as commercial grade items. The critical items procured by PEM and P-EP are identified in the table at the end of Section 3.6.3. P-EP procured 7 of the 14 items listed in Revision 1 of PG&E's PO (or 10 of the 27 items listed in Revision 3) and supplied them to PEM for installation in the generator assembly. The 7 remaining critical items listed in Revision 1 of PG&E's PO (or 17 of the 27 items listed in Revision 3) were procured by PEM from its suppliers in Europe.

PEM procurement practice consisted of purchasing items from suppliers that were selected on the basis of their performance history, which was determined through the general knowledge and experience of PEM's staff. Although this procurement practice, or custom, is commonplace for European manufacturers, the NRC placed conditions on its acceptance of this method to dedicate commercial grade items. In its Generic Letter 89-02, "Actions to Improve the Detection of Counterfeit and Fraudulently Marketed Products," dated March 21, 1989, the NRC stated that supplier/item performance history was an acceptable method to dedicate commercial grade items provided (1) the established historical record is based on industry-wide performance data that is directly applicable to the item's critical characteristics and its intended safety-related application and (2) the supplier's measures to control changes in design, materials, and manufacturing processes have been adequately implemented as verified by audit.

Most of PEM's suppliers, however, were not audited to verify that their measures to control design, processes, and material changes were adequately implemented. The performance history data that were documented and verified did not establish performance data that were directly applicable to the item's critical characteristics or its intended safety-related application. For the most part, the POs to the suppliers of these items did not impose any quality and technical requirements and none imposed the reporting requirements of 10 CFR Part 21. Therefore, the critical items for PG&E's generator were procured by PEM as commercial grade from suppliers whose ability to adequately control changes in design, materials, and manufacturing processes had not been substantiated, as necessary to support the use of acceptable supplier/item performance history as an acceptable portion of PEM's commercial grade dedication activity.

3.6.3 Verification of Suitability

The team reviewed the drawings, procedures, and material specifications for the generator and examined similar components in fabrication for a comparable generator PEM was building for WNP2. In discussions with PEM staff, the team identified what appeared to be the most likely components corresponding to the PG&E list of critical items. The team reviewed the procurement documentation for the critical items procured by PEM and evaluated PEM's methods for meeting P-EP's procurement requirements. The team also evaluated the extent to which the PG&E-listed critical characteristics (as well as others) were ultimately verified by PEM. A summary of PEM's commercial grade dedication activities for a sample of the critical items specified by PG&E in Attachment F to Revision 1 and, where applicable, Revision 3 of its PO to P-EP is given below.

(1) Lead Wire (Revisions 1 and 3)

In Revision 1 of its PO to P-EP, PG&E identified lead wire (Attachment F, item 1) as a critical item and specified the critical characteristics as (1) dielectric strength, (2) number of strands, (3) the markings on the cable, and (4) the insulation thickness. However, in Revision 3 of PG&E's PO only configuration was specified as the critical characteristic for lead wire (Attachment F, item 16). PEM had specified the lead wire to be used for dc field leads (the segment from the brush-rigging to the external terminal box) without guidance from P-EP. In all the pertinent documentation provided by P-EP, the team could not identify any wire suitable for this application. The only document that may have referred to this wire specified wire of insufficient ampacity for this application. Therefore, PEM chose what appeared to be a suitable type of wire and procured it in a similar manner to other lead wire used for this generator. However, the wire was procured without apparent knowledge or consent of P-EP, and PEM did not verify the critical characteristics specified by PG&E.

(2) Magnet Wire (Revisions 1 and 3)

In Revision 1 of its PO to P-EP, PG&E identified magnet wire (Attachment F, item 4) as a critical item. This insulated copper wire is wound in a coil of turns or windings (approximately 450 for this machine) around each of eight (for this 60-Hz, 900-rpm machine) laminated steel rotor poles. Each rotor pole creates a constant magnetic field from the direct current flowing in its windings, which induces alternating current in the stator windings (coils) as each pole passes the stator windings. A prime mover (in this case the diesel engine) turns the rotor shaft, which causes relative motion between the magnetic field of the rotor poles and the stator windings, inducing generator voltage and current. The generator is synchronous because the frequency of the output voltage and current is directly proportional to the speed of rotation of the rotor.

P-EP provided the material specification for the rotor pole magnet wire to PEM in PO 16271. The P-EP PO specified that magnet coil wire be provided in accordance with P-EP Material Specification MW-25.3, "Magnet Wire - Round, Square, or Rectangular - Unvarnished Fused Polyester Glass Covering, With or Without Enamel Undercoat, Class F (155°C)," dated June 24, 1977. This version of MW-25.3 provided detailed specifications and the codes and standards to be met for the wire and its insulating system, including enamel undercoat and fibrous (dacron and fiberglass tape) covering.

PEM procured the wire from its supplier, Insulation Systems & Machines, Ltd. (ISM), by PO EM31035 (original) dated April 27, 1990. In its PO, PEM specified, "rotor copper - unvarnished double dacron glass insulated square magnet wire," and listed material specifications that corresponded to those in MW-25.3. PEM required ISM to provide test certificates for the chemical composition of copper, the conductor resistivity, and the insulation dielectric "stress" (sic) (strength). ISM subsequently ordered the material from its Italian subsupplier, UDD-FIM, by PO P-00-86-48 (original), dated April 30, 1990. UDD-FIM supplied the material to ISM with a Quality Inspection Report (test certificate) and a COC. The COC, written in French, stated that the material was *Fil de cuivre guipé 2 DAGLAS Imprégné Classe F...* (copper wire wrapped with double dacron glass, impregnated, Class F). ISM provided the wire and documentation to PEM with a COC that certified the material met the requirements of PEM'S PO. PEM accepted the wire and used it to wind the rotor poles. However, the team noted that the French word *imprégné* means impregnated and that fiber insulation material is commonly impregnated with varnish; therefore, the insulation would not have been unvarnished as specified. PEM engineers contacted ISM who confirmed that the supplied wire had been varnished.

