LILCO, July 16, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of LONG ISLAND LIGHTING COMPANY (Shoreham Nuclear Power Station, Unit 1)	))) Docket No. 50-322-OL-4) (Low Power)))

TESTIMONY OF
THOMAS W. IANNUZZI AND KENNETH A. LEWIS
ON BEHALF OF LONG ISLAND LIGHTING COMPANY

Q.1. Please state your names and business address.

A. (Iannuzzi) My name is Thomas W. Iannuzzi. My business address is Morrison-Knudsen Company, 101 Gelo Road, Rocky Mount, North Carolina 27801.

(Lewis) My name is Kenneth A. Lewis. My business address is Morrison-Knudsen Company, 101 Gelo Road, Rocky Mount, North Carolina 27801.

Q.2. Mr. Iannuzzi, what is your current position with Morrison-Knudsen?

A. (Iannuzzi) Manager of Engineering of Power Systems Division (PSD) of Morrison-Knudsen Company, Inc. (M-K).

Q.3. Mr. Iannuzzi, does the resume designated as Attachment 1 to this testimony accurately reflect your education and professional experience?

A. (Iannuzzi) Yes it does in summary form.

Q.4. For purposes of convenience, please summarize your responsibilities in your current position as Manager of Engineering.

A. (Iannuzzi) I am responsible for direct supervision of project engineers, designers and document control personnel required to design and build diesel and turbine generator systems for utility, military and emergency applications. These include diesel generator systems used in nuclear plants. I also supervise PSD's engineering staff in the review of test reports, equipment specifications, and vendor quotations and in the provision of production assistance to PSD's shop. I write and certify design specifications for ASME Code components and review and approve design reports for nuclear projects. Additionally, I review nuclear owners' design specifications and implement codes and standards related to safety related equipment for nuclear power generating stations.

Power Systems, over the past 12 years, has designed and fabricated 137 diesel generator sets for customers in commercial applications, and 65 diesel generator sets for 21 utilities at 26 nuclear plants. In addition to these units we have provided parts, service, modification packages and consulting for 51 engines at 18 nuclear sites for which Power Systems had not provided the original units.

Q5. Please summarize your prior professional and educational experience.

A. (Iannuzzi) As stated in greater detail in my resume, I received a Bachelor of Science in Mechanical Engineering from Pennsylvania State University in 1968 and a Master of Science in Industrial Administration from Union College in 1973. From 1968 to 1973, I worked for the Machinery Apparatus Operation of General Electric Company as engineer for a procurement organization responsible for design, manufacture and refueling of nuclear pressure vessels for Navy applications. From 1973 to 1978, I was lead engineer for the Power Systems Group of Combustion Engineering, Inc. and was responsible for the specification and procurement of primary nuclear steam supply system components. In this capacity, among other things, I acted as liaison with customers and various in-house groups, provided technical expertise, prepared sections of safety analysis reports and maintained familiarity with shop operations and status of components. From 1978-1982, I was Supervisor/Systems Engineering at Colt Industries, Fairbanks-Morse Engine Division. In that capacity, I supervised a group of eight engineers responsible for the engineering of diesel engines and diesel generator units for application in a variety of government, nuclear and commercial installations. In 1982, I became manager of engineering for PSD as described earlier.

Q.6. Are you a member of any industry committees involved in nuclear work?

A. (Iannuzzi) I am a member of a committee working on draft standard ANS 59.53, "Starting Air Systems for Standby Diesel Generators."

Q.7. Mr. Lewis, what is your current position with Morrison-Knudsen?

A. (Lewis) Technical Services Manager of PSD.

Q.8. Does the resume designated as Attachment 2 to this testimony accurately reflect your education and professional experience?

A. (Lewis) It does, though without much detail.

Q.9. For purposes of convenience, what are your responsibilities as Technical Services Manager?

A. (Lewis) As Technical Services Manager, I direct and administer PSD's field service activities. I act as liaison with customers and interface with responsible division departments in the resolution of any technical problems concerning PSD supplied equipment or equipment maintained by PSD under contract.

Q.10. Please summarize your prior professional and educational experience.

A. (Lewis) I received an A.S. Degree in refrigeration from Wilson Technical College in Wilson, North Carolina. Following other jobs involving servicing of electrical and mechanical equipment, in 1972 I joined PSD, which was then a division of Bruce GM Diesel, as an Electrician A. My duties involved the building and wiring of control panels, wiring engine electrical systems and motor controls and general electrical work. From 1974-1981, I was a Senior Test Technician at PSD and was responsible for performing complete testing of PSD-supplied diesel and turbine generator sets. Also, my duties included troubleshooting electrical and mechanical systems for gas turbine and diesel powered generator sets. In 1981, I became Technical Services Manager.

Since I have been Technical Services Manager, PSD has engaged in a great deal of service work at nuclear plants, all of which is within my responsibility. A partial listing of such service work for the years 1982 - 1983 is Attachment 3 to this testimony. As is shown there, in those two years, PSD did work on diesel generators at no less than eighteen nuclear plants, such as Nine Mile Point, St. Lucie Units I and II, Watt's Bar, Surry, Robinson, Beaver Valley, LaSalle, Grand Gulf, Turkey Point and others. Attachment 4 lists additional nuclear plants at which PSD has had experience. Attachment 5 lists additional non-nuclear installations at which PSD has had experience.

Q.11. Gentlemen, what is the purpose of your testimony?

A. (Iannuzzi and Lewis) Based on our experience with and knowledge of EMD and other diesel generators in both nuclear and non-nuclear applications, and the EMD diesel generators at Shoreham in particular, we will talk about the reliability of EMD diesel generators, and specifically those at Shoreham.

Q.12. Please describe your familiarity with the use of diesel generators at nuclear power plants.

