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AUTH.NAME AUTHOR AFFILIATION
RUEGER,G.M. Pacific Gas & Electric Co.
RECIP.NAME RECIPIENT AFFILIATION
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SUBJECT: Transmits plan for pre-operational endurance testing of sixth emergency diesel generator.Testing further augments basis for commercial grade dedication of sixth emergency diesel generator.

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Pacific Gas and Electric Company

77 Beale Street
San Francisco, CA 94106
415/973-4684

Gregory M. Rueger
Senior Vice President and
General Manager
Nuclear Power Generation

April 17, 1992

PG&E Letter No. DCL-92-092

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Re: Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Pre-operational Endurance Testing of the Sixth Emergency Diesel Generator

Gentlemen:

This letter formally transmits PG&E'S plan for pre-operational endurance testing of the sixth emergency diesel generator (EDG). The purpose of this testing is to further augment the basis for the commercial grade dedication of the sixth EDG. The testing outlined in the enclosure and attachments to this letter has been formulated by PG&E based on detailed discussions with the NRC on February 20 and March 25, 1992. This additional testing is to be conducted to facilitate resolution of open items in NRC Inspection Report (IR) 50-323/91-202, dated November 15, 1991, and issues raised in NRC IRs issued to NEI Peebles - Electric Products, Inc. (IR 99900772/91-01, dated January 15, 1992) and Peebles Electric Machines (IR 99901065/91-01, dated February 13, 1992), the designer and fabricator of the generator for the sixth EDG.

The enclosure identifies the specific testing to be conducted, the equipment monitoring to be provided during the testing, the criteria to be used for evaluating component malfunctions or failures, and the inspections to be performed following completion of testing.

If you have any questions or concerns regarding the breadth or scope of this plan, we would appreciate your comments as soon as possible. We would be pleased to discuss the enclosed information with you at your convenience during or prior to the next phase of your audit of the sixth EDG scheduled for April 27, 1992, at the PG&E offices.

Sincerely,

Gregory M. Rueger

5710S/85K

A001 1/1

cc: Dyle G. Acker
Ann P. Hodgdon
Dennis F. Kirsch
John B. Martin
Philip J. Morrill
Stuart P. Richards
Harry Rood
CPUC
Diablo Distribution

Enclosure

5710S/85K/ALN/2054

ENCLOSURE

PRE-OPERATIONAL ENDURANCE TESTING OF THE SIXTH EMERGENCY DIESEL GENERATOR

1.0 INTRODUCTION

This enclosure provides a description of the onsite pre-operational endurance testing to be incorporated into Replacement Parts Evaluation (RPE) M-6602 for the sixth emergency diesel generator (EDG). This dedication testing, in conjunction with the manufacturer testing already conducted in Montreal and Toronto, will provide an additional Electric Power Research Institute NP-5652, "Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Applications (NCIG-07)," Method 1, special testing basis in support of the commercial grade dedication of the sixth EDG GE-Locomotive (GE-L) engine. This testing, in conjunction with the other NCIG-07 dedication methods, provides the basis for dedication of the sixth EDG as described below.

This testing will also be used to support the NEMP 12.4 evaluation for the NEI Peebles - Electric Products, Inc., (P-EP) generator. The NEMP 12.4 evaluation was generated to address findings from August and October 1990 PG&E audits of P-EP of Cleveland, Ohio, and Peebles Electric Machines (PEM) of Edinburgh, Scotland. Subsequent to these PG&E audits, NRC inspections were conducted at these facilities. The programmatic issues raised in Inspection Reports (IRs) 99900772/91-01, dated January 15, 1992, and 99901065/91-01, dated February 13, 1992, for these inspections were consistent with those identified in the PG&E audits. These inspections did, however, identify specific concerns relative to documentation of acceptability of specific parts. The endurance testing at DCPP will also be used to address these concerns.

This enclosure outlines the specific testing to be conducted, the equipment monitoring to be provided during the testing, the criteria to be used for evaluating component malfunctions or failures, and inspections to be performed following completion of the testing.

2.0 BACKGROUND

2.1 Engine

The engine for the sixth EDG, currently undergoing final installation at Diablo Canyon Power Plant (DCPP) Unit 2, was purchased from a commercial grade supplier (GE-L of Montreal, Canada, formerly known as ALCO). This commercial grade purchase was necessitated because GE-L did not want to undertake a 10 CFR 50, Appendix B, quality assurance (QA) program for only a single diesel engine purchase. Also, our desire to provide consistency in maintenance and operating procedures, as well as overall design of the onsite electrical power distribution system, precluded the purchase of an EDG of a different model than the existing five ALCO EDGs.

The commercial grade purchase necessitated the implementation of an extensive dedication program to ensure the quality and reliability of the engine. This commercial grade dedication program was formulated using then-current NRC and

industry guidance. This guidance consisted of NCIG-07 and Generic Letter 89-02, "Actions to Improve the Detection of Counterfeit and Fraudulently Marketed Products."

The dedication methodology uses Method 4 of NCIG-07 (performance history) and Method 2 (commercial grade survey) as the primary basis for the dedication. This methodology includes a similarity evaluation comparing the design of the sixth EDG with the original five EDGs. This basic dedication approach was augmented by Method 1 (special testing, consisting of manufacturer testing in Montreal and Toronto) as well as Method 3 (source inspection of critical stages of the manufacturing process). The combination of the above four methods is further augmented by the site endurance testing as outline below.

The Method 2 commercial grade survey of GE-L was implemented by a PG&E audit and survey of GE-L to assess the adequacy of their QA program. These audits evaluated the GE-L program with respect to the Canadian Standard CAN3-Z299.3 QA program, as well as the PG&E CG-P-Diesel QA requirements imposed by the PG&E purchase order. The CG-P-Diesel program imposed the requirements of CAN3-Z299.3. In addition, CG-P-Diesel credits GE-L's design control program and imposed annual audit requirements on the suppliers of power train components.