Therefore, the wire did not meet the P-EP material specification or the PEM PO requirement for unvarnished insulation. In addition, PEM had no documented analysis addressing the use of varnished insulation tape in this application and no information from P-EP regarding the basis for the specification of unvarnished insulation. Accordingly, PEM immediately informed P-EP of the deviation. P-EP agreed to perform a deviation evaluation (pursuant to 10 CFR Part 21) regarding the varnished insulation, including an evaluation of the compatibility of the varnish with, and its effects on the adhesion properties of, the other materials (such as epoxy adhesive) used in the assembly of the rotor poles. This is Unresolved Item 99901065/91-01-01.

Although not clearly documented, PEM was assumed to be responsible for dedication of the magnet wire for the rotor (presumably because it procured the wire). PEM's documented responsibility was to verify that the wire met the material specifications cited in P-EP PO 16271, and P-EP expected PEM would verify the PG&E-identified critical characteristics as well in the course of meeting the material specification and carrying out the specified testing.

In Revision 1 of its PO to P-EP, PG&E identified the critical characteristics of the magnet wire as size and shape, resistance, and insulation dielectric strength. Although these characteristics were critical, PG&E omitted other pertinent material properties of the magnet wire, such as mechanical strength and allowable bend radius, as well as characteristics of the insulation system, such as thermal capability. These characteristics were not merely manufacturing considerations because they could affect generator reliability given the stresses involved during normal operation of the generator (let alone the additional stresses from asynchronous events, adverse extremes of the normal service environment, or a design-basis event (DBE) such as seismic excitation). Although some of these characteristics may ultimately have been addressed by P-EP's material specification and final testing, PG&E had not identified them as critical.

ISM supplied a COC attesting that the wire met the required specifications and also supplied the COC and quality inspection report (test certificate) from UDD-FIM as required by PEM PO EM31035. However, although both the COC and the test report certify that the material met all specifications, there was no basis for acceptance of the COC. PEM did not survey either supplier and did not conduct independent testing to verify the accuracy of the COC or the test report. As a result, PEM accepted and used nonconforming material. This is one of several examples of PEM accepting a COC at face value with no audits, surveys, or verification testing to verify the validity of the COC.

The revision of June 24, 1977, of MW-25.3 listed approved suppliers and the trade names of their products. The approved magnet wire was listed as being available from two approved U.S. manufacturers and described as "Armored Polythermaleze + Dacron - Glass" (as manufactured by Belden Mfg. Co.) and also as "Polythermaleze 2000 + Dacron-Glass" (as manufactured by Phelps Dodge). Although PEM used one of these approved types of magnet wire, it obtained the wire through its regular supplier, ISM. ISM, in turn, procured the wire from a company in Italy called UDD-FIM who manufactured it under license from Phelps Dodge. However, PEM did not specify the material by trade name in its PO to ISM, which may have contributed to receiving the wrong material.

PEM prepared an engineering change note (ECN) to obtain P-EP approval to obtain the material specified in MW-25.3 from an alternate supplier to ensure conformance with QA requirements. However, the ECN was not prepared until November 15, 1990, nearly 7 months after the order had been placed with ISM and well after the wire had been received by

PEM. Nonetheless, P-EP replied that no addition to the material specification was required because the trade name was specifically identified on the material specification. Although PEM considered this response an approval, P-EP's reply was an inappropriate response because P-EP effectively abdicated its design control responsibility in granting what was tantamount to blanket supplier selection authority on the sole basis of the product's trade name.

(3) Lead to Coil Terminations (Revision 1)

In Revision 1 of its PO to P-EP, PG&E identified the lead to coil terminations (Attachment F, item 11) as critical items and specified the critical characteristics as brazing and weld materials. Revision 3 of PG&E's PO did not include the lead to coil terminations as critical items, although PEM's engineering staff agreed with the team that the lead to coil terminations were critical. Moreover, PEM pointed out that all connection and termination joints were critical to the generator's ability to perform its design and safety-related function.

The completed generator assembly contains several connections and terminations that can be classified into one of the following three types:

- brazed, high-temperature silver-solder joints that connect the magnet wires of the rotor poles to cable leads

- overlapped compression joints that connect copper conductors to copper conductors (e.g., the stator coil windings to other stator coil windings and the stator coil windings to the copper conductors of the parallel rings) or copper conductors to cable leads (e.g., the copper conductors of the parallel rings to the cable leads that run to the generator's main terminal box)

- crimped joints that connect cable leads to lugs (e.g., ring-tongue terminals used for bolted terminations)

PG&E identified the lead to coil terminations as critical items with critical characteristics listed as brazing and weld materials, even though weld materials are not used to perform brazing operations. PEM used brazed connections only to connect the magnet wires of the rotor poles to cable leads that run along the surface of the rotor shaft to the slip-ring assembly. However, PG&E did not identify the generator's other connections and terminations as critical items, even though PEM considered them to be critical.

PEM did not establish a documented procedure to control the high-temperature silver-solder brazing operation. PEM, however, did have skilled craft with several years of experience to make the brazed joints. PEM failed to document (1) qualification of the brazing materials and methods used, (2) inspection of the brazed joints, or (3) verification that the joints were adequate and met expected quality and technical requirements.

To control the overlapped compression joints in the stator assembly, PEM developed Procedure R 6081, "Compression Jointing of Copper Conductors Within a Stator Winding Using AMP Products," dated November 20, 1990. PEM prepared trial joints for the overlapped compression joints that connect the stator coil windings to each other and the stator coil windings to the parallel ring to establish the fabrication parameters for the same type of compression joints to be performed during the manufacturing of the generator. However, PEM failed to document the results of the test and inspection of the qualifying trial joints. PEM also failed to document objective evidence of any inspection or verification to ensure that the joints made during fabrication were adequate and met expected quality and technical requirements.