A. (Iannuzzi) I have been involved in the application of diesel generators at nuclear power plants since 1978. While at Fairbanks-Morse I was the project engineer for diesel generator sets being fabricated for the Marble Hill, and Hope Creek plants, and as such was involved in all aspects of the design and fabrication of those units. Also as previously stated, I supervised engineers working on units for Limerick, Seabrook, Washington Public Power Supply System (WPPSS), Callaway and Wolf Creek. Since coming to PSD I have been personally involved with diesel generator sets at Sequoya, Watt's Bar, Brown's Ferry, St. Lucie 1 & 2, Zorita and Cofrentes (Spain), and have worked on modifications to units at WPPSS and Davis-Besse. In that involvement, I have become familiar with the application of the various codes and standards used in these installations at nuclear power plants, and with the starting, testing and operational needs in these applications. I am familiar with the safety-related aspects of emergency power in carrying emergency loads to bring the plant to a safe shutdown condition.

(Lewis) My experience is detailed in part in Attachments 3 and 4. I am responsible for overseeing all of the service work performed by PSD on the diesels at the listed nuclear plants. These lists are not complete, since PSD is continuing to engage in a great deal of nuclear diesel generator work, much of which involves retrofitting of older diesel generators.

Q.13. Please describe your familiarity with EMD diesel generators in the industry and, in particular, their application at nuclear plants.

A. (Iannuzzi) EMD diesel engines have been widely used in industry. They are used, for example, in locomotives, ships and drill rigs; however, PSD/M-K has not been involved with those applications. PSD's experience with EMD diesels includes their use in hospitals, military bases, utilities and nuclear plants. These include both skid mounted and housed units, such as those at Shoreham. I personally have been involved, at a minimum, with EMD diesels at the following nuclear plants: Sequoya, Watt's Bar, Brown's Ferry, St. Lucie 1 & 2, Zorita and Cofrentes (Spain). I have also been involved with modifications to EMD diesels at WPPSS, Davis-Besse and the Naval nuclear facilities at Windsor, Connecticut, and West Milton, New York.

Additionally, I have been involved with commercial units for the Norfolk, Virginia, Naval Station; King's Bay, Georgia, Naval Base; and Kotzebue, Alaska.

(Lewis) PSD has historically specialized in the nuclear application of EMD diesels. Today, it is one of eight jobbing contractors for EMD, which is a division of General Motors, though PSD sells and services other brands of power systems. PSD services many of the diesel generator sets it sells and many that it did not sell. This service, done under my supervision, runs from complete inspections, installations and overhauls to emergency repairs. PSD has recently been involved in the retrofitting and modification of diesel generators in nuclear service to enhance their reliability and to upgrade them. We have performed this service or are in the process of contracting for this service in approximately 37 nuclear plants. Finally, I have been responsible for the installation and preoperational testing of 64 diesel generators at the PSD shop, and 30 units at nuclear plant sites including TVA, Florida Power & Light, Duquesne Light, Zorita, Cofrentes (Spain), MP&L, Duke Power, Toledo Edison, Korea and the Phillippines.

Q.14. Are you familiar with the EMD diesel generators at Shoreham?

A. (Iannuzzi and Lewis) Yes.

Q.15. How did you acquire that familiarity?

A. (Iannuzzi) I have reviewed the manuals and maintenance records concerning those units, spoken with PSD service personnel responsible for their installation and maintenance, and actually visited the site and looked at the units in detail.

(Lewis) I became familiar with the units now at Shoreham when I became Technical Services Manager for PSD in 1981 when they were still owned by New England Power Company (NEPCO). I had a crew of five men acting as a service organization in the New England area. This crew serviced these machines at NEPCO. I visited the NEPCO site at least twice a year with them. I kept up a service record and made sure that work was performed in accordance with the contract. I was also involved in the engineering to connect these EMDs at Shoreham and supervised their installation. Through field service representatives, I coordinated all changes during installation. In addition, I have visited the Shoreham plant and have viewed the EMD diesels in place.

Q.16. Based on your experience with diesel generators, what are the criteria by which their reliabity can be judged?

A. (Iannuzzi and Lewis) The EMD diesel generators do not strictly comply with all technical requirements for qualified nuclear grade diesels. Nevertheless, there are a number of factors to which one would normally look to evaluate the reliability of diesel generators and an assessment of these factors for the EMDs at Shoreham allows us to assess their reliability with some degree of confidence. These factors include the following:

(a) whether the design has been proven through operating history;

(b) evidence of proper manufacturing processes;

(c) whether the application of the unit is consistent with its design and intended purpose;

(d) the inspection and maintenance history of the specific unit;

(e) the operating history of the specific unit; and

(f) whether the manufacturer's recommendations of replacement schedules have been followed.

Q.17. Are you familiar with the operating history of EMD engines?

A. (Iannuzzi) These units are EMD 645E4 engines. EMD 645E4 engines have been in service in applications on locomotives, shipboard and land based sites for many years. They are widely used and well accepted in the industry. In fact, this engine is in use in many nuclear plants.

(Lewis) The engines and generators on the four EMDs at Shoreham are the same as those in nuclear service at several nuclear plants which PSD services. They include Nine Mile Point I, Connecticut Yankee, Beaver Valley, Turkey Point, Surry, and others. Industry experience with this design has been positive and indicates their general reliability.

Q.18. Are you familiar with manufacturing processes for EMD engines?

A. (Iannuzzi) I have visited the EMD manufacturing facility at LaGrange, Illinois, and have seen the process by which these engines are made. EMD engines are produced from standardized parts so that all engines are essentially identical. Parts are not required to be individually hand fitted. The PSD Quality Assurance Department has performed audits of the EMD facility as far back as 1974 and qualified EMD as a supplier of equipment to our nuclear program. In my experience we have seen no problem with parts provided by the manufacturer that did not perform properly. Therefore, there is assurance not only that the engines were manufactured properly based on their history of reliability, but that replacement parts are and will be of high quality to maintain the past level of high reliability.

