U. S. NUCLEAR REGULATORY COMMISSION

REGION III

Reports No. 50-282/92010(DRP); 50-306/92010(DRP)

Docket Nos. 50-282; 50-306 License Nos. DPR-42; DPR-60

Licensee: Northern States Power Company
414 Nicollet Mall
Minneapolis, MN 55401

Facility Name: Prairie Island Nuclear Generating Plant

Inspection At: Prairie Island Site, Red Wing, MN

Inspection Conducted: June 8 through July 31, and August 12 through 14, 1992

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Approved By: B. L. Jorgensen, Chief 9-9-92
Reactor Projects Section 2A Date

Inspection Summary

Inspection on June 8 through July 31, 1992 (Reports No. 50-282/92010(DRP); 50-306/92010(DRP))

Areas Inspected: Announced team inspection by regional and headquarters inspectors to review, witness, and evaluate the licensee's ongoing activities relative to in situ qualification testing of diesel generators and support equipment and verify as-built conditions for the station blackout/electrical safeguards upgrade (SBO/ESU) modification.

Results: No violations or deviations were identified. Strengths were noted in personnel knowledge and the qualification testing program organization in the SBO/ESU Project. Testing activities, in general, were satisfactory. However, the team noted that the choice of an overseas-based vendor as the principal supplier of the D5/D6 diesel-generator sets and support equipment has posed unique challenges to the licensee. Among these that the team feels will continually need to be addressed are the development of "in-house" expertise, provision of training, and assurance of availability of spare parts.

DETAILS

1. Persons Contacted

*K. Albrecht, General Superintendent, Engineering
*L. Anderson, Plant Shift Manager
*T. Brehm, Startup Support
*R. Carlson, Plant/SBO Shift Supervisor
R. Cole, SBO/ESU Project Mechanical Engineer
*E. Eckholt, Nuclear Support Services
*S. Fehn, Superintendent, SBO Startup/Integration
*G. Goering, Manager, Nuclear Projects
*J. Goldsmith, SBO/ESU Program Manager
*P. Hellen, Plant Electrical Systems Engineer
*K. Hohmeister, Power Supply Quality Assurance
M. Klee, Superintendent, Quality Services
*J. McDonald, Superintendent, Site Quality Assurance
*D. Mendele, Director, Quality Assurance
R. O'Bryan, Superintendent, SBO/ESU Project Construction
*D. Perrine, Supervisor, SBO Startup
*R. Pond, SBO/ESU Project Electrical Engineer
*M. Reddemann, General Superintendent, Electrical and Instrumentation Systems
A. Rothstein, Senior Quality Specialist
R. Sitek, Supervisor, SBO/ESU Turnover and Closeout
P. Suleski, SBO/ESU Project Mechanical Engineer
*M. Thompson, SBO/ESU Project Engineer
G. Thoraldson, Plant Mechanical Systems Engineer
*M. Wadley, General Superintendent, Operations
C. Muller, SACM Diesel Representative
*D. Thornley, SACM Diesel Representative
*G. Volkman, SACM Diesel Representative
*R. Bywater, Reactor Engineer, Region III, U. S. Nuclear Regulatory Commission (NRC)
C. Brown, Reactor Engineer, Region III, NRC
*M. Dapas, Senior Resident Inspector, Prairie Island, NRC
T. Kobetz, Reactor Engineer, Region III, NRC
*D. Kosloff, Resident Inspector, Prairie Island, NRC
J. Neisler, Reactor Inspector, Region III, NRC
*W. Shafer, Branch Chief, Region III, NRC
E. Tomlinson, Senior Reactor Systems Engineer, Office of Nuclear Reactor Regulation (NRR), NRC

*Denotes those present at the management interview of July 29, 1992.

Other member's of the licensee's staff and contract employees were also contacted during the inspection period.

2. <u>Test Program Implementation Verification (71302,70300)</u>

a. Introduction

The licensee's plan for the addition of two Class 1E emergency diesel generators at the Prairie Island Plant predates the July 21, 1988, issuance of the final NRC rule on station blackout (SBO). This regulation, 10 CFR 50.63, requires that each light-water-cooled nuclear power plant licensed to operate must be capable of withstanding SBO and maintaining adequate reactor core cooling and appropriate containment integrity for a required duration.