PEM did not establish a documented procedure to control the crimped joints that connect the cable leads to ring-tongue terminal lugs that form bolted connections (1) at the terminal box for the cable leads that run from the stator's parallel rings, (2) at the slip-ring assembly for the cable leads that run along the rotor shaft from the rotor poles, and (3) at the brush-rigging assembly and the field terminal box for the cable leads that connect those two items. In addition, PEM failed to document objective evidence of its inspection or verification of the crimped joints to ensure that the joints were adequate and met expected quality and technical requirements.

(4) <u>Roller Bearing</u> (Revisions 1 and 3)

In Revision 1 of its PO to P-EP, PG&E identified the roller bearing (Attachment F, item 12) as a critical item and specified the critical characteristics as size and type, visual inspection (the team noted that this PG&E-identified characteristic is not a valid critical characteristic of the roller bearing), catalog number, and tolerances. However, in Revision 3 of its PO, PG&E specified the roller bearing's (Attachment F, item 6) critical characteristics as part number and configuration.

PEM issued a PO to its supplier, FAG (UK) Limited, for the roller bearing and specified, "spherical roller bearing, cat. no. 22226-C3, SKF or equiv." FAG issued a COC, dated September 14, 1990, to PEM for the roller bearing certifying that the roller bearing supplied (catalog no. 22226EAS-M-C3) was equivalent to the SKF-22226-C3 ordered. The difference in design between the two bearings was that the bearing ordered had a steel cage and the bearing supplied and installed had a forged cage. PEM evaluated the difference and determined that the roller bearings were equivalent.

Even though the spherical roller bearing was procured as a commercial grade item from a supplier that had not been audited, PEM accepted the COC for the bearing, as was its custom, and performed a receipt inspection. The results of the receipt inspection documented acceptance of the bearing after verification of the catalog no. and visual inspection for damage.

(5) Rotor Shaft (Revisions 1 and 3)

In Revision 1 of its PO to P-EP, PG&E identified the rotor shaft (Attachment F, item 13) as a critical item and specified the critical characteristics as "require dedication by factory test" without specifying what should be included in the test. However, in Revision 3 of its PO, PG&E specified the rotor shaft's (Attachment F, item 1) critical characteristics as material, configuration, and integrity.

In its PO to PEM, P-EP required that the rotor shaft forging comply with Material Specification MS-70.42, "Shaft Forging, Carbon Steel (Not Recommended for Welded Lands) Used for All Flanged Shafts and All Shafts Over 10-Inch Diameter," dated November 10, 1972. MS-70.42 specified the shaft material comply with American Society for Testing and Materials (ASTM) A-470, Class 1, "Vacuum-Treated Carbon and Alloy Steel Forgings for Turbine Rotors and Shafts." However, P-EP's Drawing C-67400-1, "Shaft, Single Bearing, Forged, Flanged for Alco Engine," Revision 7, dated November 19, 1990, specified that the shaft material comply with ASTM A-292, Class 1. The team determined that ASTM A-292 was superseded by ASTM A-469, "Vacuum-Treated Steel Forgings for Generator Rotors," and that P-EP Drawing C-67400-1 had not been revised to reflect ASTM A-469 for generator rotor shafts instead of the obsolete A-292 specification. The issue of concern is that PEM did not document a reconciliation of the apparent conflict between the material specified in the drawing and the material specified in

MS-70.42. Neither PEM nor P-EP documented the basis or rationale for ordering the generator's rotor shaft to a material specification intended for turbine rotors and shafts (ASTM A-470) as opposed to the material specification for generator rotors (ASTM A-469).

ASTM A-469 required a permeability test of the rotor shaft be performed in accordance with ASTM A-341, "Test Method for DC Magnetic Properties of Materials Using DC Permeameters and the Ballistic Test Methods," or ASTM A-773, "Test Method for DC Magnetic Properties of Materials Using Ring and Permeameter Procedures with DC Electronic Hysteresigraphs." ASTM A-470 did not require a permeability test of the rotor because the specification was intended for turbine rotors. Moreover, a permeability test was not performed or documented in PEM's inspection records for the rotor shaft. Neither P-EP nor PEM evaluated the necessity to determine the rotor shafts permeability; therefore, the proper material and its characteristics were not adequately verified by PEM.

PEM ordered the rotor shaft from La Forgia di Bollate s.p.a. of Milan, Italy. PEM's PO specified "shaft forging to Drawing B-67405-1, to be rough turned condition, material spec: ASTM A-470-77, Class 1, also BS-970 080 M40," even though PEM did not document an equivalency evaluation between ASTM A-470-77, Class 1, and BS-970 080 M40. La Forgia di Bollate issued its COC, dated December 6, 1990, to PEM and certified that the rotor shaft complied with PEM's Drawing B-67405-1 and Material Specification BS-970 080 M40. The COC also certified the shaft was nondestructively examined (NDE) according to the requirements of ASTM A-418, "Ultrasonic Inspection of Turbine and Generator Steel Rotor Forgings," and reported that "no noteworthy defect was found, positive results." The shaft was shipped to Weir Engineering Services, Alloa Works, located in Alloa, Scotland, where PEM procured the final shaft machining in accordance with Drawing C-67400-1. Weir Engineering Services issued a COC to PEM that certified that the shaft had been inspected and conformed to Drawing C-67400-1. PEM performed a dimensional verification of the shaft to Drawing C-67400-1 during receipt inspection to ensure the configuration characteristic of the rotor shaft.

The only NDE performed on the rotor shaft was an ultrasonic (UT), straight beam, examination, which may not detect shallow internal discontinuities (i.e., cracks or tears and bursts that occur during the processing of ingots or billets) immediately below the surface of the rotor shaft. Although PG&E identified integrity as a critical characteristic of the rotor shaft, PEM did not perform a magnetic particle (MT) examination, which would detect these

discontinuities, even though certain conditions peculiar to forgings require the use of more than one NDE method to provide reasonable assurance of the integrity of the rotor shaft forging.