Q.19. Is the application of the EMD diesel generators at Shoreham consistent with the design and intended purpose of the units?

A. (Iannuzzi and Lewis) Yes. These units were designed for emergency duty and for use as peaking units. Originally, these were peaking units with minimum dead load pickup capability. When LILCO purchased them, LILCO installed, through PSD, the maximum dead load pickup capability so that the units can function most effectively in emergency situations. Again, as stated earlier, the same generator and engine is, in fact, in use at a number of nuclear plants as an emergency AC power source.

Q.20. Are you familiar with the inspection and maintenance history of the EMD diesels at Shoreham?

A. (Iannuzzi) Yes. I have reviewed the maintenance records from 1978 through 1983, and reports of work performed back to 1974. PSD has had the service contract for these units since 1978.

(Lewis) Yes. I have been responsible for inspection and maintenance of these units since 1981 and have reviewed the PSD and NEPCO maintenance records before that. From that review, it appears that the machines have been inspected and maintained in accordance with the manufacturer's recommendations.

Q.21. Describe the maintenance history of the EMDs now at Shoreham.

A. (Iannuzzi and Lewis) Since 1978, these units have been maintained in accordance with the PSD maintenance service contract which meets or exceeds the maintenance schedule published by EMD. The maintenance program consisted of monthly service trips to perform the maintenance program according to a set service schedule. The maintenance contract by which this service schedule was established is Attachment 6 to this testimony. All recommended maintenance has been performed and any conditions, which were discovered during these visits and which required additional service, were taken care of. There is but one exception. In 1981, EMD recommended that the viscous dampers on this model be changed to a different design which provides a longer service life. The viscous damper is a device which absorbs torsional vibration in crankshafts. The viscous damper has not been changed on three of the four units at Shoreham. If necessary, this change could be accomplished in two to three weeks. Even a failure of the viscous damper would not lead to an immediate catastrophic failure of the unit. In our opinion, the unit could run approximately 150 hours after such a failure before the unit would develop problems causing it to shut down. This is greater than the number of hours one would expect annually on such an emergency diesel generator at a nuclear plant at full power. Importantly, based on PSD's inspection of these units at Shoreham, there is no evidence of any problem with the viscous dampers on the three units still having the original design.

Additionally, the service records for the Shoreham EMD diesels show a number of instances of cracked cylinder heads. It has been our experience that early design heads produced by EMD were prone to cracking. These heads were commonly designated by EMD as "Circle 1 and 2" style heads. Later improved designs, designated as "Circle 3," "Diamond 3," or "Diamond 4," have corrected this problem. All heads on the four EMD units at

Shoreham are of the new design, that is, Circle 3, Diamond 3, or Diamond 4. From the maintenance records of the EMDs at Shoreham, it is evident that there have been no instances of cracking with the new heads.

Unit 1 (NEPCO's Unit 5) received all new power packs, consisting primarily of a cylinder liner, piston, connecting rod, and head, at 12,932 hours; Unit 3 (NEPCO's Unit 7) at 13,153 hours. Inspection of the other two units shows the power packs to be recommended for continued use and they have approximately 1,000 hours of use remaining before an overhaul is recommended by the manufacturer.

Units 3 and 4 (NEPCO's Units 7 and 8) had new turbo-chargers installed at 13,153 hours for Unit 3 and 10,962 and 11,696 hours for Unit 4. Presently we know of no reason the turbo-chargers on all four units should not continue to function properly.

Q.22. What does their maintenance history tell you about the reliability of the four EMD diesel generators at Shoreham?

A. (Iannuzzi and Lewis) The maintenance records show that these units have been properly maintained, and we therefore believe, based on our experience with EMD engines, that they should continue to operate reliably for the foreseeable future. This presumes that regular and proper maintenance continues.

Q.23. What should that maintenance consist of?

A. (Iannuzzi and Lewis) A continuation of the schedule referenced earlier and in Attachment 6.

Q.24. Are you familiar with the industry experience concerning starting reliability of EMD diesels?

A. (Iannuzzi) Yes. In the years 1968 through 1970, "fast-start" tests were performed by EMD on 17 diesels of the 645E4 type. A total of 1,720 successful starts in ten seconds or less were completed, and three failures were recorded for a total of 1,723 attempts or 99.9% success.

In the years 1971 through 1973, a total of 632 "fast-starts" were performed on five model 20-645E4 (20 cylinder) EMD engines by Bruce GM Diesel (the predecessor of Power Systems Division of Morrison-Knudsen). All starts were "successful" starts in ten seconds or less.

The engines subjected to the above tests were the same type of engine (645E4) as those at Shoreham, with the exception that the starting motors on the tested units consisted of redundant air start motors rather than the single electric motor used on the Shoreham units. Additionally, the engines were fitted with a backup electric fuel pump which would be used in the event of failure of the engine driven pump.

Q.25. Are you familiar with starting reliability of electric start units of the type used on the Shoreham engines?

A. (Iannuzzi) In 1967, EMD reported a success rate of 29,136 starts in 29,362 attempts on electric start units, or 99.23%.

(Lewis) PSD experience also shows that electric start units are reliable. There are many such electric start units in commercial use and a few in nuclear use. PSD services many such units and has experienced very few problems with their starting reliability.

Also, the log books for the four EMD diesels at Shoreham show that throughout their lifetime, there have been no failures to start. This is a reliability of 100% which is comparable to and better than the starting reliability found by EMD in its own tests discussed previously.

Q.26. What does this indicate about the starting reliability of these units?