A representative sample of parts was identified for evaluation during performance of the commercial grade survey of GE-L. To provide a comprehensive evaluation of the GE-L program, this sample of components was identified by establishing critical attributes of engine components to be evaluated. This list of attributes was then used to identify specific components and categories of components to ensure that the attributes of significance were appropriately addressed during the survey. All components of the engine were then correlated to the applicable component category. The list of representative components, one from each category, formed the basis for the audit and provided a means for ensuring the validity of the audit in assessing GE-L program implementation for all engine components.

As a result of the commercial grade survey, several areas of weakness were identified. To address these weaknesses, additional inspections and evaluations were conducted. These inspections were used to assess the quality of the products used in the engine assembly and were conducted using a sampling of components from each component category identified for the engine to provide a comprehensive evaluation of the implemented program with respect to all engine parts. The results of these inspections indicated that, due to the highly experienced personnel used in the engine manufacturing process, the identified weaknesses in the GE-L program did not impact the quality of the engine. However, review by the NRC of the engine dedication methodology (IR 50-323/91-202, dated November 15, 1991) has identified concerns regarding the adequacy of the dedication methodology used for the engine.

2.2 Generator

The generator for the sixth EDG was purchased from P-EP, who is a 10 CFR 50, Appendix B, supplier. PG&E implementation audits of P-EP and the generator manufacturer (PEM) identified significant deficiencies in their QA programs, and subsequently required compensatory measures to be implemented to assure acceptability of the generator. NRC inspections of PEP and PEM in 1991 raised

additional concerns regarding their qualification, and also questioned the adequacy of several of PG&E's compensatory measures.

2.3 Pre-Operational Endurance Testing

In order to facilitate resolution of NRC concerns regarding the commercial grade dedication of the EDG, and to provide additional basis for resolution of generator manufacturer QA issues, proposed additional testing of the engine generator unit has been identified for inclusion in the basis for engine dedication. The testing, the associated equipment monitoring, and the post-test inspections to be conducted are outlined below.

It should be noted that the proposed additional onsite testing is pre-operational testing, not post-installation testing. The testing will be conducted using a temporary load bank, not actual plant loads. The temporary loadbank, however, will be capable of simulating the resistive and reactive loads.

Testing of spare parts for the diesel engine generator, as well as other equipment for DCPP, typically uses Method 1 dedication via special testing of the component parts. This is expected to continue to be the case. In addition, post-installation testing of spare parts is not normally considered to be an appropriate means of performing commercial grade dedication activities due to the potential impact on plant operation and the limited ability to simulate plant emergency conditions for testing of the parts. Therefore, the commercial grade dedication testing of the sixth EDG is not considered to be post-installation testing nor is it considered a precedent relative to use of post-installation testing for dedication.

3.0 ENGINE GENERATOR UNIT TESTING

This section provides the details with respect to the pre-operational endurance testing to be conducted as part of the sixth EDG installation. This testing, in conjunction with the manufacturers' functional testing (at GE-L in Montreal and General Electric Canada (GEC) Alsthom in Toronto), forms the basis for the Method 1 dedication of the EDG. This testing also provides additional basis for resolution of generator manufacturer QA program issues.

3.1 Specific Tests to be Performed

The following tests constitute the sixth EDG pre-operational endurance testing:

A) 200 hours of pre-operational endurance testing (200 cumulative hours of onsite pre-operational endurance testing required). The endurance run test will be comprised of segments of no less than 8-hour runs. Shutdown of the engine between each eight-hour cycle is not required but may be implemented per a predefined testing schedule outlined in the final test procedure. During each segment, the engine generator will be run at 100 percent of rated load for seven hours with a step reduction in load greater than or equal to that of the largest single plant load for the one remaining hour. At the end of the 25 eight-hour runs, a two-hour run at 110 percent of rated load will be performed. Successful completion of the test requires completion of a cumulative run time of 200 hours. Failures during engine operation which are not considered

valid failures or for which component replacement can be accomplished by substitution of an item that was dedicated by a specific RPE shall not require restart of the 200-hour test. For any item replaced during the test, an evaluation shall be conducted to assess the potential impact of the failure on the qualification of other components of the engine generator.

Testing of the unit at 100 percent of rated load will generate the greatest stress on the unit while simulating required emergency operation. The step reduction in load will simulate the most severe load change expected during emergency operation.

The endurance test provides for operation of the engine generator unit in excess of 10 million cycles. (See Attachment 1 for the number of cycles for each type of component.) The number of cycles corresponding to the minimum ratio of fatigue strength versus tensile strength for a compilation of steels has been found to occur at 1 million cycles. At this number of cycles, steels reach an endurance limit or fatigue limit beyond which, no matter how great the number of cycles, fatigue failure is not expected to occur. (Mechanical Engineering Design, J. E. Shigley, 3rd edition, Section 5-11, Figure 5-14). The endurance test outlined here will correspond to a number of cycles which is significantly greater than that at which the fatigue limit is expected to occur (based upon 900 rpm, for 200 hours). Attachment 1 identifies the various engine parts and the number of cycles experienced by these parts.

B) An additional run with a duration of no less than eight hours will be conducted subsequent to completion of the endurance test and associated inspections (Section 3.4) to verify performance of the assembled engine.

C) Equipment monitoring will be performed during these runs as described in Section 3.2.