The new emergency diesel generators, support equipment, safeguards power distribution systems, and seismic Category I building constitute the principal features of the licensee's station blackout/electrical safeguards upgrade (SBO/ESU) modification. The generators, D5 and D6, are to serve as the dedicated source of emergency power for Unit 2 and as an alternate AC source for Unit 1. The existing emergency diesel generators, D1 and D2, will serve as the dedicated source of emergency power for Unit 1 and as an alternate AC source for Unit 2.

The new gen-sets are supplied by the French firm, Societe Alsacienne de Constructions Mecaniques de Mulhouse (SACM). Each gen-set is a tandem arrangement of two SACM Model UD45-V16-S-D-5 engines directly coupled to a dual bearing Jeumont-Schneider generator, with a continuous rating of 5400 kW.

In submittals to the NRC dated September 29 and December 15, 1989, the licensee described its qualification program for factory testing and site testing of the new diesel generators. The NRC approved the program by issuance of a safety evaluation report dated January 31, 1990. The program is based upon meeting criteria specified in IEEE Standard 387-1984, Regulatory Guide 1.9, Revision 2, and Regulatory Guide 1.108, Revision 1. A reduction in the number of required fast start preoperational tests as specified in Section 7.2.2 of IEEE 387, from 300 per gen-set to 35 per gen-set without a failure, was allowed based upon the previously demonstrated reliability of this model engine at other locations.

Site testing to verify in-situ performance of the gen-sets and support systems consists of four major phases:

(1) Component Prerequisite Testing

This was an initial testing phase, during which gen-set support systems were tested individually to ensure functionality of components as a system. Also, initial runs of the engines were performed in a variety of conditions (e.g. uncoupled/coupled to the generator and unloaded/loaded to a load bank or to the grid) to verify gen-set operation and control.

(2) Diesel Generator Preoperational Testing

This phase encompasses operation of the gen-sets and support systems to ensure that operation is in accordance with design criteria and functional requirements. This includes support system tests, performance of 24-hour load runs, loss of short-time load (110%) tests, and performance (with no failures) of 35 consecutive start demands followed by generator loading to at least 50 percent of continuous rating for at least 1 hour. These tests constitute the acceptance tests of systems prior to system turnover to the plant operations department.

(3) Integrated Safeguards Preoperational Testing

This is the final phase of preoperational testing, demonstrating automatic safeguard sequencer loading of the Class 1E electrical distribution system in response to simulated SBO and safety injection scenarios.

(4) Plant Surveillance Tests

Routine surveillance testing will be required by the Technical Specifications to ensure continued reliability of power systems after they are placed in service.

The 35 starts per gen-set portion of the preoperational testing phase did not commence until after the end of the inspection period. Portions of these tests will be the subject of future inspection. The integrated safeguards preoperational tests will occur during the upcoming dual unit outage in October-November 1992 and will also be subject to inspection.

b. Review of Program

The inspectors reviewed the licensee's management control system to determine whether it was effectively discharging its responsibilities in SBO/ESU program oversight and gen-set qualification. This was accomplished by review of the licensee's project organization; attendance at meetings; interviews with personnel; tours of the facility; and review of procedures, nonconformances, and quality assurance/quality control (QA/QC) activities.

The SBO/ESU project is administered by the licensee's Nuclear Projects Department (NPD). Construction activities relative to the project have been the subject of prior NRC inspections. This inspection primarily focused on "startup" activities in the qualification process which includes work involved in preparing to turn over responsibility of the gen-sets from NPD to the Plant.

The SBO/ESU Startup Group prepared Release for Test (RFT) Packages for systems or subsystems of the project consisting of a boundary drawing, detailed descriptions of components within the boundary, and other pertinent information on activities to be completed by the Construction Group. Upon completion of system construction activities, a walkdown by members of the Startup and Construction Groups was performed to identify items that were incomplete that had to be addressed before testing began or items that could remain open without delaying the RFT. Inspector Followup Items were entered into a master system punch list which tracked the disposition of the items to ensure completion. Upon review and acceptance of the final RFT Package by the Startup Supervisor, prerequisite testing of that system or subsystem could begin.