A. (Iannuzzi and Lewis) It is evident that EMD 645E4 diesel engines are extremely reliable in starting, regardless of the type of starting motors used.

Q.27. Are you familiar with the operating history of the four EMDs now at Shoreham?

A. (Iannuzzi and Lewis) Yes. We have described above our familiarity with the engines and review of their operational as well as maintenance records.

Q.28. Describe their operating history and state what, if anything, can be deduced about their reliability from their operating history.

A. (Lewis) These units have been operated for periods of time between 12,833 and 13,277 hours. For the most part, they have been used as peaking units by NEPCO and were run at 2750 KW which is 110% of rated load. During this time, they operated very reliably. There were few problems and no shutdowns for major repairs because of an operating condition. In contrast, at Shoreham they would only be subject to 100% rated load on an infrequent basis which is a less severe load than the engines have already proven themselves capable of carrying.

Q.29. In assessing a diesel generator's reliabilty, do you distinguish between its past unavailability because of scheduled maintenance and its past unavailability because of unscheduled outages and, if so, why?

A. (Iannuzzi) Scheduled maintenance for a diesel generator normally implies work which is to be done for the purpose of maintaining the longevity of or improving the unit. Such work is normally planned for a time when the unit is not required to be available for service and can be rescheduled if the unit becomes needed. For this reason, it is my opinion that in assessing reliability, only unavailability due to unscheduled outages should be considered. That would be particularly appropriate here since low power testing presumably could be suspended if the diesel generators were out of service for scheduled maintenance.

Q.30. What is the historical availability of these units eliminating unavailability due to scheduled maintenance outages?

A. (Iannuzzi and Lewis) We are aware of no instance in which the units shutdown for repairs during operation as peaking units at NEPCO. Therefore, the historic availability of these units has been very high.

Q.31. What about compliance with the manufacturer's suggested replacement schedule?

A. (Lewis) Except for the viscous dampers mentioned earlier, all replacements have been made. It is further assuring to observe that NEPCO always replaced parts with new parts when available. It only used UTEX parts, which are parts rebuilt by EMD, when new ones were not available. In my experience, the UTEX parts are perfectly reliable.

Q.32. Can you compare the features of the EMD diesel generators at Shoreham with EMD diesel generators which have been qualified for use at nuclear power plants?

A. (Iannuzzi and Lewis) The EMD model 645E4 diesel engine is a standardized design which has been in continuous production since 1965. There have been 843 units provided for service worldwide in the configuration similar to the units at Shoreham and a total of 16,230 turbocharged 645E4 engines produced. M-K Power Systems Division has provided 65 generator sets, and 110 engines for service in nuclear power plants; additional units have been provided to nuclear plants by GM-EMD and other packagers. The 645E4 engines are the same regardless of the application. Similarly, the generators on the units at Shoreham are identical to those in service at some nuclear plants.

The difference between the Shoreham units and diesel generators which have been qualified for use at nuclear power plants is in the auxiliary equipment which supports the operation of the engine. That equipment includes such items as piping, valves, pumps, heat exchangers, tanks, supports, and electrical equipment. The equipment qualified for use at a nuclear power plant is usually designed and manufactured to specific codes and standards, with consideration given for environmental and seismic qualification and quality assurance documentation. These requirements for the auxiliary equipment are different from the standard commercial items otherwise used. Despite these different component items, the systems and the design parameters for them remain the same.

For example, the design requirements in ASME Section 3 -- a major design criterion -- are intended to ensure the integrity of the pressure boundary of the components and systems during operation under design conditions. Units of the Shoreham design, though not designed to ASME Section 3, have nevertheless withstood many thousands of hours of operation and we are aware of no catastrophic failures of the pressure boundary related to auxiliary equipment. By this, we mean that there have been no failures causing the units to shut down. If such failures had occurred, we would expect to know about them either because they would have been incurred by one of PSD's many customers or because it is our business to keep abreast of such problems industry-wide in order to better perform our jobs.

Similarly, the diesels at Shoreham do not have Class I-E wiring and electrical equipment which means that the equipment has not been environmentally qualified for these specific units. Nevertheless, this same grade of equipment is in use in many of the EMDs with which we are familiar and has suffered no major failures of which we are aware. The equipment in the specific units at Shoreham is the original equipment and likewise has suffered no major failures. Similarly, the electrical equipment in LILCO's EMD diesels at Montauk is the same and has functioned with no major failures in an environment similar to Shoreham with respect to temperature, humidity, air quality and the like.

One important factor to note in comparing these diesels to those in nuclear service is that these diesels do not have to "fast start." Unlike qualified nuclear diesels necessary for full power operation which must reach their rated speed in a matter of seconds, the

EMDs at Shoreham can idle for several minutes and still have power supplied in timely fashion. This reduces excessive wear on the engine and reduces stress on the auxiliary package. Additionally, the duration over which these EMDs will be used at Shoreham for emergency AC power is limited especially when compared to the 40 year expected life of qualified diesels.

Q.33. Please address the fire protection available to the EMDs at Shoreham and how that might affect their reliability.

A. (Iannuzzi and Lewis) Fire protection available at the EMD units at Shoreham consists of hand held fire extinguishers. Our experience with stationary diesel units of this type is that fires are very rare occurrences. In fact our servicemen have been called in to service only one stationary unit which had been involved in a fire. That fire was caused by a component in the starting system overheating as a result of repetitive start attempts. The consequences of the fire were confined to limited electrical damage. We have not received any other reports of stationary EMD units which have been involved in fires of any kind.

Q.34. Do you have any overall opinion as to the reliability of the four EMD diesel generators at Shoreham and as to whether one of the four can be expected to start and operate when needed in an emergency situation?

