U.S. NUCLEAR REGULATORY COMMISSION
REGION 1

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REPORT NOS.	92-15
LICENSE NOS.	NPF-69
LICENSEE:	Niagara Mohawk Power Corporation 301 Plainfield Road Syracuse, New York 13212
FACILITY NAME:	Nine Mile Point Nuclear Power Station, Unit 2
INSPECTION AT:	Scriba, New York
INSPECTION DATES:	May 12-14 and May 26-29, 1992
INSPECTORS:	C. H. Woodard, Reactor Engineer, DRS C. Bennett, Reactor Engineer, DRS J. Rajan, Mechanical Engineer, NRR/EMEB E. Murphy, Consultant Inspector, American Systems Corp.

INSPECTOR: C. H. Woodard — 7/01/92
C. H. Woodard, Reactor Engineer, Electrical Section, EB, DRS — Date

APPROVED BY: W. J. Ruland — 7/1/92
W. Ruland, Acting Chief, Electrical Section, Engineering Branch, DRS — Date

Inspection Summary: Please see the Executive Summary

EXECUTIVE SUMMARY

This inspection was in response to the licensee's inspection findings which identified engine cylinder liner and piston distress in their Cooper KSV-16 emergency diesel generator (EDG). This distress was identified as similar to that found in 1989 at Susquehanna in their Cooper KSV-16 engines as precursors which had led to several crankcase explosion events.

The inspectors found that the Cooper EDG users group had developed a draft inspection manual in April 1992 to be used as a guide in inspecting the Cooper KSV engine cylinder liners and pistons for distress. This manual included input from the Susquehanna root cause evaluations which were concluded late in 1991. It included color photographs of distressed and damaged KSV-16 pistons, cylinder liners wrist pins, and wrist pin bearings from Susquehanna and told the users how to look, what to look for, and what constitutes the distress indications which could lead to EDG failure. It also covered corrective actions which included the removal of piston wrist pin end cap seals and the piston bottom of skirt oil scraper ring to improve cylinder lubrication.

The inspectors found that the licensee had completed the inspection and changes to the Division II EDG. Inspection procedures, methods, results and changes were reviewed for this unit. The inspectors witnessed the inspection of the Division I unit. As a consequence of the distress indications found, the licensee has replaced six of the pistons and liners on the Division I EDG and nine of the pistons and liners on the Division II EDG. With Cooper concurrence, all of the wrist pin end caps and bottom piston skirt oil scraper rings were removed in both EDG units in order to improve piston to liner lubrication. The licensee found no damage to wrist pins, wrist pin bearings, crankshaft journals, and connecting rod bearings.

The inspectors concluded that the licensee had aggressively pursued the EDG inspection with a dedicated system engineer aided by onsite Cooper representatives in identifying the distressed components, replacing them and in making engine modifications to overcome the potential root causes of the problems. This work was actively supported by upper management with much day-to-day direct involvement in the EDG rooms. Modifications were made in accordance with approved procedures and included appropriate QA involvement in all areas. Licensee root cause analyses with followup enhanced inspections are planned to provide additional confirmation that the basic problems (root causes) have been corrected.

1.0 BACKGROUND

Niagara Mohawk (NM) Unit 2 Nuclear Power Plant utilizes a Cooper KSV-16 emergency diesel generator (EDG) unit in each of the Division I and Division II safety-related electrical power trains. Cooper KSV-16 EDG units at the Pennsylvania Power and Light (PP&L) Susquehanna Nuclear Power Plants underwent a series of crankcase explosions the last of which occurred in 1989. Distress and damage found in the failed Susquehanna EDG units included piston and cylinder liner distress in which piston tin coating (bearing material) was wiped (galled/scraped) off onto the liners. Piston wrist pins and wrist pin bearings were damaged and press-fit piston wrist pin end cap seals had moved out and galled cylinder chrome-plated liners.

As a consequence of these events, PP&L took corrective actions and made modifications based upon suspected root causes. These included the replacement of all distressed cylinder liners, pistons, wrist pins and bearings; the removal of the piston wrist pin end cap seals and the piston skirt bottom oil scraper rings to provide for better piston/liner lubrication; the elimination of cold, dry and unnecessary fast starts; and modifications to provide for warm pre-lubricated engines. PP&L has not reported any evidence of cylinder distress since these changes were made in 1989. Since 1989, PP&L conducted extensive root cause evaluations including extensive proof testing of a similar Cooper KSV engine which was heavily instrumented and operated under controlled conditions to confirm the root causes of the cylinder distress and engine failures. These evaluations were concluded during late 1991. Based upon the evaluations, PP&L along with other nuclear utilities which use the Cooper KSV EDG units prepared a draft inspection manual. This inspection manual provided the details needed for inspection of the EDG units. It included vivid detailed color photographs of normal and distressed pistons and cylinder liners. It provided information as to what to look for, how to look for it and what constitutes distress which could lead to EDG failure.