Prerequisite tests of systems that were approved for RFT were performed to verify construction activities, ensure that the system was ready for preoperational testing, and provide for interim operation of the system. Prerequisite test procedures were prepared by the Startup Group with review by QC. Problems encountered during the prerequisite tests were followed up on by nonconformance reports, engineering change requests, and work requests, as required, and the master system punch list was updated accordingly. Following tests, rework, retests, results review by the Startup Group and QA, and disposition of comments, the prerequisite test was accepted as complete.

Preoperational tests involve the operation of all items in a system to assure that operation is in accordance with the design criteria and functional requirements. The tests serve as final acceptance tests that the system is ready for turnover to the Plant Operations Department. The procedures are developed by the Startup Group and require review and approval from the Joint Test Group (JTG) (a subcommittee of the licensee's onsite operations safety review committee), QC, QA, and the plant manager or his designee. Results from system preoperational tests require review and approval by the JTG.

Final turnover of a system to the Plant requires development of a System Turnover Package. These packages include documentation of preoperational testing results, a listing of reviewed and approved operating procedures for the system, P&IDs, component listings, and listing/status of master system punch list items. The final package requires QC, QA, and JTG approval before the turnover actually occurs.

The above requirements are documented in reviewed and approved Project Procedures used by the SBO/ESU organization. The inspectors noted as strengths the personnel knowledge and program organization in the SBO/ESU Project.

The inspectors also reviewed a sample of nonconformance reports. This included a sample of both those with disposition consisting of rework and those with engineering justification for "use as is." Activities in this area were, in general, satisfactory.

The QC and QA organizations were adequately performing their functions in the procedural and test results review process; and, in conducting inspections, surveillances, and audits. One QA-identified issue involved QC installation inspection requirements as they relate to performing "100 percent final inspection" and "random inspection" of installations. Another involved the resolution of deviations in vendor-supplied basic components without performing an evaluation of whether a defect exists, as defined in 10 CFR 21. This latter item resulted from an interpretation in NPD that a component has not been "delivered" until post installation testing and turnover of the component to the plant has occurred. Discussions on this issue between QA and NPD were continuing at the conclusion of the inspection period. This issue is considered an Inspector Followup Item, pending further review by the inspectors. (Inspector Followup Item 282/92010-01; 306/92010-01).

Some other general programmatic observations made during facility tours, interviews, or test witnessing were as follows:

(1) Equipment in the D5/D6 building was well marked.

(2) Daily planning and scheduling meetings were well run and informative.

(3) Testing of the gen-sets was performed in a controlled and professional manner. However, control of escorted visitors in the D5/D6 building (which is within the plant protected area) was weak. The inspectors noted instances of visitors being momentarily out of the sight of their escort and being switched to another escort without proper use of escort transfer procedures. The inspectors informed the licensee of these observations and corrective actions were taken. Visitor control improved after these observations were made.

(4) Vendor representatives were relied upon heavily in performing troubleshooting adjustments during gen-set test runs. Licensee involvement with actual adjustments on the gen-sets was often limited to observations. The licensee was cautioned to ensure that adequate in-house expertise be developed on the gen-sets so that personnel have the capability to perform efficient and thorough troubleshooting and repair, when necessary, once the gen-sets are in service.

(5) The inspectors expressed a concern that the licensee ensure that access is available to spare parts and technical support for the gen-sets and support equipment.

No violations, deviations, or unresolved items were identified. One Inspector Followup Item was identified.

3. Verification of As-Built Condition (37301)

The inspectors verified the as-built condition of the following diesel generator subsystems: fuel oil storage and transfer system (FOST), starting air (SA), lube oil (LO), low temperature/high temperature water cooling (LT/HT), fuel oil (FO), combustion air intake and exhaust (CAE), fire protection (FP), and heating, ventilation, and air conditioning (HVAC). In conducting these verifications, the inspectors utilized the following documentation: applicable flow diagrams and construction drawings, sections of NUREG-0800 (Standard Review Plan), applicable Regulatory Guides, Prairie Island Nuclear Generating Plant (PINGP) Station Blackout/Electrical Safeguards Upgrade (SBO/ESU) Design Report Revision 1, sections of PINGP's current Updated Safety Analysis Report (USAR), and PINGP's License Amendment of March 20, 1992. The inspectors also reviewed a concrete placement incident that occurred during construction of the D5/D6 building.

a. Fuel Oil Storage and Transfer System (FOST and FO)