A. (Iannuzzi and Lewis) Given the previous starting history of these units, their overall condition, their maintenance records and our experience with EMD engines, it is our opinion that the reliability of these four units will continue to be good for the foreseeable future. We would expect the likelihood that all four units will start and operate in an emergency situation is very high, and that therefore the likelihood that one of the four will start and operate is virtually assured.

POWER SYSTEMS DIVISION/MANAGER OF ENGINEERING

MORRISON-KNUDSEN COMPANY, INC.

JOB TITLE: MANAGER OF ENGINEERING

NAME: Thomas W. Iannuzzi, P.E.

EDUCATION: Pennsylvania State University, 1968
Bachelor of Science, Mechanical Engineering

Union College, 1973
Master of Science, Industrial Administration

BUSINESS EXPERIENCE:

1982 - Present — POWER SYSTEMS DIVISION OF MORRISON-KNUDSEN COMPANY, INC.

Manager of Engineering - Responsible for direct supervision of project engineers designers and document control personnel required to design complete diesel and turbine generator systems for utility, military and emergency applications. Participation in meetings with customers/vendors as a technical advisor. Supervision of engineering staff in review of test reports, equipment specifications, review of vendor and Power Systems' quotations and production assistance. Writes and certifies Design Specifications for ASME Code components and reviews and approves design reports for Nuclear Projects. Reviews Nuclear Owner's Design Specifications, and implements Codes and Standards related to safety class equipment for Nuclear power generating stations.

1978 - 1982 — COLT INDUSTRIES
FAIRBANKS MORSE ENGINE DIVISION
BELOIT, WISCONSIN

Supervisor/Systems Engineering - Supervisor of a group of eight engineers responsible for the engineering of diesel engines and diesel generator units for application in a variety of Government, nuclear and commercial installations.

Responsible for projects involving the application of diesel generators for standby power in nuclear power plants. Units were designed and built to ASME Section III Class 3, and this position required detailed knowledge and application of Code requirements in all phases. Included working within the guidelines of the Nuclear Quality Assurance program in effect in the department and reviewing available nuclear industry reports for overall applicability to the equipment.

Thomas W. Iannuzzi, P.E.

BUSINESS EXPERIENCE: (Continued)

Earlier position was as a Project Engineer, responsible for projects involving the application of diesel generators for standby power in nuclear power plants, including all phases of the project, from specification review through design, drawing preparation, manufacturing, test and shipment. This included close coordination with the customer and many individuals within the company to assure timely completion of the project.

1973 - 1978

COMBUSTION ENGINEERING, INC.
POWER SYSTEMS GROUP
WINDSOR, CONNECTICUT

Lead Engineer - Responsible for the specification and procurement of major nuclear steam supply system components built to ASME Code Section III requirements. This involved translating contract requirements into technical specifications and providing technical follow of the order, including liaison with the customer and various in-house groups. Specific duties as a Lead Engineer included: providing technical expertise and performing detailed review of all safety related work performed by three engineers in the procurement of the components; preparing sections of the Safety Analysis Reports which are used in obtaining the Operating License for the power plant; obtaining and evaluating quotations for equipment, and preparing cost estimates for changes to existing contracts; and maintaining familiarity with shop operations and status of components.

1968 - 1973

GENERAL ELECTRIC COMPANY
MACHINERY APPARATUS OPERATION
SCHENECTADY, NEW YORK

Cognizant Engineer - Engineer for a procurement organization responsible for design, manufacture and refueling of nuclear pressure vessels for Navy applications. Specific duties included: writing specifications for new procurements; reviewing vendor drawings, procedures and schedules for conformance to contract and military specifications; rendering technical assistance in vendor production problems; evaluating manufacturing discrepancies and proposed changes to design for operational suitability; making and substantiating technical recommendations for design improvements to the government; resolving problems arising during installation, and coordinating activity and planning concerning pressure vessels during refueling; and establishing a computer system for maintaining control of shipping and storage equipment.

PROFESSIONAL REGISTRATION:

Professional Engineer, State of Connecticut

POWER SYSTEMS DIVISION/TECHNICAL SERVICES MANAGER
MORRISON-KNUDSEN CO., INC.

TITLE: Technical Services Manager

NAME: Kenneth A. Lewis

EDUCATION: Wilson Technical College, Wilson, North Carolina
A. S. - Electronics

BUSINESS EXPERIENCE:

June 1981 - Present
Power Systems Division/Morrison-Knudsen Company, Inc.
Technical Services Manager

Administers and directs Division field service activities, acts as liaison with customers and interface with responsible Division department in the resolution of any technical problems concerning Power Systems Division supplied equipment or equipment being maintained under contract.

October 1974 - June 1981
Power Systems Division/Morrison-Knudsen Company, Inc.
Senior Test Technician

Responsible for performing complete testing of Power Systems Division supplied diesel and turbine generator sets. Additional duties included troubleshooting electrical and mechanical systems on generator sets, design of mechanical and electrical systems for gas turbine and diesel powered generator sets.

March 1972 - October 1974
Power Sytems Division/Bruce GM Diesel
Electrician A

Job duties required the building and wiring of control panels, wiring engine electrical systems and motor controls, general electrical work.

February 1970 - March 1972
Pullen Refrigeration
Service Mechanic

Responsible for job estimates, servicing all types of refrigeration equipment, control wiring and general electrical duties.

September 1969 - February 1970
Bedgood Heating and Air Conditioning
Installation Mechanic

Duties were the installation and servicing of residential heating and air conditioning systems.