The draft inspection manual was received by NM Unit 2 on April 30, 1992. At this time the Division I EDG had completed its outage maintenance, surveillance, testing and was considered operable. The Division II EDG was near completion of the same. Although there was no requirement for NM to conduct the draft manual inspections, both the Division II and I EDG units were sequentially declared inoperable and inspected per the draft manual by NM personnel with the direct assistance of Cooper field service personnel. (The EDG units each had started approximately 350 times and had operated approximately 750 hours.)

2.0 INSPECTION DETAILS

2.1 EDG Tin Smearing

The inspectors reviewed the "Draft Inspection Manual for Cooper Bessemer (C-B) Model KSV Diesel Engine Cylinder Liners, Pistons and Bearings," dated April 9, 1992. The manual was prepared by and for the use of the utilities which comprise the C-B KSV EDG users group for the 16 nuclear power stations which use this EDG unit. The stated purpose of this manual is to provide guidance for the evaluation of degradation of cylinder liners, pistons, main and connecting rod bearings and camshafts. These components were selected for inclusion due to the potential for a significant reduction in reliability if the degradation is not identified, or because the mode of degradation is relatively unique to C-B KSV diesel engines. The intent was to provide general industry guidelines for identifying the various modes of component degradation. The manual was incomplete in that it did not yet include guidance for the evaluation of bearings and camshafts. However, the inspectors found the draft manual to be adequate for inspection for the tin smear degradation of the pistons and cylinder liners. The information presented relating to the piston-to-liner tin smearing found in the inspection manual represents information not previously available from the EDG manufacturer, other users or the NRC.

At the time of this inspection, the licensee had completed the inspection and refurbishment of the Division II EDG by the replacement of nine of sixteen (16) pistons and cylinder liners and by the removal of all 16 cylinders piston wrist pin seal end caps and the piston skirt bottom oil scraper rings. Cooper concurred by letter to the licensee in the modification, including the removal of end cap seals and bottom piston skirt oil scraper rings. By conducting a review of the licensee's documentation of the inspection of the Division II EDG, including color photographs of each of the cylinders and liners, the inspectors concluded that the licensee had conservatively identified and replaced all distressed pistons and cylinder liners. In addition, the inspection of the piston wrist pins and piston bronze insert bearings met the inspection criteria. No indications of damage were evident.

The inspectors witnessed portions of the licensee's inspections, replacements and modification of the Division I EDG unit including the removal of three of the six pistons and liners that were replaced. The inspection and modifications were performed in accordance with the licensee's approved NMP 2 simple design change (SDC) Procedure No. SDC 2-0136-92 and the user's Group Inspection Manual. Initial inspection of each of the 16 cylinders was conducted by observing the upper cylinder liner and piston crown through the fuel injection port, by means of a borescope and then by inspecting the lower portion of the cylinder liner and piston skirt via the crankcase access cover openings. With the limited visibility provided during this initial inspection, the licensee indicated that as many as 10 cylinders liners and pistons were suspect. By the sequential removal of cylinder heads, pistons and liners from the engine for all 16 cylinders, the licensee was able to thoroughly inspect each cylinder. As a consequence, the licensee found that six of the pistons and liners required replacement. The licensee found no indications of overheating or damage to any of the wrist pins and wrist

pin bearings. Since the connecting rod caps were removed to pull the pistons, the licensee was able to inspect all connecting rod caps and bearings and the crank shaft journals. There was no evidence of damage. The inspectors found active quality assurance and management involvement evident in all of the procedures and in the EDG rooms on a routine daily basis. The inspectors also found that the licensee's EDG system engineer had "changed hats" to become a maintenance mechanic in order to be able to participate with "hands-on" direct involvement. This direct hands-on involvement was considered to be a positive factor in conducting this major effort. Overall, the inspectors concluded that the inspection, modifications, and replacements were conducted in a professional manner, by experienced/trained professionals who used approved procedures, and whose efforts were monitored effectively on an on-going basis by quality assurance and plant management.