The FOST for each diesel generator set consists of two storage tanks mounted in a concrete vault located adjacent to the D5/D6 building plus two transfer pumps located in the diesel room pit area of the D5/D5 Building. A shared, above ground, receiving tank is also provided. Diesel engine fuel oil transported to the site will be off-loaded initially to the receiving tank and tested to ensure compliance with the fuel oil specifications. After compliance is verified, the fuel oil in the receiving tank can be transferred to any diesel engine fuel oil storage tank. The fuel oil storage tanks, concrete structures, transfer pumps, piping and electrical equipment are Seismic Category I. The receiving tank, recirculating pump, associated piping, and piping components are non-safety related, but are designed to withstand Safe Shutdown Earthquake (SSE) loads without failure (Seismic II over I). The storage tank level instruments for indication and alarm are not safety related and are seismically mounted only to preclude damage to safety related equipment (Seismic II over I). The control switches to indicate operation of the transfer pumps (also day tank level switches) are Seismic Category I. At the time of the inspection, PINGP's USAR stated that the diesel generator day tanks store sufficient fuel oil for 2 hours of operation at full load. However, the inspectors determined that the capacities of the D5 and D6 day tanks only provide sufficient fuel for approximately 90 minutes of operation at full load. The D5/D6 Design Report states that each day tank will provide a supply of fuel for a minimum of 1 hour of operation at full load. Although the 2 hour figure in the USAR refers to the D1 and D2 gen-sets, this will remain an Inspector Followup Item pending review by the inspectors of the adequacy in reduced day tank capacity for D5 and D6 from the previously established USAR value. (Inspector Followup Item 282/92010-02; 306/92010-02).

b. Starting Air (SA)

The starting air system for each tandem diesel generator set consists of four subsystems, each including its own compressor, dryers, and air receiver tank. The air receivers were sized based upon test data for SACM engines and corrected for system inertia specific to the Prairie Island diesels. Each of the four sets of redundant components provides starting air to a bank of eight engine cylinders via an air distributor. Each air receiver is sized to provide 10 starts of the engines without recharging, and any two of the four charged receivers will start the engines within 10 seconds. A single receiver will start the engines within approximately 12.9 seconds.

During the walkdown of this system, the inspectors noted that starting air to the fuel rack stopping devices of each engine (one for each of the two fuel racks per engine) could be supplied by any of the four starting air systems. Each engine has a mechanical overspeed detection device that upon reaching its overspeed setpoint of 1380 rpm, will cause a solenoid valve to open in the SA system to provide air to the fuel rack stopping devices, thereby stopping the flow of fuel to the engine. A modification was made to interconnect the stopping device air lines for both engines to ensure that a mechanical overspeed trip of one engine would cause the fuel racks to go fully closed for both engines. Upon reviewing PINGP's SBO/ESU Design Report, the inspectors noted that the SA system's design "consists of four independent subsystems." Since this design requirement was intended to meet the requirements of NUREG-0800, Section 9.5.6, Paragraph 4.f, system independence had been compromised by the stopping device air supply cross connection. This issue was discussed with the licensee and further clarification of SA system independence will be required in a revision to the Design Report. This is considered an Inspector Followup Item pending further review by the inspectors. (Inspector Followup Item 282/92010-03; 306/92010-03).

Additionally, the inspectors noted several minor discrepancies with drawings not reflecting actual valve installation and the mislabeling of valves. These issues were discussed with the licensee and were addressed as Engineering Change Requests. The inspectors also noted material rigging paths in the D5 and D6 areas of the D5/D6 building that allow for transport of equipment over SA system receiver tanks and compressors. This was discussed with the licensee for future review to ensure these components are not damaged during rigging activities.

c. Lube Oil (LO)

The engine LO system consists of two cross-tied loops, pressurized by two 50 percent capacity engine-driven pumps. The pumps discharge supply oil from the crankcase sump through the lube oil cooler and a duplex-type filter for cleaning, and distribute lube oil to the engine block to lubricate moving parts and to provide piston cooling. The LO system is provided with a pre-lube subsystem to maintain constant flow of lubricating oil to critical areas during standby mode to minimize wear during engine starts. The pre-lube system maintains lube oil in the "keep warm" temperature through the lube oil preheating heat exchanger to enhance the "first-try" starting reliability of the engine in the standby condition. A sufficient quantity of lube oil to permit 7 days of continuous operation at rated load is maintained on site for each [illegible] generator. Lube oil is stored in a lube oil storage tank [illegible] elevation to permit filling of each engine crankcase by [illegible] gravity flow, which is controlled by a manually-operated [illegible] valve.