PARTIAL LISTING OF SERVICE WORK 1982/1983

(A) NUCLEAR
DOMESTIC

	CUSTOMER	LOCATION	WORK PERFORMED
1.	Niagara Mohawk Corp. 9 Mile Point	Oswego, N.Y.	Supervised Annual Inspection Upgrade EMD Engines
2.	Florida P&L Co. St. Lucie I&II	Hutchinson Is., FL	Furnished Material and Supervised Total EMD Retrofit Package. Held 5 day Training School.
3.	Tennessee Valley Authority Watts Bar	Spring City, TN	Inspect Retrofits and Installation
4.	Sacramento Municipal Utility District Ranch Seco	Sacramento, CA	Performed Annual Inspection and Minor Repairs
5.	Virginia Electric Power Co. Surry	Surry, VA	Emergency Repair Speed Sensing and Control Panel
6.	Carolina Power & Light Robinson	Hartsville, SC	Supervised Annual Inspection
7.	Portland G.E. Co. Trojan	Ranier, Oregon	Supervised Installation of Retrofit Equipment
8.	Duquesne Light Co. Beaver Valley	Pittsburgh, PA	(a) Supervise Annual Inspection EMD 999 Units (b) Start-up New PSD-M-K 2500 KW Unit
9.	Newport News Ship-building Nuclear Aircraft Carrier	Newport News, VA	Supervise Repair of Four (4) Engines
10.	Commonwealth Edison Co. La Salle	Marseilles, Ill.	Performed Turn-Key Modification On 6 Engines

PARTIAL LISTING-(A) NUCLEAR/DOMESTIC (contd.)

11.	Jersey Central Power & Light Oyster Creek	Toms River, NJ	Inspection and maintenance on EMD MP45 Units
12.	Duke Power Co. Oconee	Clemson, S.C.	Training School and startup of PSD-MK Furnishe Gen Set
13.	Ebasco-TVA Phipps Bend	Knoxville, TN	Supervise removal and loading for transfer to another Nuclear Plant
14.	Mississippi Power & Light Grand Gulf	Port Gibson, Miss.	Held three (3) consecutive Training Schools
15.	Northeast Utilities Connecticut Yankee	Hartford, Conn.	Performed Annual Inspectic on TW (2) EMD 999 Units
16.	Florida Power & Light Turkey Point	Miami, FL	Performed Inspection & Services
17.	Wasington Public Power	Washington	Install Engine Modificatio
18.	Main Yankee Atomic Power Co.	Wiscasset, ME	Supervise Installation of Modification To EMD Engine

(B) COMMERCIAL

1.	AT&T (Formerly Western Electric)		Work performed all parts of U.S.-Startup Retrofit-Emergency. Schools and Training held semi-annuall
2.	Panama Pipeline		Start-up, maintenance and personnel training of 20 M PSD-M-K provides power pla
3.	Abbott Labs Rocky Mount		Check-out and start-up DDAD Unit.
4.	Florida Power & Light Flagler Street Station		Emergency Electrical Repai
5.	Detyens Shipyard Mt. Pleasant, SC		Performed Engine Overhaul on USS Mohawk

PARTIAL LISTING-(B) COMMERCIAL (contd.)

6.	Military Sealift Command Little Creek, VA	Inspection of Main Propulsion Engine
7.	Kotzebue Electric Alaska	Startup on two Diesel Gen Sets
8.	New England Telephone Co. Essen Junction, Mass.	Emergency Repair and Modifications
9.	West Indies Oil St. Johns, Antiquia	Emergency Repair
10.	Horne Bros.	Assist in Sea Trials on LST
11.	Cementios Nationales Dominican Republic	Install and Start up Two 2500 KW Units
12.	VA Hospital Vermont	Perform Inspection and Repairs to standby Gen Set

FOREIGN

CUSTOMER	LOCATION	WORK PERFORMED
Uniona Electrica Zorita	Spain	Supervise start-up 2000 KW PSD/M-K Diesel Gen Set
Almaraz	Spain	Supervise Modifications to Engine Gen Sets
Cofrentes	Spain	Supervise Total Retrofit of Engine - Start-up and Commissioning
Westinghouse Philippines	Philippines	Start-up two PSD/M-K Tandem Units
Westinghouse Korea	Korea	Start-up two PSD/M-K Tandem Units
Taiwan Utility Taiwan	Taiwan	Supervise Start-up 4400 KW Tandem Diesel Gen Sets

EXPERIENCE

Nuclear Plants

Sacramento Municipal Utility District
Rancho Seco Nuclear Generating Station
Bechtel Corporation, Vernon, California, Engineers
2 - 2750 KW units Single Engine

Power Authority of the State of New York
James A. Fitzpatrick Nuclear Power Plant
Stone & Webster Engineering Corporation
Engineers 4 - 2600 KW units - Single Engine
Forced Synchronized

Tennessee Valley Authority
Sequoyah Nuclear Plant
TVA - Engineer
4 - 4000 KW units - Tandem Engine

Portland General Electric Company
Trojan Nuclear Plant
Bechtel Corporation, San Francisco, California - Engineers
2 - 4416 KW units - Tandem Engine

General Electric Company
Atomic Power Equipment Division
1 - 2600 KW - Standby for HPCS Pump - Single Engine

Taiwan Power Company
Chin-Shan Nuclear Power
Ebasco Services, Inc. - Engineers
4 - 3650 KW units - Tandem Engine

Toledo Edison Company
Davis Bessee Nuclear Plant
Bechtel Corporatioin, Gaithersburg, Maryland, Engineers
2 - 2600 KW units - Single Engine

Tennessee Valley Authority
Browns Ferry Nuclear Plant
TVA - Engineer
4 - 2600 KW units - Single Engine

GEAPED - Atomic Power Equipment Division
Laguna Verde - Mexico
2 - 2200 KW - Standby for HPSC Pump - Single Engine