(6) Stator and Rotor Core (Revision 1)

In Revision 1 of its PO to P-EP, PG&E identified the stator and rotor core as a critical item (Attachment F, item 14) and specified their critical characteristic as factory testing (electrical losses). However, in Revision 3 of PG&E's PO the stator core and rotor pole were omitted as a critical item and stampings was identified (Attachment F, item 2) with the critical characteristics of configuration and material. The stator core and rotor pole stampings are addressed separately below.

- Stampings (Stator Core) (Revision 3)

In PO 16271 to PEM, P-EP specified that stator core stampings (electrical steel) be provided in accordance with P-EP Material Specification MS-70.77, "Steel-Electrical Sheet - Fully Processed." The February 14, 1991, revision of MS-70.77 allowed core steel material for machines built by PEM to be purchased according to PEM Specification R 8046, "Electrical Core Steel For Rotating Machines, Coated On Both Sides With An Insulating Resin Or Varnish," and stated that "Grade 310-50-A5... is universally acceptable under MS-70.77."

PEM procured the material from Joron Steel by PO EM31024 (original estimated date February 1990). PEM's PO specified "stator core steel to purchase standard R 8046, Grade 310-50-A5" and required test certificates for the chemical composition of steel and insulation resistivity.

Joron procured the steel from EBG in Germany. EBG provided a test report indicating the steel core loss, but not the chemical composition or insulation resistivity. Joron subsequently provided the test report to PEM with some additions (coils numbers, contract number, and purchase order number).

Although PEM specified testing for both chemical composition and insulation resistivity in its PO to Joron, it accepted the material without either of those tests being performed. This is another example of PEM accepting material from a supplier who has not met the PO requirements without generating a discrepancy report. In addition, although Revision 1 of the PG&E PO required

factory testing for electrical losses, PEM did not pass this on to its supplier. Even though EBG provided the results of the factory test for electrical losses to PEM through Joron, there is no basis for accepting the EBG test report because PEM did not audit its suppliers.

- Stampings (Rotor Pole) (Revision 3)

  In its PO to PEM, P-EP specified that rotor pole stampings (pole iron) be provided in accordance with P-EP Material Specification MS-70.38, "Steel - Hot Rolled Pole Steel." The February 14, 1991, revision of MS-70.38 allowed rotor pole steel material for machines built by PEM to be Tensiloy 250.

  PEM issued PO EM31042 to British Steel Corporation requesting Tensiloy 250 steel. The PO required test certificates for chemical composition, mechanical properties (tensile, yield, percent-elongation), and dc permeability.

  Although Revision 1 of PG&E's PO identified "losses" (presumably referring to ac hysteresis) as a critical characteristic, PEM recognized that to be inappropriate for dc rotor pole stampings, even though it did not notify P-EP, because the critical characteristic of rotor pole stampings are mechanical and dc permeability. Thus, even though PEM did not pass on the "losses" requirement to its supplier, PEM did specify the correct critical characteristics. PEM's supplier, British Steel Corporation, did supply a certificate of magnetic testing (dc permeability) that identified the product as Tensiloy 250 and provided results of mechanical and dc permeability testing. Chemical composition of the steel was not provided. Again, PEM accepted the test certificate without an adequate basis since no audits of British Steel Corporation had been performed.

(7) Stator Resistance Temperature Detectors (Revision 1)

In Revision 1 of its PO to P-EP, PG&E identified the stator resistance temperature detectors (RTDs) as critical items, but P-EP did not invoke or provide a material specification for the RTDs. However, P-EP PO 16271 to PEM included, in the description of the generator, "6 embedded 10-ohm detectors," which indicated that P-EP supplied the RTDs to PEM for PG&E's generator. However, PEM issued PO JA30241 (original) (date not discernible on copies) to Carel Components Ltd. for "8 ea stator winding resistance temp detectors 10-ohms at 25°C, 3 wire 6-inch lg x 11/32-inch wide x 0.50-inch thk," which showed that PEM had procured

the RTDs that were actually installed in the generator. Carel subsequently procured the RTDs from its subsupplier, Minco Products, Inc. Although the original PO from PEM did not specify the insulation material, PEM modified its PO in a telex to Carel, dated March 28, 1990, which Carel acknowledged by letter dated March 29, 1990. The modification specified the Minco part number in accordance with the catalog description. The Minco part number identified the model number (including element type, insulation class and thickness, and lead wire size), length, lead wire insulation, width, number of lead wires, and lead wire length. PEM did not require a COC from Carel in its original or revised (by telex) PO.

Revision 1 of the PG&E PO inadequately identified the critical characteristics of the stator RTDs as only size and shape; Revision 3 did not identify the stator RTDs as critical items at all. Although Revision 1 of the PG&E PO did require a shop test for RTD continuity, resistance (but no associated temperature), and insulation, PEM identified none of these characteristics to Carel in PO JA30241. The RTDs were shipped by Minco on May 4, 1990, and were received by PEM on May 15, 1990. According to the PEM record of a telephone conversation of September 14, 1990, to Carel, PEM requested a COC for the RTDs. Minco issued a COC (undated) to Carel, which was then provided to PEM certifying that the RTDs met the specifications as defined by the PO (i.e., part number). PEM performed its standard receipt inspection, verifying dimensions and shop testing for insulation resistance. In addition, PEM stated that its standard practice was to test RTDs during stator winding and also during testing of the completed generator. However, PEM test records did not indicate the expected values and tolerance for the RTD resistance with regard to temperature and the temperature at which the RTD resistance was measured was not recorded. Therefore, it was difficult to determine if the measured value was within the expected range.

PEM receipt inspectors did not always have all applicable documents available. PEM receipt inspectors were supposed to verify that incoming materials met the PO specifications by checking the delivered material against a copy of the PO. In this case, the PO was changed by telex to specify a part number and the receipt inspector was not provided a copy of the change notification. Therefore, the receipt inspector was not able to verify that the correct part number was received. Checking against the PO could have led to accepting incorrect material because Minco provides 2 different classes of RTDs that are identical except for the body material and the PO did not specify body material.