3.2 Equipment Monitoring During Testing

Monitoring for the above tests will include all instrumentation outlined in IEEE 387-1984, Section 6.2.1.(2).(b). In addition, vibration monitoring shall be provided to allow trending of vibration data. The expected locations of vibration monitors will be chosen so as to assess vibration at the lube oil pump, fuel oil pump, jacket water pump, and the free end of the generator. Engine analyzer data will also be taken during 100 percent power runs to trend performance of the engine on a cylinder-by-cylinder basis. This data will be collected after one hour of operation at rated load, once during the middle of the runs, and again toward the end of the runs. Electrical data (i.e., voltage, frequency, current, and power factor) for the generator will be monitored during these runs.

Lube oil samples will be taken for analysis prior to start of the endurance test, every 24 hours of engine run time during the test, and after completion of the endurance test.

Acceptance criteria for equipment monitoring instrumentation shall be as prescribed in the EDG operating/ maintenance vendor manual.

Acceptability of values outside specified ranges in the vendor manual will require evaluation by PG&E and vendor personnel. The acceptance criterion for vibration monitoring shall be the demonstration of stable readings with respect to increases in vibration levels between initial data collection and final runs of the endurance test.

Fuel oil level and ambient temperature will also be used to calculate fuel oil consumption at the beginning and end of the endurance test with a correction for ambient temperature. Fuel oil and lube oil filter differential pressure will also be monitored as will lube oil level (via crankcase dipstick) to assess excessive lube oil consumption.

3.3 Criteria to be Used for Evaluation of Component Malfunctions/Failures

The criteria contained in Reg Guide 1.108, Rev. 1, Section C.2.e, for valid tests and failures will be used to evaluate any test failures or malfunctions.

3.4 Post-testing Inspections (inspections by PG&E personnel and qualified vendor representative)

Engine

1- Following the completion of endurance testing, inspections will be performed using existing plant maintenance procedures including 18, 36, 54, 72, 90 and 108-month surveillance test procedures. Attachment 3 provides preliminary markups of these procedures; finalized procedures will be provided in a subsequent letter to the NRC. Only the visual inspections specified in these procedures will be performed. Engine running tests and replacement of parts specified in the procedure will not be done. These inspections, in conjunction with the monitoring and diagnostic instrumentation employed, will be reviewed to determine the need for disassembly of engine parts. Running of the engine beyond the fatigue endurance limit, in conjunction with the extensive monitoring to be conducted, will ensure that any degradation or failure of equipment will be identified.

2- A fiberscope or boroscope inspection of the cylinders for all power assemblies will be performed.

3- In-situ inspection of main bearing clearance for all main bearings per manufacturer recommendations also will be performed. In addition, two main bearing lower shells will be removed for inspection. Conduct of inspections will be based on manufacturers recommendations.

4- Disassembly and inspection of four power assemblies, including cylinder head, piston, connecting rod and connecting rod bearing will be performed. One assembly will be chosen from each quadrant of the engine. Cylinder liners will not be removed from the engine block but will be inspected in place.

5- Criteria for the above inspections shall be the vendor maintenance manual criteria for measured parameters and vendor manufacturer representative judgement for visual inspections.

Generator

1- Subsequent to completion of endurance testing, inspections will be performed using the existing plant maintenance procedure for 18-month surveillance. Visual inspection, using a boroscope or fiberscope as necessary, will be performed to inspect all items identified in the NRC IRs for P-EP and PEM as potential areas of concern. (See Attachment 2 for details.) In addition, electrical tests will be performed as outlined in Attachment 2.

2- The concerns identified for the generator for the sixth EDG also apply to the spare generator purchased by PG&E in 1986. Acceptability of the spare generator will be assessed by performance of the post-endurance test inspections identified in item 1 above. No further testing of the spare generator is considered necessary for this inspection. In addition, any potential problems identified in the testing and inspection of the generator for the sixth EDG will require evaluation of impact on the spare generator.

4.0 BASIS FOR RESOLUTION OF IR 50-323/91-202 OPEN ITEMS

Each deficiency and unresolved item identified in IR 50-323/91-202 is addressed in the discussion provided below. The primary bases for resolution of these items are clarifications of the PG&E dedication approach, completion of nuclear industry surveys for the ALCO EDG, documentation of a detailed design review of changes between the original five DCPP EDGs and the sixth EDG, and expanded testing as described above.

The numbering of open items used in the discussion below is consistent with that used in the PG&E response to IR 50-323/91-202 (PG&E Letter DCL-92-009, dated January 17, 1992).

Open issues associated with generator procurement are discussed in Section 4.11 and 4.12.

4.1 IR 50-323/91-202, Deficiency 91-202-01

A. Use of differing terminology between Purchase Order (Critical Component) and QA Specification (Critical Part).

Clarification was provided in Revision 3 of CG-P-Diesel. Evaluation of CG-P-Diesel Revision 1 versus Revision 3 will be documented in RPE M-6602.

B. Review of Engineering change notice procedure in GE-L qualification audit.

Detailed review by PG&E of GE-L design changes provides a basis for acceptability of identified changes.

C. Material traceability for power train parts.

Traceability is provided by subsupplier material certifications. PG&E performed non-destructive testing to provide additional assurance that the certifications were valid. A review of the material testing conducted to support these certifications is being performed to address the basis for the materials tested and their significance with respect to material characteristics.

In addition, the endurance test described above and the subsequent inspections will provide additional basis for ensuring that the materials used for the power train parts are adequate for the required function and that no fatigue failures of the components will result.

D. Subsupplier qualification did not substantiate quality of power train parts taken from stock.

See item C above.

E. Audit evaluation of process control.

The PG&E audit checklist erroneously identified process control as pertaining to paragraph 4.18.2 of CG-P-Diesel. The correct reference is Section 4.17.2.

4.2 IR 50-323/91-202, Deficiency 91-202-02

A. Technical and quality requirements for the mechanical components.

Controls for all mechanical items (excluding annual subsupplier audits) are the same as for power train parts. See CG-P-Diesel, Revision 3, for clarification.