Walkdown and review of the LO system was completed without comment.

d. Low Temperature/High Temperature Water Cooling (LT/HT)

Each engine is provided with two independent closed loop cooling systems consisting of a high temperature (HT) system and a low temperature (LT) system. The HT system cools the engine jacket, cylinder heads, and turbochargers. The LT system supplies the aftercoolers and lube oil heat exchangers. Both HT and LT systems are provided with an engine driven circulating pump, expansion tank, water-to-air heat exchanger (radiator), and a three-way thermostatic valve. In addition, the HT system is provided with a nonsafety-related preheating subsystem to reduce thermal stress and wear during fast starts of the diesel engine. A thermostatically controlled electric heating element is designed to keep HT coolant temperature at least 95 degrees Fahrenheit during standby conditions. This subsystem also preheats lube oil via the lube oil preheating heat exchanger. Both the HT and LT systems are intended to operate with a 50-50 percent by weight mixture of demineralized water and ethylene glycol, treated with a rust inhibitor.

The licensee experienced cleanliness problems with the HT and LT systems on all four engines. Cooling system components off of the engine skids (piping, radiators, expansion tanks) were installed to achieve Class C cleanliness standards as defined by ANSI 45.2.1-1973. When the engines were installed onsite and factory preservation seals broken, foreign material was observed in the HT and LT systems. To minimize transport of material to other parts of the systems and facilitate its removal, strainers were installed in the piping systems. Many flushes of the systems were performed with demineralized water, removing particulate materials such as iron, paint chips, and gasket sealant caulk. Initial engine runs were performed (with vendor approval on an interim basis) using demineralized water coolant without ethylene glycol or inhibitor. These initial engine runs would result in rapid clogging of the strainers. Early engine runs were as short as 10 minutes before the strainers were clogged and required cleaning. The source of iron contamination was determined to be from cooling system equipment on test benches at the vendor's factory. The source of paint was postulated to be from overspray/misdirected engine block primer paint, applied at the factory and partially dissolved during an alcohol drying procedure.

With repeated engine runs and strainer cleaning, LT/HT system cleanliness improved steadily through the inspection report period. However, the inspectors questioned what potential adverse effects on engine operation the contamination might present. The vendor has documented in correspondence with the licensee that ANSI Class C cleanliness conditions far exceed what is necessary for engine operation; however, gradual degradation due to abrasive wear of thermostatic soft seat O-ring seals could occur as well as reduced performance of the nonsafety-related keep warm system due to localized flow restriction. As cleanliness of the HT and LT systems has improved, potential for abrasive wear of piping and pumps or flow blockage of instrument ports and tubing may have decreased. However, pending further review, this issue will remain an Inspector Followup Item. (Inspector Followup Item 282/92010-04; 306/92010-04).

Walkdowns and reviews of the LT and HT systems were completed without comment.

e. Combustion Air Intake and Exhaust (CAE)

Each engine is provided with an independent combustion air intake and exhaust system. The combustion air system includes an air intake filter that functions in accordance with the engine manufacturer's recommendations. The air intake system is located such that fresh outside air is not diluted with exhaust gases. The air intake system is designed to prevent water from entering the engine air intake.

The combustion air inlet piping system has been reviewed by the engine manufacturer to assure each engine's ability to start and run during site design basis tornado depressurization conditions. Additionally, each engine's ability to start and run in extremely cold weather conditions has been reviewed by the manufacturer. The engines have been rated to a minimum combustion air intake temperature of -30 degrees Fahrenheit.

Walkdown and review of the CAE system was completed without comment.

f. Heat, Ventilation, and Air Conditioning (HVAC)

Each of the two diesel generator rooms has an independent ventilation system which will function to limit the maximum ambient temperature to 120 degrees Fahrenheit in conformance with equipment ratings. The ventilation system also supplies the minimum required volumetric flow of air necessary to directly cool the generator bearings. All components of the diesel generator room ventilation system have been designed to perform their function in a 120 degree Fahrenheit environment with a relative humidity range of 20 to 90 percent. The heating, ventilation, and air conditioning systems' capacities are based on an outdoor ambient temperature range of -20 degrees to +96 degrees Fahrenheit. This is the 99% occurrence range recommended by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE).