The inspectors tried to determine when some of the tin removal from the pistons occurred. Since some of the tin removed from the piston will be washed down into the crankcase, engine oil, analyses were examined for preceding years for tin content. The licensee performed no detailed analyses for tin prior to 1990. These monthly analysis did not disclose any significant variations in tin content of the lube oil. Therefore, the inspectors could not identify a specific time during the preceding two years in which significant tin transfer occurred. This does not rule out tin transfer during this time. Flakes of tin transferred from the piston to the engine crankcase will tend to float in the oil and much of it could be filtered out by the engine oil filters. The licensee had made no periodic analyses of engine oil filters for collected elements. Oil samples had been taken from shutdown units crankcase without regard to time after shutdown and crankcase location. The licensee agreed to establish a meaningful oil sampling procedure that will permit comparing and trending subsequent samples on known reference basis.

The inspectors found that "pop testing" of fuel injectors was not routinely performed to verify proper performance. (It was not included in the vendors routine periodic maintenance instructions.) The "pop test" verifies that the injector will open at the proper fuel oil pressure and that the injector produces a conical spray mist of fuel. The proper operating pressure and spray characteristics are essential to a balanced combustion engine which produces its peak operating pressure in each cylinder at the proper (approximately the same) crank shaft angle. Injectors that weep or dribble or pop early or late can be compensated for by adjusting the fuel rack for each cylinder; however, this does not resolve the basic engine combustion problem. The inspectors found up to eight degrees difference in the fuel pump rack setting between cylinders. The licensee is currently addressing this potential problem.

The inspectors questioned the licensee's continuing approval as satisfactory the EDG lube oil based upon satisfactory viscosity when the monthly analysis received (since February 1991) show fuel oil dilution in the engine oil ranging between 5 and 6%. This represents approximately 20 gallons of fuel contamination in the oil. Fuel dilution in engine oil above 2% is generally considered to be a problem. A source of raw fuel oil is from fuel injectors down past the pistons into the crankcase. Any liquid fuel oil degrades piston to liner lubrication as it moves from injectors to the crankcase and also reduces the lubricity of the oil

in the crankcase. During the inspection, the licensee obtained information which indicates that there was an error in the analysis as a consequence of the contract laboratory using an improper oil standard. Since the inspection, the inspectors were advised that new analyses made utilizing the proper standard indicated that the fuel oil dilution was less than 2%. The licensee has now established acceptance limits on the permissible levels of fuel oil in the engine oil (the C-B EDG manual did not provide the licensee with limits). Although this item is now resolved, the inspectors considered it a weakness in that the high dilution had not been properly addressed.

2.2 EDG Fuel Oil Receipts

The inspector found that the licensee's procedures permit up to 30 days to accomplish the full analysis of the EDG fuel oil after it is added to the EDG fuel tanks. This procedure is generally in accordance with the guidance provided to the licensee in the NRC Standard Technical Specifications and in the NRC Regulatory Guide 1.137. However, the licensee had not recognized that by adding this unanalyzed class 1E material to the class 1E EDG units, that the operability status of each of the EDG is in question until the confirming analysis is received. In fact, by topping off all of the EDG fuel tanks from a single tanker (the common practice), there exists a means for the simultaneous common mode failures of all EDG units.

Prior to the conclusion of this inspection, the licensee had confirmed the analysis of the fuel oil in each of the EDG tanks and had implemented temporary procedural changes to address this problem. Draft procedure N2-PM-015, Diesel Fuel Off Load, was reviewed. It includes provisions for holding the fuel oil in the tanker until full analysis is made prior to adding it to the tanks. According to the licensee, previous procedure N2-DDI-5.19 is to be superseded by the new procedure effective June 1, 1992. Implementation of the new procedure will resolve this problem.

2.3 Fast Start and Load

Fast starting and fast loading of cold, dry (not pre-lubed) EDG units is considered to contribute to the unreliability of the units. NRC Generic Letter 84-15 requested that licensee's address this issue by making changes in their surveillance and testing procedures to minimize or eliminate this type of starting and loading. The inspectors determined that NM had addressed this issue except for a 184-day test when the units are dry-fast started and fast loaded into the grid. The dry start and fast loading during the six-month test are required by licensee Technical Specification 4.8.1.1.2.a.5 and are conducted in accordance with EDG test procedure N2-OSP-EGS-M001. The inspectors questioned the need for the six-month dry start, fast load test. The licensee plans to review the need and, if not required, to request a Technical Specification amendment to delete this requirement.