In addition, even though PEM had completed PG&E's generator before Revision 3 was issued and reported that Revision 3 was not considered during the design, procurement, and manufacturing activities of the generator, PEM acknowledged that certain items specified in Attachment F of Revision 3, although not listed in Attachment F of Revision 1, had been considered critical to the generator's ability to perform its intended design and safety-related function and, therefore, included in PEM's commercial grade dedication and verification activities. The team's review of a sample of these critical items is given below.

(1) Stator Coils (Revision 3)

Although Revision 1 of PG&E's PO inappropriately omitted the stator coils as critical items, Revision 3 did identify stator coils (Attachment F, item 15) as critical items with critical characteristics of configuration, chemical composition, and coating insulation. Nevertheless, in PO 16271 to PEM, P-EP invoked material specification MW-25.5 for the stator coil magnet wire. The MW-25.5 revision dated May 10, 1982, "Magnet Wire - Round, Square, or Rectangular Class H (180°C)," provided detailed specifications, including codes and standards to be met for the copper wire, enamel first insulation coating, and packaging. ANSI Standard C7.9 (for square or rectangular soft or annealed copper wire) and ASTM B-3 (for soft or annealed copper wire) were among the standards called for. In addition, MW-25.5 listed approved suppliers and the trade names of their products to meet the material specification. One approved magnet wire of the type available to PEM was listed in MW-25.5 as "Polythermaleze 2000," manufactured by Phelps Dodge.

PEM procured the stator magnet wire from its supplier, ISM, by PO EM31003. In its PO, PEM appropriately specified the material by trade name as well as by description (stator copper 0.256-inch-wide x 0.102-inch-thick insulated with polythermaleze 2000 enamel). The PO listed material specifications corresponding to those specified in MW-25.5 with the exception of ASTM B-3, which was not contained in any of the other specifications listed.

PEM (PO EM31003) required (1) a test certificate for chemical composition of copper, electrical resistivity, and insulation dielectric strength and (2) a COC attesting to conformance with the National Electrical Manufacturers Association, Standard Publication MW1000, "Thermal Classification and Insulation Voltage Withstand Level for the Type of Wire Specified." ISM subsequently supplied the

material to PEM with a test certificate from ISM's subsupplier, SAFI-CONEL, and an ISM COC. However, PEM could produce no documentation that could connect the SAFI-CONEL test certificate to the PEM purchase order.

Although Revision 3 to PG&E's PO was issued less than 1 month before the generator was shipped, P-EP passed it on to PEM, and PEM tried to dedicate the stator coil wire in accordance with the new revision. However, PG&E inadequately listed the critical characteristics of the stator coils as configuration, chemical composition, without specifying particulars for the latter two. PEM's dedication methodology, apart from final testing, consisted of invoking P-EP's material specifications through PO requirements for its supplier, but the material and/or documentation received did not always meet these requirements.

PEM PO EM31003 to ISM required a test certificate indicating the chemical composition of the copper, electrical resistivity, and insulation dielectric strength. ISM supplied a COC attesting that the wire met the required specifications and also supplied a test certificate from SAFI-CONEL, but the test certificate addressed only the insulation dielectric strength. PEM apparently had not received any test certificates indicating the chemical composition of the copper or the insulation resistivity, and there was no documented basis for acceptance of the COC. PEM had not surveyed ISM or SAFI-CONEL and did not provide independent testing to verify the accuracy of the COC or the test report.

PEM maintained that it should not be held responsible for inadequate dedication of an item after the fact. The team determined that, although PEM accepted and used the stator coil wire without an adequate COC and test report, this did not constitute a deviation from the P-EP PO or the PG&E PO because Revision 1 to the PG&E PO did not specify the stator coil wire as a critical item and Revision 3 was issued well after the generator had been assembled.

However, of greater concern to the team were the issues of controlling and surveying suppliers, identifying nonconforming material, and holding suppliers accountable for nonconformances. At the time of the inspection, PEM was not in the practice of auditing or surveying its suppliers; therefore, its basis for accepting COCs from its suppliers was inadequate. In addition, PEM accepted and used material for which the COC certified that PO requirements had been met when, in fact, the requirements had not been met. In the stator coil procurement, the material supplier certified

that PO specifications were met but did not furnish test certificates as required by the PO. PEM neither held the supplier (ISM) accountable nor documented this as a supplier noncompliance for future reference.

The team's tour of the material receiving area, review of documents, and interviews with PEM personnel generally supported PEM's claim that it inspected all incoming material for compliance with PO requirements. Nonconforming material was quarantined until the engineering staff determined disposition. If PEM's engineering staff determined the material to be unacceptable, it would be rejected (returned to the supplier) and a discrepancy report would be prepared. Discrepancy reports were to be reviewed on a routine basis to evaluate supplier performance. If, however, the material were to be evaluated by PEM's engineering staff as acceptable as is, no discrepancy report would be issued, even if the material (or the documentation) did not meet all the PO requirements. However, this practice, with regard to discrepancy reports, would not identify and track the performance of vendors who may occasionally, or even routinely, provide marginally acceptable materials or incomplete or inadequate documentation.

(2) Bearing Bracket (Revision 3)

In its PO to P-EP, PG&E identified the bearing bracket (Attachment F, item 4) as a critical item and specified its critical characteristics as configuration and material. PG&E's generator was a single bearing design. One end of the generator's rotor shaft was supported by a spherical roller bearing and bearing bracket assembly while the other end of the rotor shaft was flanged for mounting to the diesel engine.

PEM Drawing RA-14896, "Non-Drive End Roller Bearing Bracket Kit," Revision 0, dated February 16, 1990, was the design drawing for the bearing bracket assembly. The assembly consisted of (1) a spherical roller bearing, (2) the bearing bracket hub, (3) the bearing seal, (4) the bearing cover, and (5) the insulation ring.