Walkdown and review of the HVAC system was completed without comment.

g. Fire Protection

The diesel generators are separated from each other and from the remainder of the plant by reinforced concrete walls having a fire rating of at least 3 hours. In light of its proximity to the Turbine Building and Auxiliary Building, the east wall and a portion of the north wall are also 3-hour fire rated. All penetrations in fire walls will be 3-hour fire rated.

Each redundant electrical train will be separated by 3-hour rated fire barriers. The pipe trench running through both fire areas on the grade level will be separated from the remainder of the building area by a 3-hour rated barrier. Fire doors of equivalent rating will be provided in fire walls.

Cable and cable tray penetrations as well as piping and ventilation duct penetrations through fire area boundaries, are sealed with a penetrat on seal having a 3-hour fire rating. Adequacy of these seals was demonstrated by fire test conducted in accordance with IEEE G 4-1978 by Southwest Research Institute (test reports SWRT 03-1402/ Quadrex-NOR-0176 and NOR-0179, PO 5364).

Each gen-set's fuel oil day tank and lube oil storage tank are all contained in separate rooms constructed of reinforced concrete with 3-hour fire rated walls, floor and ceiling. Room doors and fire dampers in ventilation ducts are fire rated for 3 hours. All penetrations through the room boundaries that are fire area boundaries are sealed with 3 hour penetration seals. Floor drains and curbs are provided for each room which discharge into a dirty oil tank and fuel oil/lube oil sump.

In high intensity fire areas, all structural steel forming a part of or supporting a fire barrier wall or slab will be coated with fire proof material to provide a fire rating equal or greater than the fire barrier.

Walkdown and review of the FP system was completed without comment.

h. Expansion of Stay Form for D5/D6 Building Wall During Construction

NRC inspection report 50-282/91019; 50-306/91019 documented an incident that occurred on December 21, 1990, during concrete placement of the "G" (north) wall of the D5/D6 building. An expanding stay form failed during the pour of approximately 26 cubic yards of concrete and caused a significant distortion in the siding and girt framing of the turbine building wall (immediately north of G-wall) between the 705 foot and 725 foot elevations. The turbine building has a concrete flood wall which extends up to the 705 foot elevation.

The D5/D6 building is built to be a Seismic Category I structure and is intended to be structurally independent from the turbine building. A 0.5 inch clear distance between the two buildings is designed to permit maximum out-of-phase displacements of the buildings due to wind or seismic events. Because the turbine building concrete flood wall only extends to the 705 foot elevation, the 0.5 inch separation (maintained by a compressible board) below this elevation may have been maintained. However, the inspectors questioned whether any loading of slumped concrete on the turbine building flood wall from above would affect the structural independence. This is considered an Inspector Followup Item pending review of the licensee's analysis. (Inspector Followup Item 282/92010-05; 306/92010-05).

No violations, deviations, or unresolved items were identified. Four Inspector Followup Items were identified.

4. Test Witnessing and Results Evaluation (70441)

The inspectors conducted observations of tests in progress. These included tests of D5/D6 systems and subsystems, initial engine runs coupled/uncoupled to the generators, and loaded gen-set operation via load bank and grid. Some highlights of these activities are as follows:

a. SA System 24 Hour Drop Test

The air compressors in the SA system for each engine fill air receiver tanks to a pressure 588 psig. In the drop tests, power is removed from the compressors and receiver tank pressure is measured after 24 hours. The maximum permissible pressure drop is 123 psig. These tests failed on several occasions and leak tracing indicated that pipe fittings were susceptible to leakage. This issue was not resolved at the end of the inspection period and is considered an Inspector Followup Item pending further review by the inspectors. (Inspector Followup Item 282/92010-06; 306/92010-06).

b. Electronic and Hydraulic Governor Setting

The inspectors observed test runs of D6 Engine 2 to adjust governor settings. The fuel limiter solenoid (used during "maintenance mode" of engine operation) failed and had to be overridden to run the test. A replacement was available in spares and installed, but it failed also. The next replacement had to be ordered from the vendor. The inspectors noted this series of component failures an indicator among other examples of a potential overall spare parts problem.