EXPERIENCE CONTINUED

Nuclear Plants Continued

GEAPED - Atomic Power Equipment Division
Grand Gulf Nuclear Plant I & II
Mississippi Power and Light
2 - 3300 KW - Standby for HPSC - Tandem

Empresarios Agrupados - Spain
Central Nuclear de Almaraz
Gibbs & Hill - Engineers
3 - 4406 KW, 50 Hz. units - Tandem

GEANED - General Electric Nuclear Energy Division
Kuo Sheng
Taiwan Power Authority
2 - 2400 KW Units - Standby for HPCS Pump - Single Engine

Tennessee Valley Authority
Watts Bar
TVA Engineer
4 - 4750 KW Units - Tandem

Electric Boat Division
General Dynamics Corporation
West Milton, New York Facility
2 - 1700 KW Units - Single Engine

GENED - General Electric Nuclear Energy Division
COFRENTES - Spain
1 - 2400 KW, 50 Cycle Unit - Tandem Engine

GENED - General Electric Nuclear
Energy Division CNV
Val de Caballeros - Spain
2 - 2600 KW, 50 Cycle Unit - Tandem Engine

HIDRO ELECTRICA ESPANOLA
2 - 4407 KW, 50 Hz. Tandem

FLORIDA POWER & LIGHT
ST. LUCIE II Nuclear Plant
2 - 3800 KW Tandem Units

Westinghouse International
KRSKO Nuclear Plant
Yugoslavia
2 - 3920 KW, 50 Hz. Tandem

EXPERIENCE CONTINUED

Nuclear Plants Continued

GENED
Skagit Nuclear Plant
1 - 3300 KW Tandem Unit

GENED
TVA Hartsville & Phipps Bend
6 - 2500 KW Units

Rental Unit - Housed
Dresden Nuclear (1 Yr.)
1 - Housed 2500 KW

GENED
Black Fox Nuclear 1 ea.
2 - 2500 KW Units 1 ea.

GENED
Allens Creek Nuclear (1)
1 - 2500 KW Unit

Westinghouse International
PHPP - 1 Nuclear Power Plant
2 - 4840 KW Tandem Units

Ebasco Engineers
CFE - Mexico
Laguna Verde Nuclear
2 - 3676 KW Tandem Units

Duke Power
Oconee Nuclear
1 - 3500 KW Tandem Unit

Westinghouse International
Kori Nuclear - Korea
2 - 4840 KW Tandem Units

Tennessee Valley Authority
Sequoyah Nuclear
Watts Bar Nuclear
2 - 4750 KW Tandem

Union Electrica, S.A.
Zorita Nuclear Plant
1 - 2600 KW Unit

Pennsylvania Power & Light
Susquehanna Nuclear
1 - 5000 KW Unit

NON-NUCLEAR INSTALLATIONS

U.S. Health, Education and Welfare Dept.
Research Triangle, Raleigh, NC
1 - 1150 KW Unit

Western Electric Company
Long Line Communication Center - Via Satellite
323 Broadway, New York
4 - 2500 KW Units

Southern Bell Telephone Company
Orlando, Florida
1 - 1200 KW Unit

Southern Bell Telephone Company
Miami, Florida
1 - 1200 KW Unit

Orange Hospital
Orange, New Jersey
1 - 1575 KW Unit

Guam Power Authority
2 - 2500 KW UNits

Meadowbrook Hospital
East Meadow, Long Island, NY
2 - 1575 KW Units

U.S. Navy
Guantanamo Bay, Cuba
2 - 2100 KW Housed Units

Southern Bell Telephone Company
Jacksonville, Florida
1 - 2500 KW Unit

PANAMER
Departamento del Distrito Federal (City of Mexico)
Mexico
2 - 2100 KW Units, 50 Hz. and 1 - 1750 KW Units, 50 Hz.

Departamento del Distrito Federal (City of Mexico)
Mexico
2 - 1350 KW Units, 50 Hz.

U.S. Navy
12 - 2000 KW Trailer Mounted Gas Turbine Units

NON-NUCLEAR INSTALLATIONS CONTINUED

Kansas City Power & Light
La Cygne Power Station
1 - 2200 KW Housed Unit

Eureka Stone Quarry, Inc.
1 - 2100 KW Unit
1 - 2500 KW Unit

Brooklyn V.A. Hospital
New York
1 - 2000 KW Housed Unit

City of Petersburg, Alaska
1 - 2500 KW Unit

Spanish Air Ministry
Madrid, Spain
8 - 3100 KW, 50 Hz. - Housed Units - Forced Synchronized

Instituto Ecuatoriano de Electrificacion
Manta, Ecuador
1 - 2500 KW Unit

National Electric Power Authority
Lagos, Nigeria
3 - 2100 KW, 50 Hz., Housed Units

New York & Honduras Rosario Mining Co.
Honduras, Central America
1 - 2500 KW Unit

Allis Chalmers Corporation
City of Winston Salem, NC
1 - 2350 B.H.P. Pump Unit for Raw Water

International Manufacturing and Equipment Company
Impergilio
Salto Grande, Argentina
1 - 2100 KW, 50 Ha. Unit

Instituto Ecuatoriana de Electrification
Esmaraldes, Ecudor
2 - 2500 KW Unit

Flintkote Company
Calavaras Cement
Calavaras, California
1 - 750 KW Unit

NON-NUCLEAR INSTALLATIONS CONTINUED

Western Electric
A. T. & T. Cambridge, Mass.
2 - 2500 KW Units

INECEL - Ecuador
1 - 1575 KW Unit

Merk Sharpe & Dohme
1 - 2500 KW Unit

Spanish Air Ministry
Madrid, Spain
2 - 2100 KW, 50 Hz., Housed Units - Forced Synchronized