The bearing bracket hub (part no. 30767-0274, Drawing B-66863-1) was a welded assembly of two concentric machined rings. The inside diameter (ID) of the inner ring of the bearing bracket hub abutted the outside diameter (OD) of the roller bearing and held the roller bearing in place, laterally, on the rotor shaft. This ring was machined with ports to lubricate (grease) the bearing. Welded to the OD of the inner ring was a mounting ring, with a smaller

L-shaped cross section attached to the inner ring by a continuous 3/8-inch fillet weld on both sides. The mounting ring was drilled to accommodate eight bolt holes, equally spaced circumferentially.

PEM procured this fabricated assembly from its supplier as a commercial grade item. PEM Material Specification MS-70.14 specified that the material for both rings comply with BS-4360, Grade 43A. However, the supplier did not provide PEM with a COC for the material or the fabrication. Although PEM's receipt inspection appeared to consist of a visual inspection for workmanship, the results of the inspection were not documented. In addition, PEM failed to specify any NDE of the continuous fillet welds that form critical load-bearing members of the support assembly of the bearing-end of the rotor shaft.

The insulation ring (Drawing A-64934-A) provided the electrical separation between the bearing bracket assembly and the generator frame. The ID of the 0.437-inch-thick (± 0.010-inch) insulation ring was fitted over a portion of the L-shaped mounting ring on the bearing bracket hub. The OD of the insulation ring appeared to be larger than the OD of the mounting ring and, therefore, the insulation ring stood proud of (extended beyond) the mounting ring. This configuration required the insulation ring to abut directly to the generator frame in such a way that it appeared to constitute a load-bearing component part of the support assembly for the bearing end of the rotor shaft. PEM's Material Specification MI-5.3, specified the material for the insulation ring as C.B. Bakelite. The insulation ring also was drilled to accommodate eight bolt holes, equally spaced circumferentially, that aligned with the bolt holes in the mounting ring. The eight bolts (5/8-inch hex-head) placed through the holes in the mounting ring and the insulation ring were attached to the generator frame and formed the supporting attachments for the bearing end of the generator.

PEM procured the fabricated (ID and OD cut to size and the bolt holes drilled) insulation ring from its supplier as a commercial grade item. However, the supplier did not provide PEM with a COC for the material or the fabrication. Although PEM's receipt inspection appeared to consist of a visual inspection for workmanship, the results of the inspection were not documented. Neither P-EP nor PEM demonstrated an engineering basis for the design of the insulation ring in combination with the mounting ring of the bearing bracket hub, which used the insulation ring as a load-bearing component part of the support assembly of the bearing end of the rotor shaft.

Therefore, PEM's inspection or verification of the commercial grade bearing bracket hub and insulation ring failed to demonstrate reasonable assurance that the parts were adequate and met expected quality and technical requirements.

Although not specifically a component part of the bearing bracket assembly, the brush-rigging was attached to the bearing bracket assembly by using a threaded stud. To form the electrical separation between the brush-rigging and the bearing bracket assembly (and, therefore, the rotor shaft), the stud was installed inside a mounting tube insulator. The material for the mounting tube insulator was specified in Drawing A-18405 as Grade X Spaudite Bakelite. PEM agreed that the tube insulator was a critical item, even though no critical characteristics were identified by either PG&E or P-EP and PEM did not perform any dedication activities to ensure that the tube insulator met expected quality and technical requirements.

(3) Stud/Threaded Rod (Revision 3)

In its PO to P-EP, PG&E identified the threaded rod studs (Attachment F, item 5) as critical items and specified their critical characteristics as dimensions, material, and welding. The generator's rotor spider assembly was formed by steel stampings that were laminated together and fitted concentric over the rotor shaft. The rotor spider assembly was designed with eight, equally spaced, dovetail grooves, which were used to mount the eight rotor pole assemblies. The rotor spider stampings were produced with penetrations to accommodate eight threaded rod studs. The studs were placed through the laminated stamping penetrations and extended the entire axial length of the rotor spider assembly. The exposed threaded ends of the studs were fitted with nuts, which were torqued to compress the rotor spider lamination and hold the assembled stampings together. When the proper compression of the rotor spider lamination was achieved, the nuts were tack welded to the studs to prevent loosening.

The threaded studs (Drawing A-66668-G 354, Revision 3, dated June 11, 1980) were 7/8-inch-diameter x 35-1/2 inches long, and 3-inches of each end were threaded with UNC-2A threads. The material for the studs was specified as ASTM A-108 and the minimum yield strength was required to be 72000 psi, even though the material actually used by PEM was BS-970, Grade 605 M36, Condition T. Although PEM's supplier furnished a COC that the stud material complies with BS-970, Grade 605 M36, Condition T, the COC did not provide the yield or tensile strength values for the material. PEM, in conjunction with P-EP, performed an equivalency

evaluation of the material specified, compared the material actually used, and determined the material was acceptable, even though the technical basis to support that determination was not adequately documented.

Although the threaded studs were procured as commercial grade items from a supplier that had not been audited, PEM accepted the COC and performed a receipt inspection. The material for the nuts (7/8-inch x UNC-2A thread) was not specified and a COC for the commercial grade nuts was not included. PEM's receipt inspection appeared to consist of a visual inspection for workmanship; however, the results of the inspection were not documented. PEM also failed to document objective evidence of its inspection or verification of (1) the torque pressure applied to the nuts to compress the spider stamping assembly and (2) the tack welds that joined the nuts to the threaded studs.

(4) Spider End Rings (Revision 3)

In its PO to P-EP, PG&E identified the spider end rings (Attachment F, item 7) as critical items and specified their critical characteristic as configuration. The generator's spider end rings (one on each end of the rotor spider assembly) consisted of a head ring with eight mounting-lug ribs welded in an equally spaced configuration that extended radially from the axis of the head ring.