B. Basis for considering mechanical components as non-critical.
Controls for all mechanical items (excluding annual subsupplier audits) are the same as for power train parts. See CG-P-Diesel, Revision 3, for clarification.

4.3 IR 50-323/91-202, Unresolved Item 91-202-01

A. Adequacy of CAN3-Z299.3 QA program.

Audits and surveys of GE-L have assessed the controls with respect to CAN3-Z299.3 as well as CG-P-Diesel (CG-P-Diesel provides a means for assessment of design control requirements, manufacturing controls, and internal audits which are not a part of CAN3-Z299.3) which were implemented by GE-L to ensure appropriate controls of material, process and design. Where controls provided did not meet PG&E requirements, additional compensatory actions were taken.

B. CAN3-Z299.3 does not provide design control.

See response to Item 4.3.A above.

C. Design specification criteria for determining if a component is critical.

Clarification of QA program requirements for critical versus non-critical (yet safety-related) components is provided in CG-P-Diesel, Revision 3.

D. Listing of power train parts included valve inserts, connecting rod bolts and connecting rod nuts, which were not listed in the design specification.

These items were considered to be part of the valves and connecting rods per the GE-L scope of inspection document; therefore, they were also considered as "critical parts".

4.4 IR 50-323/91-202, Unresolved Item 91-202-02

A. Documentation of bases used to select DCPP failures applicable to the performance history evaluation.

Details of the bases for selection of applicable DCPP failures is provided in RPE M-6602. These bases exclude from review only those work orders associated with preventive maintenance, equipment cleaning, replacement of consumables, tightening of fasteners, failures of non-mechanical components (since these components are not covered by RPE M-6602), and replacement of parts attributable to normal periodic maintenance activities.

B. Evaluation of Nuclear Plant Reliability Data Systems data for ALCO EDG failure at Palisades.

Consumers Power Company's Palisades plant was erroneously identified by PG&E in the RPE as Consolidated Edison's Indian Point, Unit 2. This error has been corrected.

C. EPRI NP-4264 and EPRI/NSAC-108 performance history data exclusion of beginning of life failures.

The extensive pre-operational endurance testing will envelope beginning of life failures for the sixth EDG.

D. Expansion of nuclear industry survey of ALCO EDGs.

This survey has been expanded to include input from all nuclear utilities using ALCO EDGs covering the operating life of those EDGs at each utility.

E. Applicability of GE-L equipment bulletins.

All bulletins associated with the model 18-251-F engine were considered applicable. Recommendations associated with the identified bulletins were evaluated against the final PG&E sixth EDG design. A review of these bulletins with respect to the sixth EDG design has been performed and is documented in RPE M-6602.

F. Auburn Technologies, Inc. (ATI) audit implications on quality of sixth EDG.

Concerns identified during the ATI audit conducted by GE-L were primarily associated with control of subsuppliers. The additional testing of components supplied by ATI in conjunction with the pre-operational endurance testing provide the basis for acceptability of ATI as well as other subsupplier parts. The commercial grade survey results reinforced the major ATI finding with respect to control of subsupplier materials and manufacturing processes. Specific compensatory actions, including additional test and inspection, was implemented for all parts supplied by ATI.

In addition, based upon the compensatory actions associated with lack of power train part subsupplier audits and those resulting from the commercial grade survey, it was determined that critical characteristics of primary concern with respect to subsupplier control are associated with material characteristics. Critical characteristics such as configuration were adequately controlled by the GE-L program through inspections and manufacturer testing. The additional endurance testing will provide a basis for evaluation of adequacy of subsupplier materials by subjecting these components to cyclical fatigue beyond the point at which minimum fatigue strength is encountered (greater than 1 million cycles). This testing and subsequent inspections will therefore identify those subsupplier materials which may not be adequate for ensuring proper operation of the EDG.

4.5 IR 50-323/91-202, Unresolved Item 91-202-03

A. Commercial quality controls for mechanical components.

Controls for all mechanical items (excluding annual subsupplier audits) are the same as for power train parts. See CG-P-Diesel, Revision 3, for clarification.

B. Adequacy of selection criteria for representative mechanical components.

The basis used for selection of a sample of components for assessment during the survey considered the subsupplier, the product type, the manufacturing process, industry experience, and performance record. These component samples were used to assess the GE-L program controls with respect to all mechanical components and power train parts. The weaknesses identified in the commercial grade survey were addressed by additional inspections. These inspections, in conjunction with the manufacturer tests, are considered to have adequately assessed all critical characteristics with the exception of characteristics associated with material control. See discussion in Item 4.4.F for applicability of pre-operational endurance testing to evaluation of critical characteristics associated with material control.

4.6 IR 50-323/91-202, Unresolved Item 91-202-04

A. Adequacy of quality program elements surveyed and applicability of survey results to remaining mechanical components.

See response to Item 4.5.B above.

4.7 IR 50-323/91-202, Unresolved Item 91-202-05

A. Inspection plan did not include GE-L quality control elements to be verified, surveillance methods or verification activities to be performed, and an evaluation of results.

Quality control element evaluation is addressed by audit and survey, not via the source inspection plan. Acceptance criteria for source inspection is provided in the inspection plan. Surveillance methods are in accordance with PG&E source inspection procedures and use qualified, experienced personnel.

4.8 IR 50-323/91-202, Unresolved Item 91-202-06

A. Limited sampling of GE-L's verification activities were witnessed during source verifications for engine block.

The source inspection plan included witness points for machining inspection, hydrostatic testing, and magflux inspection. Independent material and material strength testing was also performed. In addition, the pre-operational endurance test and subsequent inspections will provide a basis for identification of inadequacies in block material and in associated welds by subjecting the equipment to cyclical testing beyond the minimum fatigue endurance limit.