During the test, the hydraulic governor droop curve did not match the factory curve. The zero setting on the fuel rack position indicators and zero stroke setting for each injector pump had to be verified and reset. Troubleshooting activities would be performed by the vendor representative without a procedure and the licensee would observe the process to learn the techniques. When the zero settings were set correctly, adjustment of the hydraulic and electronic governor settings went very well. Droop curves were virtually identical to the factory curves and the engine performed well up to 110 percent load. A load rejection from 110 percent load was handled well also.

c. Stepwise Load Acceptance Tests

The inspectors observed performance of this test on D6. The test applied step loads representative of the loads that might be experienced during actual loading events. Loading steps during this sequence were:

0 kW
1647 kW
2635 kW
3432 kW
4245 kW
5151 kW
5445 kW
310 kW

The test results indicated that D6 would accept the step loads and would reject loads of 5[illegible] kW without tripping.

d. <u>24 Hour Loaded Tests</u>

The inspectors observed portions of two different attempts to complete the 24 hour loaded test of D5. The initial attempt was terminated approximately 22 hours into the test due to a failure of the D5 voltage regulator. The failure was caused by the failure of a 600 volt, 0.68 microfarad capacitor and 200 ohm, 25 watt resistor. Engineering analysis determined these components to be undersized for the application. The capacitor was replaced with a 1000 volt, 0.68 microfarad capacitor and the resistor with a 200 ohm, 100 watt resistor. The voltage regulators for D5 and D6 were returned to the manufacturer for component upgrade and qualification.

The second run was successful. The gen-set was operated at 75 percent of rated load for 2 hours, then 20 hours at rated load, followed by the final 2 hours at 110 percent of rated load. The test demonstrated that the gen-set was capable of carrying rated load for an extended period of time and 110 percent capacity for 2 hours.

e. <u>Engine Cylinder Exhaust Temperature Differential</u>

The inspectors noted a large temperature differential (approximately 200 degrees Fahrenheit) between the highest and lowest cylinder exhaust temperatures of the engines of D5 and D6 during gen-set operation. In response to the inspectors' concern, the licensee and engine vendor provided information regarding the design of the engines which explained why the large temperature differential phenomenon exists.

In sum, the design of the diesel engine exhaust system, in conjunction with the firing order of the engines, creates a valve overlapping condition which impacts on cylinder scavenging in three different ways. This results in three cylinder exhaust temperature regimes as described below.

The relationship of the cylinders connected to exhaust "1" of turbocharger "1" on the clockwise engines of D5 and D6 was reviewed with the following results:

* Cylinders A2, B3, B2, and A3 feed exhaust 1 of turbo. 1.
* Cylinder firing order is A2, B3, B2, A3.
* Cylinder B3 fires 230 degrees of crankshaft angle after A2, B2 fires 180 degrees after B3, A3 fires 130 degrees after B2, and A2 fires 180 degrees after A3.

Starting with cylinder A2, the following is the sequence of events with respect to valve movement:

* B3 exhaust valve opens 50 degrees (crankshaft) after A2 intake valve opens.

* B2 exhaust valve opens at the same time as B3 intake valve opens.
* A3 exhaust valve opens at 50 degrees (crankshaft) ahead of B2 intake valve.
* A2 exhaust valve opens at the same time as A3 intake valve.

(Note: for each cylinder, there is a fixed overlap of the exhaust and intake valves of about 135 degrees).

For the cylinder A2-B3 relationship, there is a 230 degree (crankshaft) firing difference. This causes the B2 exhaust valve to open 50 degrees after A2 has fired. Consequently, the A2 intake valve opens when there is a minimum energy level in the exhaust manifold. This allows maximum cylinder scavenging and a corresponding low cylinder exhaust temperature.

For the cylinder B3-B2 relationship, there is a 180 degree firing difference. This causes the B3 intake valve to open at the same time the B2 exhaust valve opens. At this point, the energy levels in the intake and exhaust manifolds are about equal. This results in reduced cylinder scavenging of B3 (as compared to A2) and a correspondingly higher cylinder exhaust temperature.

For the cylinder B2-A3 relationship, there is a 130 degree firing difference. This causes the A3 exhaust valve to open 50 degrees before the B2 intake valve. At this point, the energy level in the exhaust manifold is high. This results in reduced cylinder scavenging of B2 (as compared to B3) and a correspondingly higher cylinder exhaust temperature.