PEM Drawing B-66865, "#408 Pole Rotor Spider Head," Revision 4, dated February 6, 1970, prescribed the assembly of the head ring and the eight mounting-lug ribs. The ID of the head ring was concentrically fitted over the rotor shaft and abutted the spider stamping assembly. The OD of the head ring was smaller than the circumference formed by the eight threaded studs that held the spider stampings in a compressed assembly. Each head ring was produced with eight penetrations, equally spaced circumferentially to accommodate the eight rivets that extended through the spider stamping assembly and were welded to the head rings on each end. Eight mounting-lug ribs were attached to each head ring (1/4-inch fillet welds on each side of the mounting-lug ribs) in an equally spaced arrangement so that the ribs extended radially from the rotor's axis. The mounting-lug ribs were drilled and tapped to accommodate the bolted attachments of the rotor end ring and the generator's fan assembly.

PEM procured the spider end rings from its supplier as commercial grade fabricated assemblies. Although PEM's supplier provided a COC for the spider end rings, the COC failed to address NDE or visual inspection of the mounting-lug attachment welds, which form the critical load-bearing members of the support assembly for the generator's fan assembly. PEM's receiving inspection appeared to consist of a visual inspection for workmanship; however, the results of the inspection were not documented.

(5) Short Circuit Bars (Revision 3)

In its PO to PEM, P-EP specified that damper bars (short circuit bars or rotor bars) of hard oxygen free copper be provided in accordance with P-EP Material Specification MC-80.6, "Copper - Hard Drawn Oxygen Free or Deoxidized - Bar Rods and Shapes." However, the MC-80.6 revision of February 14, 1991, allows damper bars to meet BS-1433, Grade 103C.

Therefore, PEM issued PO JA30274 to Thomas Bolton & Johnson Ltd. for, "copper rods 1/2-inch dia. X 34-inch lg to conform to ASTM B-187 high conductivity round bar to BS-1433, 1970, hard drawn, designation C103." The PO required test certificates for chemical composition, tensile strength, percent elongation, and conductivity, hardness, and embrittlement tests.

Revision 3 of PG&E's PO identified the short circuit bars (damper bars) as critical items with critical characteristics of configuration and material. Bolton provided the material to PEM with a test certificate specifying all applicable requirements. Once again, PEM accepted the COC from Bolton without an adequate basis.

(6) Rivets (Revision 3)

In its PO to P-EP, PG&E identified the rivets (Attachment F, item 13) as critical items and specified their critical characteristic as configuration. The eight rivets were placed through the rotor spider assembly and extended its entire axial length. The ends of the rivets penetrated the head ring of the spider end ring assembly and were chamfered to facilitate performing a groove weld that joined the rivet to the head ring of the spider end ring assembly.

PEM Drawing RE-1734, dated November 15, 1990, prescribed the details for the 7/8-inch-diameter x 35-5/8 inches long rivets made from material complying with BS-970, PT1 (1983), Grade 605 M36, Condition T. PEM, in conjunction with P-EP, performed an equivalency evaluation of the material specified, compared the material actually used, and

determined that the material used was acceptable, even though the technical basis to support that determination was not adequately documented. PEM's receiving inspection appeared to consist of a visual inspection for workmanship; however, the results of the inspection were not documented. PEM failed to specify any NDE examination of the groove welds that attach the rivets to the head ring of the spider end ring assemblies, which form load-bearing members of the support assembly for the generator's fan assembly.

(7) Stator Frame (Revision 3)

In its PO to P-EP, PG&E identified the stator frame (Attachment F, item 18) as a critical item and specified the critical characteristic as configuration. The stator frame formed the structural support for the stator and the completed generator assembly.

P-EP Drawing D-66825-1, Revision 3, dated November 17, 1970, described the construction details of the stator frame. Although P-EP's stator frame drawing was furnished to PEM, PEM's engineering staff found the drawing to be unacceptable for construction use. Specifically, PEM found that portions of the stator frame drawing were too difficult to read and properly interpret and noted that the drawing did not specify certain critical fabrication details, such as the length and pitch of the increments of intermittent fillet welds that join structural members.

P-EP's drawing, which was originally prepared by the Electric Products Division of Portec, Inc., specified the structural details of the stator frames in PG&E's five existing 1969 generators, which were qualified with respect to DCNPP's seismic requirements. PG&E required the new no. 2-3 generator to be identical to PG&E's 1986 spare generator and DCNPP's five 1969 generators in an apparent attempt to demonstrate compliance with the requirements for safety-related equipment suitability, including seismic and any environmental qualification requirements. However, PEM's new drawing consisted of some design changes from the original drawing in areas where the original was not clear or the details were not specified and, therefore, constituted changes to the original design.

PEM's new drawing for the frame was not reviewed and approved by P-EP and no evaluation was performed or documented to establish that the new drawing of the frame design was identical to the frame design of the previous frames supplied to PG&E. Fabrication of the stator frame to PEM's new drawing did not ensure that the stator frame was identical to the original seismically qualified 1969 stator frames.

PG&E selected and specified the critical items and their critical characteristics for its generator, and P-EP agreed to perform the tests necessary to verify the specified characteristics. However, P-EP supplied the generator to PG&E as a basic component that complied with the quality requirements of Appendix B to 10 CFR Part 50 and, therefore, was responsible for establishing reasonable assurance that the generator and its critical items will perform their respective design and safety-related functions. Therefore, P-EP failed to identify all of the design critical characteristics of the critical items (i.e., the properties or attributes that are essential for the item's form, fit, and functional performance) and P-EP did not demonstrate its bases for determining that the critical characteristics specified by PG&E were relevant to the critical item's (1) credible failure modes, (2) ability to perform its safety-related function, and (3) properties or attributes necessary to withstand the effects of long-term degradation and cyclic fatigue.