B. Adequacy of Nondestructive Examination (NDE) sampling of weldments.

100 percent of welding was NDE'd. Ultrasonic testing was conducted on all full penetration welds with magflux inspection conducted for fillet welds. A portion of the NDE was witnessed by PG&E. PG&E personnel also reviewed the qualification certifications for inspectors used by GE-L. Documentation for all NDE performed was also reviewed and found acceptable.

C. Use of less sensitive rejection criteria for air and exhaust valve inspections.

The two inspection methods are in accordance with GE-L specification.

D. Adequacy of technical bases for critical characteristics chosen and verified during the source verification activities.

The verification activities that were conducted in conjunction with the associated engineering evaluations provide reasonable assurance that these subsupplier components were adequate. The pre-operational endurance testing will provide additional assurance of

the quality of these components. A detailed review of critical characteristics of engine component categories will be conducted to identify those characteristics addressed by inspection, manufacturer testing, and pre-operational endurance testing.

In addition to the above inspections, a detailed review of the sixth EDG design versus the design for the original five EDGs is being performed to provide a basis for ensuring that DCPP performance history is applicable to all items. For those items for which DCPP performance history is not applicable, additional testing will be conducted (as part of the pre-operational endurance testing program or as specific component testing as applicable) to ensure adequacy of the components.

4.9 IR 50-323/91-202, Unresolved Item 91-202-07

A. Inspection plan did not address special test and inspection activities.

These activities are addressed in the RPE, not in inspection plans DC-271 or M-6602-1.

B. Need for documented plan to control and prescribe the GEC Alsthom special test and inspections.

GEC Alsthom manufacturing processes and special tests and inspections were based on GE-L specifications. Problems were identified as a result of a GE-L implementation audit of GEC Alsthom in the adequacy of the inspections conducted by GEC. Resolution of the audit open items resulted in reinspection based on a plan generated by a group of GE-L, PG&E and GEC engineering, and QA personnel, and was implemented by GE-L, PG&E, and GEC personnel. In addition, an inspection plan was generated to address concerns with GEC subsuppliers which were not qualified to the CAN3-Z299.3 specification. This plan conducted configuration and material tests on components of all unqualified suppliers. The suppliers of concern were primarily suppliers of commodity-type items.

These inspections in conjunction with the pre-operational endurance test will provide the basis for demonstrating adequacy of the GEC Alsthom assembly.

4.10 IR 50-323/91-202, Unresolved Item 91-202-08

A. Technical bases for the special tests and inspection activities.

See Section 4.8.D above.

4.11 IRs 99900772/91-01 (P-EP) and 99901065/91-01 (PEM) Issues

The final resolution of issues identified in NRC inspections of the generator designer (P-EP) and manufacturer (PEM) will be documented in accordance with PG&E NEMP 12.4 procedure requirements. This revision of the NEMP 12.4 evaluation will include the resolution of comments with

respect to the PEM inspection. The inspections outlined for the generator in this document, in conjunction with documentation reviewed by PG&E for dedication of items purchased by P-EP and documentation generated in the audit of PEM, will provide the basis for resolution of all NRC open issues.

List of Attachments

Attachment 1	Summary of Cyclical Effects on Engine Components
Attachment 2	Post-Endurance Test Monitoring of Generator Component Critical Characteristics
Attachment 3	Marked-up EDG Inspection Procedures (M-81 A to F)

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

This summary of engine component types is derived from RPE M-6602, Attachment AR.

The V, L, Cycles heading below designates whether the equipment is subject to:

- V: vibration loading,
- V,L: pressure retaining components subject to vibration with failure resulting in observable leakage.
- Cycles: the fraction of 900 rpm that applies to that component or sub-component.
- SKID: components which are only subject to the general vibration levels of skid mounted components.
- T/C: means that the driving vibration source is the turbocharger which changes speed depending on engine load from approximately 10 to 20 times the 900 RPM of the engine.

The listing below identifies the minimum number of cycles for the types of components in the engine and auxiliary systems which will be experienced during the endurance test.

Part Description	V, L, Cycles
Lube Oil Cooler	V,L
Engine Exhaust Pipe Expansion Joint	V,L, 1/2
Governor, Drive, and Linkage	V, 1.0
Air Start Motor Lubricator	V,L, 1/2
Lube Oil Spray Nozzle	V, 1/2
Lube Oil Pump Relief Valve	V,L, 1.3
Radiator	V,L,SKID
Engine Air Filter Sleeve	N/A, mounted on wall
Overspeed Trip	V, 1/2
Fuel Injection Tube	V,L, 1/2
Fuel Oil Pressure Regulating Valve	V,L,SKID
Fuel Oil Filter Relief Valve	V,L, 1/2

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Fuel Injection Snubber Valve	V,L, 1/2
Air Start Motor	V
Extension Shaft Oil Seal, Internal to Damper	V,L, 1.0
Extension Shaft Oil Seal, External to Damper	V,L, 1.0
Cylinder Head	V, 1/2
Air Valve	V, 1/2
Exhaust Valve	V, 1/2
Air and Exhaust Valve Springs	V, 1/2
Air and Exhaust Valve Spring Seat	V, 1/2
Air and Exhaust Valve Spring Seat Lock	V, 1/2
Air and Exhaust Valve Inserts	V, 1/2
Air and Exhaust Valve Guide	V, 1/2
Valve lever yoke guide	V, 1/2
Nut, special, injection tube stud	V, 1/2
Push Rod Sleeve	V, 1/2
Water Elbow, head to block	V, 1/2
Valve Lever Assembly	V, 1/2
Valve Lever Shaft Support	V, 1/2
Valve Lever Shaft	V, 1/2
Air and Exhaust Valve Yoke	V, 1/2
Air and Exhaust Valve Yoke Spring	V, 1/2
Valve Lever Casing	V, 1/2