For the cylinder A3-A2 relationship, the firing difference is again 180 degrees. This means the A2 exhaust valve and the A3 intake valve open at the same time. The scavenging of cylinder A3 is about the same as B3, and the cylinder exhaust temperatures are approximately the same.

The same relationship exists for each group of four cylinders on each exhaust manifold.

Some conclusions from this review are as follows:

* The firing sequence and exhaust arrangement of the cylinders adequately explains the high temperature differential that was of concern to the inspectors.

* There are three distinct relationships between cylinders in the same exhaust system which result in three cylinder exhaust temperature regimes as follows:

    * 230 degree firing difference -- lowest cylinder temp.
    * 180 degree firing difference -- higher cylinder temp.
    * 130 degree firing difference -- highest cylinder temp.

* The engine vendor should be able to provide acceptable temperature ranges (for normal operation) for each of the cylinders having the 230, 180, and 130 degree firing difference. These could be translatable into ranges for review and acceptance criteria in surveillance testing and used as bases for trending analyses.

f. Gen-Set Vibration and Engine Smoking

The inspectors also noted high vibration readings and engine smoking during gen-set operation. Generator bearing vibration would change in magnitude for bearing #1 (engine #1) and bearing #2 (engine #2) in correlation with fuel rack differential position. This may indicate the presence of excessive torsional stresses in the engine and generator shafts due to an imbalance in engine #1 versus engine #2 loading. Cylinder imbalance has been determined not to be the cause, as shown by the analysis of the cylinder exhaust temperature differential. However, these issues could indicate a serious problem and should be investigated thoroughly. They are considered an Inspector Followup Item pending further review by the inspectors. (Inspector Followup Item 282/92010-07; 306/92010-07).

g. Miscellaneous Items

(1) Control Panel Indicator Lights

The inspectors observed that some indicator lights on the gen-set control panels in the D5/D6 building operate in ways that are inconsistent with indicator lights in the existing plant. Specifically, for some 480 v. breakers, the indicator lights were wired to indicate breaker control power, but not actuating relay power. Loss of power to actuate the breaker (e.g. breaker inoperability) could be undetectable. The licensee noted that it would write an engineering change request to address this issue.

(2) Temporary System Alterations

During the initial test involving D5 synchronization and loading to the grid, the inspectors observed that stable load was not able to be maintained. The licensee's troubleshooting determined that a previously performed temporary system alteration resulted in the load differential reference unit being disabled. This was a condition required in prior tests where speed control rather than load control was required; however, the alteration should have been restored prior to this test. When the system was restored, the test continued successfully. The inspectors re-emphasized to the licensee the need for maintaining adequate controls over these alterations. The inspectors will review this area in a future inspection and it is considered an Inspector Followup Item. (Inspector Followup Item 282/92010-08; 306/92010-08).

(3) Training

The inspectors discussed the issue of training with the licensee. The plant simulator in the training center has been modified to include the future Class 1E power supply and distribution panel that will be installed in the plant during the upcoming dual unit outage. Operations personnel have been training on this panel during their routine rotations in the training department. The licensee stated that there have been delays in providing D5/D6 training to other personnel due to some disagreements between different labor unions. The inspectors emphasized the importance of adequately trained personnel in maintenance and surveillance activities as well as operations in order to maintain high reliability of the gen-sets. The area of training for personnel, including for maintenance, surveillance, and operations, is considered an Inspector Followup Item pending further review by the inspectors. (Inspector Followup Item 282/92010-09; 306/92010-09).

No violations, deviations, unresolved, or Inspector Followup Items were identified.

5. Inspector Followup Items

Inspector Followup Items are matters which have been discussed with the licensee, which will be reviewed further by the inspector, and which involve some action on the part of the NRC or licensee or both. Inspector Followup Items disclosed during the inspection are discussed in paragraphs 2.b., 3.a., 3.b., 3.d., 3.h., 4.a., 4.f., 4.g(2), and 4.g(3).

6. Management Interview

The inspectors met with the licensee representatives denoted in paragraph 1 on July 29, 1992. Additional debriefing meetings were held with licensee representatives at the conclusion of each inspection window. The scope and findings of the inspection were discussed, as described in these "Details." On the meeting of July 29, the licensee was asked whether any documents or processes inspected were proprietary. None were identified.