PEM failed to demonstrate that its dedication activities for critical items procured as commercial grade resulted in establishing reasonable assurance that the generator and its critical items will perform their respective design and safety-related functions. PEM procured the critical items for PG&E's generator as commercial grade from suppliers whose ability to adequately control changes in design, materials, and manufacturing processes had not been substantiated, as necessary to support the use of acceptable supplier/item performance history as an acceptable portion of its commercial grade dedication activity. Apart from final testing, PEM's dedication methodology consisted largely of imposing the material specification requirements on its suppliers and then verifying conformance of the material to those material specifications. Verification methods included basic receipt inspection and review of the suppliers' documentation, which was typically accepted without verification of its validity through audits or surveys of the supplier, as is common practice among European businesses. However, there were instances in which PEM accepted material through engineering resolution without the supplier having supplied all the documentation specified in the PO.

PEM failed to demonstrate reasonable assurance that the critical items and their critical characteristics chosen by PG&E were adequately verified during the commercial grade dedication and verification activities to ensure (1) that the critical items and the generator will perform their safety-related function and (2) that the critical items have the properties or attributes necessary to withstand the effects of long-term degradation or cyclic fatigue. This is Nonconformance 99901065/91-01-02.

TABLE

A Comparison of PG&E's Purchase Order Revision 1 and 3 for Critical Items and Their Critical Characteristics

ITEMS PROCURED BY PEM:

Critical Item	PO Revision	Attachment F	Critical Characteristics
Lead wire	1	Item 1	• Dielectric strength • Number of strands • Marking on cable • Insulation thickness
	3	Item 16	• Configuration
Magnet wire	1	Item 4	• Size and shape • Resistance • Insulation • Dielectric strength
	3	Item 3	• Material • Insulation • Dielectric strength
Copper bus (in terminal box)	1	Item 10	• Size • Resistance • Silver plating
Lead to coil terminations	1	Item 11	• Brazing • Weld materials
Roller bearing	1	Item 12	• Size/type • Visual inspection • Catalog number • Tolerances
	3	Item 6	• Part number • Configuration
Shaft/casting	1	Item 13	• PEM test
	3	Item 1	• Material • Configuration • Integrity

Critical Item	PO Revision	Attachment F	Critical Characteristics
Stator and Rotor core	1	Item 14	PEM test (losses)
Stampings	3	Item 2	• Configuration • Material
Stator coils	3	Item 15	• Configuration • Chemical composition • Coating insulation
Bearing bracket	3	Item 4	• Configuration • Material
Stud/threaded rod	3	Item 5	• Dimensions • Material • Welding
Spider end rings	3	Item 7	• Configuration
Pole end rings	3	Item 8	• Configuration • Material
Short circuit bars (damper bars)	3	Item 9	• Configuration • Material
Pole head	3	Item 10	• Configuration
Tapered keys	3	Item 11	• Configuration • Material • Hardness
Rotor wedge	3	Item 12	• Material
Rivets	3	Item 13	• Configuration

Critical Item	PO Revision	Attachment F	Critical Characteristics
Insulating washers	3	Item 14	• Configuration • Material • Dielectric strength
Stator frame	3	Item 18	• Configuration
ITEMS PROCURED BY P-EP:			
Insulators (5-kV in terminal box)	1	Item 1	• Dielectric strength • Size and weight
	3	Item 22	• Dielectric strength • Configuration
Insulating bushings (lead wires through motor case)	1	Item 3	• Size and shape
	3	Item 24	• Configuration
Insulating material (sheets, tape, & rings)	1	Item 5	• Thickness
	3	Item 26	• Thickness
Bearing seals (felt)	1	Item 6	• Thickness and shape • Texture
	3	Item 23	• Configuration • Texture
Brushes and Brush Holders	1	Item 7	• Size and shape • Final generator test: resistance, material, and contact pressure

Critical Item	PO Revision	Attachment F	Critical Characteristics
Brushes	3	Item 20	• Configuration
Brush Holder	3	Item 19	• Configuration
Stator resistance temperature detectors (RTDs)	1	Item 8	• Shape and size • Shop test: continuity, resistance, and insulation
Current transformer and test switch	1	Item 9	• Size and weight • Dielectric strength • Continuity
Current transformer	3	Item 21	• Configuration • Mounting • Insulation • Resistance • Continuity
Current transformer test switch	3	Item 25	• Configuration • Dielectric strength • Continuity
Slip-rings	3	Item 17	• Configuration • Material
Adhesives	3	Item 27	• Material

APPENDIX

PERSONS CONTACTED

The U.S. Nuclear Regulatory Commission staff participating in the evaluation of Peebles Electrical Machines's design interface activities, procurement, commercial grade dedication, and manufacture of an emergency ac power generator for Pacific Gas and Electric Company's Diablo Canyon Nuclear Power Plant Unit 2 and the persons contacted during the inspection are listed below.

NEI Peebles Limited, Peebles Electrical Machines:

•	*	Brunton, David	Insulation and Development Engineer
	*	Francis, Les	Drawing Office Manager
•	*	Holroyd, Peter R.	Manager
•	*	Mac Naughton, Harry	Calibration Engineer
•	*	Miller, John	Quality Assurance Engineer
•	*	Nicoll, Harold W.	Quality Manager
•	*	Smith, Robert B.	Engineering Manager
•	*	Taylor, James	Chief Inspector
		Tweedale, Les	Chief Mechanical Designer

U.S. Nuclear Regulator Commission:

•	*	Alexander, Stephen D.	Environmental Qualification and Test Engineer, Reactive Inspection Section 2 (RIS2) Vendor Inspection Branch (VIB), Division of Reactor Inspection and Safeguards (DRIS), Office of Nuclear Reactor Regulation (NRR)
•	*	Cwalina, Gregory C.	Section Chief, Special Projects Section, VIB/DRIS/NRR
•	*	Matthews, Steven M.	Team Leader, RIS1/VIB/DRIS/NRR

• Attended the entrance meeting.
* Attended the exit meeting.