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Air and Exhaust Pushrod	V, 1/2
Air Elbow, head to block	V, 1/2
Locating Plate, elbow to cylinder head	V, 1/2
Fuel Oil Filter	V,L, 1/2
Lube Oil Regulating Valve	V,SKID
Fuel Pump Support	V, 1/2
Fuel Pump Crosshead	V, 1/2
Auxiliary Spring Retainer, upper and lower	V, 1/2
Auxiliary Spring FP crosshead, inner and outer	V, 1/2
Fuel Pump Crosshead Lifter Assembly	V, 1/2
Inspection Cover at lower F.P support	V, 1/2
Fuel Pump Support Cover	V, 1/2
Cover Fastening Knob	V, 1/2
Stopper in grommet	V, 1/2
Engine Base	V, 1/2
Tube, Lube Oil Header to base	V,L, 1/2
Lubricating Oil Depth Gage	V,L
Leather Gasket	V,L, 1/2
Base Cover	V,L, 1/2
Base Cover Locking Bar	V, 1/2
Main Bearing Header	V, 1.0
Lube Oil Header Support	V, 1/2
Base Sump Screen	V,SKID

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Special Tube in Base	V,SKID
Engine Base Door	V,L, 1/2
Camshaft right section, free end cylinder 1	V, 1/2
Camshaft right section cylinders 2 & 3	V, 1/2
Camshaft right section cylinders 4 & 5	V, 1/2
Camshaft right section cylinders 6 & 7	V, 1/2
Camshaft right section cylinders 8 & 9	V, 1/2
Special stud bolt, section fastening	V, 1/2
Special Key, gear to shaft	V, 1/2
Camshaft left section, free end cylinder 1	V, 1/2
Camshaft left section cylinders 2 & 3	V, 1/2
Camshaft left section cylinders 4 & 5	V, 1/2
Camshaft left section cylinders 6 & 7	V, 1/2
Camshaft left section cylinders 8 & 9	V, 1/2
Camshaft Gear, right and left side	V, 1/2
Special Nut, gear to shaft	V, 1/2
Molykote "Z" powder	N/A
Locquic "T" primer	N/A
Loctite stud lock, camshaft stud	N/A

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Camshaft Housing	V, 1/2
Camshaft Thrust Bearing	V, 1/2
Camshaft Flywheel	V, 1/2
Thrust Plate, bearing to flywheel	V, 1/2
Flywheel Cover	V, 1/2
Bearing Housing Cover	V, 1/2
Camshaft Gear Cover, right side	V, 1/2
Camshaft Gear Cover, left side	V, 1/2
Crankshaft	V, 1.0
Crankshaft Gear	V, 1.0
Extension Shaft with Nut	V, 1.0
Vibration Damper	V, 1.0
Spider and Intermediate Ring	V, 1.0
Outer Ring	V, 1.0
Gear, water and lube oil pump drive	V, 1.0
Lubricating Oil Pump	V,L, 1.32
FP Control Shaft left	V, 1/2
FP Control Shaft right	V, 1/2
Control Shaft section couplings	V, 1/2
Retainer Dog	V, 1/2
Control Shaft lever, left side	V, 1/2
Roller, lever, left side	V, 1/2
Roller, lever, right side	V, 1/2

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Needle Bearing	V, 1/2
Collar at lever, right side only	V, 1/2
Control Shaft Bracket	V, 1/2
Control Shaft Bracket Bushing	V, 1/2
Spring Lever	V, 1/2
Lever Sleeve	V, 1/2
Lever Spring	V, 1/2
Spring Retainer	V, 1/2
Control Shaft Compartment Cover	V, 1/2
Control Shaft Compartment Cover Bushing	V, 1/2
Linkage Shield, RS control shaft	V, 1/2
Oil Seal, right side, control shaft drive end	V,L, 1/2
Oil Seal Retainer, right side, control shaft drive end	V,L, 1/2
Control Shaft link, right to left side	V, 1/2
Yoke	V, 1/2
Control Shaft Collar, right and left sides	V, 1/2
Eccentric Adjustment Lever	V, 1/2
Water Pump and Drive	V,L, 1.98
Pipe, cylinder head, left side	V, 1
Pipe, cylinder head, right side	V, 1

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Pipe, cylinder 4, 5, 6 right side pipe to bellows	V, 1
Pipe, cylinder 7, 8, 9 right side pipe to bellows	V, 1
Pipe, cylinder 7, 8, 9 left side pipe to bellows	V, 1
Pipe, cylinder 4, 5, 6 left side pipe to bellows	V, 1
Bellows Connector	V, 1
Hex Support, air elbow to support	V, 1/2
Support, hex support to brackets	V, 1/2
Bracket, long, support to manifold pipe	V, 1/2
Bracket, short, support to manifold pipe	V, 1/2
Strongback, air elbow and exhaust manifold to head	V, 1/2
Shroud, free end, left side	V, 1
Shroud, free end, right side	V, 1
Shroud, intermediate, left and right side	V, 1
Shroud, drive end, left side	V, 1
Shroud, drive end, right side	V, 1
End shroud, drive end	V, 1
Shroud support, free end, left side	V, 1
Shroud support, free end, right side	V, 1