3.0 CONCLUSION

The licensee acted responsively to the EDG Draft Inspection Manual and proceeded with further inspection in which precursors of potential EDG failure were identified and corrected prior to plant startup. The inspection was made by the licensee with good management support, active QA involvement, with the effective utilization of a knowledgeable systems engineer using approved procedures and with the support of the EDG manufacturer. Although the license's high fuel oil concentration in the EDG lube oil proved to be an analysis error, they failed to properly question the high concentration. The Cooper-Bessemer (CB) KSV engine is susceptible to piston-to-liner tin smear degradation in the nuclear power industry which can lead to EDG failure.

APPENDIX A

PERSONS CONTACTED

Niagara Mohawk Power Corporation

*G. Brownell, Site Licensing Supervisor
*G. Thompson, System Engineering Supervisor
*M. McCormick, Plant Manager
T. Fiorenza, Diesel Generators Systems Engineer
K. Murray, Engineer
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K. Coates, Maintenance Manager
R. Dean, Lead Systems Engineer
J. Blasiack, Plant Chemistry Supervisor
J. Savoca, Maintenance Support Manager
J. Doherty, Procurement Engineer

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E. Murphy, Diesel Generator Specialist, American System Engineering Corporation

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J. Horn, Manager, Engineering

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E. Tomlinson, Diesel Generator Specialist, NRR
J. Rajan, Supervisor, Mechanical Engineering Branch, NRR
*W. Mattingily, Resident Inspector
*C. Bennett, Inspector
W. Schmidt, Senior Resident Inspector

Asterisk (*) indicates those present at the exit meeting.

APPENDIX B

DOCUMENTS REVIEWED

1. Inspection Manual for Cooper-Bessemer Model KSV Diesel Engine Cylinder Liners, Pistons and Bearings. Draft Issue, dated April 8, 1992.

2. U.S. NRC Safety Evaluation of the Emergency Diesel Generator (EDG) Crankcase Overpressurization Events, Susquehanna Steam Electric Station, Units 1 and 2 (TAC Nos. M81347 and M81348) dated May 11, 1992.

3. Cooper-Bessemer Instruction Manual #93080, KSV Turbo Charged Diesel Generating Unit, Nuclear Power Plant-Emergency Standby. *200xx--, Rev 9/81.

4. Pennsylvania Power and Light Company (PP&L) Root Cause Investigation. Piston Tests at SMLP and Distortion/Contact Patch Analysis, dated September 1991.

5. Susquehanna Steam Electric Station EDG Root Cause Investigation Baseline Engine Test Report Cooper-Bessemer KSV-12-GT Diesel Engine at Sumner Municipal Light Plant, MPR-1218, Revision A, dated December 1990.

6. U.S. NRC Region I Inspection Report of Cooper Diesel Generator Failures at PP&L Susquehanna Power Station, Reports 50-387/89-30 and 50-388/89-27.

7. U.S. NRC Memorandum for Hehl, Region I from Varga, NRR Task Interface Agreement Regarding Emergency Diesel Generator Failures at Susquehanna Steam Electric Station, Units 1 and 2.

8. NMPC #2 Technical Specification 3/4.8, Electrical Power Sources.

9. NMPC #2 Division I and II Diesel Generator Operability Test Procedure N2-OSP-EGS-M001, Rev. 3, dated 12/22/90.

10. U.S. NRC Generic Letter 84-15, Proposed Staff Actions to Improve and Maintain Diesel Generator Reliability.

11. NMPC #2 Divisions 1,2 and 3 EDG Lube Oil Analysis Summaries (2/17/91-5/24/92).

12. NMPC #2 Chemistry Procedure N2-CSP-17V Hydraulic and Lubrication Oil Surveillance, Rev. 4/23/91.

13. NMPC #2 Division 1 and 2 EDG Operating Logs (Operation through 4/15/92).

14. NMPC #2 Division I and II Diesel Generator Operating Cycle 24-hour Run and Load Rejection Test Procedure N2-OSP-EGS-R002, Rev. 2, dated 8/6/90.

15. NMPC #2 Division I and II Diesel Generator Operating Cycle Simulated Loss of Offsite Power with ECCS, Test Procedure N2-OSP-EGS-R004, Rev. 3, dated 8/22/90.

16. NMPC #2 Division I and II Diesel Generator Operating Cycle Simulated Loss of Offsite Power with No ECCS, Test Procedure N2-OSP-EGS-R003, Rev. 1, dated 2/7/91.

17. NMPC #2 Division I and II Diesel Generator ECCS Start, Test Procedure N2-OSP-EGS-R001, Rev. 1, dated 10/26/92.