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Support, left and right side to manifold flange	V, 1
Shroud support, intermediate, right and left side	V, 1
Shroud support, drive end, left side	V, 1
Shroud support, drive end, right side	V, 1
Shroud brace, shroud to branch pipe, upper	V, 1
Shroud Section, free end, left side	V, 1
Shroud Section, free end, right side	V, 1
Corrugated Pad, free end	V, 1
Shroud Section, center, left side	V, 1
Shroud Section, center, right side	V, 1
Shroud Section, drive end	V, 1
Latch Hook, shroud to block	V, 1
Clip, latch to shroud	V, 1
Cylinder Block	V,L, 1/2
Cylinder Head to Block Tubing	V,L, 1/2
Cylinder Head Stud	V, 1/2
Cylinder Head Nut for exposed stud	V, 1/2
Cylinder Head Nut for stud under valve lever casing	V, 1/2
Camshaft Bushing	V, 1/2
Lifter eyebolt	N/A

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Sleeve, liner to block, lower	V, 1/2
Main bearing cap, intermediate and thrust	V, 1.0
Main Bearing Shell	V, 1.0
Main Bearing Thrust	V, 1.0
Camshaft Bore Cover, right and left side	V,L, 1/2
Sealant, lower liner sleeve to cylinder block	V,L, 1/2
Aftercooler Core	V,**
Aftercooler Back Cover	V,**
Aftercooler Vertical and Horizontal Seal Strip	V,**
Aftercooler Front Cover	V,**
Turbo support cover, right side	V,**
Centering Plate, cover to RS turbo support	V,**
Lube Oil Strainer	V,SKID
Flywheel, generator shaft to ring gear	V, 1.0
Ring Gear	V, 1.0
Loctite "C" thread compound	N/A
Air Starting Motor and barring Device mounting plate right side	V
Air Starting Motor Mounting Plate	V
Air Starting Motor Support, right side	V

** Denotes combined vibration levels of engine and turbocharger.

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Air Starting Motor Support, left side	V
Air Start Motor Adjusting Plate, right and left side	V
Flywheel Guard, right and left sides	V, 1.0
Mounting Plate Tab	V, 1/2
Timing Pointers	V, 1/2
Fuel Oil Booster Pump and Drive	V, 1.94
Barring Device Housing	V, 1/2
Barring Device Housing Bushing	V, 1/2
Barring Device Housing Grease Fitting	V, 1/2
Barring Device Shaft	V, 1/2
Barring Device Cover	V, 1/2
Barring Device Cover Bushing	V, 1/2
Barring Device Cover Grease Fitting	V, 1/2
Barring Device Gear	V, 1/2
Barring Device Spring Seat	V, 1/2
Barring Device Spring	V, 1/2
Retaining Ring, gear to shaft	V, 1/2
Retaining Ring, at spring seat and cover	V, 1/2
Fuel Injection Pump	V, 1/2
Turbo Adapter, straight, 20" Flange	V,T/C > 10
Turbo Adapter, straight, 22" Flange	V,T/C > 10

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Turbo Adapter, elbow, 20" Flange	V,T/C > 10
Turbo Adapter, elbow, 22" Flange	V,T/C > 10
Turbocharger	V,T/C > 10
Turbocharger Support	V,T/C > 10
Air Elbow, turbo-inner sleeve	V,T/C > 10
Inner Sleeve, Expansion Joint	V,T/C > 10
Gland, Expansion Joint	V,T/C > 10
Air Elbow, gland to turbo support	V,T/C > 10
Coupling, drive shaft to extension shaft	V, 1.0
Drive Bolt Assembly, coupling	V, 1.0
Drive shaft	V, 1.0
Coupling, drive shaft to clutch drive shaft	V, 1.0
Radiator Fan Drive	V,2/3
Gear Box Inspection Plate	V,2/3
Orifice Elbow	V,2/3
Input Shaft Bearing	V,2/3
Input Shaft Pinion Gear	V,2/3
Output Shaft bevel ring gear	V,2/3
Input Shaft Oil Seal Retainer	V,2/3
Output Shaft oil seal Housing	V,2/3
Pump Housing	V,2/3
Input shaft oil seal housing	V,2/3
Bevel Ring Gear Hub	V,2/3.

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Mounting Bracket	V,2/3
Input Shaft	V,2/3
Output Shaft	V,2/3
Output Shaft Bearing Housing	V,2/3
Output Shaft mounting housing	V,2/3
Bevel Gear Case	V,2/3
Input Shaft Ball Bearing	V,2/3
Output Shaft cup bearing	V,2/3
Output shaft cone bearing	V,2/3
Reducing Bushing	V,2/3
Sleeve	V,2/3
Tube, 1/4 OD	V,2/3
Inner Shaft Oil Seal	V,2/3
Output Shaft Oil Seal	V,2/3
Air Vent	V,2/3
Pump to Output Shaft Coupling	V,2/3
Gear Pump	V,2/3
Radiator Fan Shaft Coupling	V,2/3
Radiator Fan Shaft	V,2/3
Radiator Fan Hub	V,2/3
Blade Clamping Cap	V,2/3
Fan Blade	V,2/3
Upper Fan Shaft Bearing Block	V,2/3
Tie Rod Turnbuckle	V,2/3
Clutch Coupling	V,2/3

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Pillow Block Ball Bearing	V,2/3
Steel Capped Piston	V, 1/2
Crown Plasma Ring	V, 1/2
Taper Face Ring	V, 1/2
Conformable Ring	V, 1/2
Scraper Ring	V, 1/2
Piston Pin	V, 1/2
Piston Pin Sleeve	V, 1/2
Connecting Rod	V, 1/2
Piston Pin Bushing	V, 1/2
Connecting Rod Bolt	V, 1/2
Connecting Rod Nut	V, 1/2
Bearing Shell in Connecting Rod	V, 1/2
Bearing Shell in Connecting Rod Cap	V, 1/2
Cylinder Liner	V, 1/2
Fuel Injection Nozzle and Holder	V,L, 1/2
Safety Door Assembly	V,L, 1/2
Adapter	V,L, 1/2
Clamp	V,L, 1/2
Filter/Strainer	V,SKID
O-Ring	V,SKID
Gasket	V,SKID
Hoses	V,SKID
Stud/Capscrew	V,SKID

SUMMARY OF CYCLICAL EFFECTS ON ENGINE COMPONENTS

Part Description	V, L, Cycles
Washer/Lockwasher	V,SKID
Dowel	V,SKID
Plug	V,SKID
Machine Screw	V,SKID
Sleeve	V,SKID
Nut/Locknut	V,SKID
Grommet	V,SKID
Male Connector	V,SKID
Pin	V,SKID
Elbow	V,SKID

POST-ENDURANCE TEST MONITORING OF GENERATOR COMPONENT CRITICAL CHARACTERISTICS

Since concerns have been expressed by the NRC regarding the adequacy of the qualification of several critical items for the sixth EDG, PG&E has undertaken the task to perform an endurance test on the generator whereby all 27 items listed as critical items will be collectively evaluated through the performance of the 200-hour endurance test. PG&E believes that the functional and structural integrity of all critical items will be adequately demonstrated during the course of the endurance testing. Any flaw or weakness in the material will show up during the testing and would be readily detectable either through the monitoring of the electrical parameters (i.e., current, voltage, frequency) or from the specific post-endurance test physical inspection. Specific post-endurance test physical inspection supplemented by electrical test would be employed for this monitoring activity as outlined in the following list. All other items will be evaluated based on the monitoring of electrical parameters of the generator. The item numbers shown below correspond to the same item numbers listed in Revision 3 of PG&E's Purchase Order.

Item No.	Description	Monitoring Activity
4	Bearing Bracket	Visual inspection
6	Bearing seals	Visual inspection for extrusion of grease
9	Short circuit bars (damper)	Visual inspection
11	Tapered keys	Visual inspection
15	Stator coils	Visual inspection for cracking and loose wedge
16	Lead wire	Visual inspection for surface damage
17	Slip-rings	Visual inspection for deformity
18	Stator frame	Visual inspection for physical damage
19	Brush-holder	Visual inspection for damage
20	Brushes	Visual inspection for damage
21	Current Transformer	Insulation resist. measurement using megger
22	Insulators, 5kV (term. box)	Dielectric strength measurement using 2500V DC
23	Bearing seals (felt)	Visual inspection

POST-ENDURANCE TEST MONITORING OF GENERATOR COMPONENT CRITICAL CHARACTERISTICS

Item No.	Description	Monitoring Activity
24	Insulating bushings (lead wire through box)	Visual inspection for surface damage
25	Current transformer	Insulation resis. test using 500 VDC

Additional issues raised in NRC inspection of P-EP and PEM:

1. Brush-Rigging Mounting Tube Insulator

   This is considered critical to the extent that it supports the voltage difference of the dc field circuit, rated for 103.5V. Its functionality is verified by functional testing of the machine to IEEE 115. The stresses of operation under a design base event are essentially same as those under normal operation. The insulation integrity of the Bakelite material will be verified by insulation resistance measurement using 500 VDC after the endurance test.

2. Slip Ring Insulating Mounting Sleeve

   This is similar to Item 1 above. The insulation integrity of the mounting sleeve will be verified by insulation resistance measurement using 500V DC after the endurance test.

3. DC Permeability Test on the Rotor Shaft

   DC permeability of the rotor shaft is not a design consideration. The flux densities are calculated based on the flux being carried within the rotor spider. The ultimate verification of the design is through the performance test per IEEE 115. The 200-hour endurance test will document the voltage, wave shape of the voltage, losses and efficiency, load excitation, voltage regulation, temperature rise, and other machine parameters.

4. Use of Load Bank for Generator Performance Test

   The load bank testing package offers assorted load steps with multiple combinations of resistive and reactive load which allow variable power factor testing. This is ideally suitable for simulating the starting current inrush seen by a motor as well as the running load of a motor. Additionally, starting and running of sequenced blocks of loads can be simulated by controlled switching of resistive and reactive elements. Although the use of the loadbank provides a static loading simulation compared to a dynamic motor load, the generator voltage dip during a motor starting using a loadbank simulation would be practically the same as an actual motor starting.

POST-ENDURANCE TEST MONITORING OF GENERATOR COMPONENT CRITICAL CHARACTERISTICS

5. Pole Drop Tests for Rotor Poles

Measure voltage drop across the rotor poles using 120V 60 hz ac to detect any shorted pole.

Table 1 - Critical Items Procured by P-EP

The dedication of the following items was performed by P-EP and has been evaluated by PG&E via the NEMP 12.4 evaluation.

Critical Items	Item No.
Insulators (5 kV box)	22
Insulating Bushings (motor case)	24
Insulating Material	26
Bearing Seals (felt)	23
Brushes	20
Brush Holder	19
Current Transformer	21
Current Transformer Test Switch	25
Slip-rings	17
Adhesives	27

POST-ENDURANCE TEST MONITORING OF GENERATOR COMPONENT CRITICAL CHARACTERISTICS

Table 2 - Critical Items Procured by PEM

Critical Items	Item No.
Lead Wire	16
Magnet Wire*	3
Roller Bearing*	6
Shaft/Casting*	1
Stator Coils	15
Stampings*	2
Bearing Bracket*	4
Stud/Threaded Rod*	5
Spider End Rings	7
Pole End Rings	8
Short Circuit Bars	9
Pole Head	10
Tapered Keys	11
Rotor Wedge	12
Rivets	13
Insulating Washers	14
Stator Frame*	18

*Items reviewed by PG&E and P-EP during QA audit of PEM

ATTACHMENT 3

MARKED-UP EDG INSPECTION PROCEDURES