Electricity Board of Isafjordur
Iceland
1 - 2100 KW, 50 Hz. Unit

County of Fairfax
Lower Potomac Pollution Control Plant
Fairfax, Virginia
3 - 2500 KW Housed Units

Power Equipment Company, Inc.
City of Euclid, Ohio
1 - 1575 KW Unit

Rosario Resources Corporation
Puerto Cortez, Honduras
1 - 2500 KW Unit

Western Electric
A. T. & T. Rego Park, New York
2 - 2500 KW Units

City of Norton
Kansas
Housed 2500 KW Unit

U.S. Naval Facilities Command
12 - 2500 KW Housed Portable Sets

Potashnik Contractors
Barge - Operating
Arabian
5 - 2500 Skid Mounted

Pecon
Dept. of Water & Electricity
ABU DHABI
7 - 2100 KW, 50 Hz. Housed Units

NON-NUCLEAR INSTALLATIONS CONTINUED

Deputy Ministry of War
For Armament
Iran
1 - 2500 KW Skid Mounted

Miles Laboratory
Elkhart, Indiana
2 - 2500 KW Skid Mounted

PEMEX
Oil Drill
Gulf of Mexico
3 - 2500 KW Skid Mounted

Sistema Electrica Regional Manabi
City of Manta
Ecuador
1 - 2500 KW Skid Mounted

Jeddah Hospital
Saudi Arabia
2 - 2500 KW Skid Mounted

PEMEX
Oil Drill
Gulf of Mexico
3 - 2500 KW Skid Mounted

Williams Export
Paper Plant - Ecuador
1 - 2500 KW Skid Mounted

City of Malagro
Ecuador
2 - 2500 KW Housed Units

Rosario Resources
Puerto Cortez, Honduras
1 - 2500 KW Skid Mounted

Carolina Power & Light
H.B. Robinson Nuclear Plant
1 - 2500 KW Housed Unit

City of Iola
Kansas
1 - 2500 KW - Housed - MP

NON-NUCLEAR INSTALLATIONS CONTINUED

City of Russell
Kansas
1 - 2500 KW - Housed - MP

General Electric International
Saudi Arabia
1 - 1600 KW Skid Mounted

American Samoa
1 - 2500 KW Skid Mounted

American Samoa
1 - 2500 KW Skid Mounted

Hankook Tire Company
Pusan, Korea
2 - 2000 KW Skid Mounted

Georgia Power Company
Wansley
1 - 2200 KW Housed

General Public Utilities
Three Mile Island
1 - 2500 KW Housed

General Public Utilities
Three Mile Island
1 - 2500 KW Housed

Cementos Nationale
Dominican Republic
2 - Housed 2500 KW Units

Kansas Power & Light Co.
Hutchinson Energy Center
1 - 2750 KW Peaking Housed Unit - MP

N.Y. State Electric & Gas Corp.
Somerset Station
1 - 2200 KW Skid Mounted
1 - 1600 KW Skid Mounted

Duquesne Light Company
Beaver Valley Nuclear Plant
1 - 2500 KW Skid Mounted

NON-NUCLEAR INSTALLATIONS CONTINUED

Balbina Project
Brazil
1 - 2150 KW Housed Unit

St. John River Project
Jacksonville Electric Co.
1 - Tandem - 1400 KW Housed Unit

Jefferson Parish
New Orleans, LA
3-2305 BHP Pump Drives

Kotzebue, Alaska
1 - 20-645E4 Engine For Existing Gen.
1 - 1750 KW, 720 RPM Unit

U.S. Government - USN
Kings Bay, GA
3-2500 KW Housed Units

U.S. Government - USN
Norfolk, VA
1 - 2000 KW, 11.5 KV Unit

U.S. Government - USN
Norfolk Naval Shipyard
1 - 2500 KW Unit

Martin Marietta Alumina
St. Croix - Virgin Islands
1 - 2600 KW Unit

Perulack Compressor Station
Texas Eastern - Dresser Clark
DC - Turbine (Replaces Obsolete Turbine)

Amtrak New Haven Maintenance
Dresser Clark
1 - DC-990 Gas Turbine Unit, 4580 KW

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APPENDIX "B"

Power Systems Division will provide the following services:

PART I

Periods of Inspections:

(a) Monthly, Every 3 Months, Every 6 Months, Annually, After 3 Years, After 6 Years.

(b) After First 350 Hours of Operation, Every 350 Hours Thereafter, After 700 Hours, After 1400 Hours, After 2000 Hours, After 4000 Hours, After 8000 Hours, After 12,000 Hours, After 16,000 Hours, After 24,000 Hours, and After 72,000 Hours.

Every Month:

A. VISUALLY INSPECT FOR LEAKS

1. Cooling system at following locations:

   a. Radiators and headers
   b. Marmon flexible couplings
   c. Thermostatic valves
   d. Immersion heaters, pump and piping
   e. Engine water pumps
   f. Water expansion tank, gauge glass and piping
   g. Water connections, valves and plugs on engine

2. Fuel System at following locations:

   a. Fuel transfer pumps and piping
   b. Filters
   c. Engine driven pumps and piping
   d. Day tank connections
   e. Fuel transfer system and piping
   f. External fuel manifolds and connections

3. Lube Oil System at the following locations:

   a. Filters and piping
   b. Circulating pump and strainer
   c. Auxiliary lube oil tank and piping connections
   d. Connections to the lube oil cooler
   e. Main bearing pressure switch and gauge connections
   f. Piping, valves, and plugs under the deck

g. Turbine filters and oil lines
h. Engine pressure and scavenging oil pumps, oil separator
i. Engine gaskets
j. Governor, priming

4. Exhaust system at the following locations:

a. Exhaust manifold base flanges
b. Exhaust manifold to turbocharger
c. Turbocharger to outlet piping
d. Exhaust manifold section connections

B. ENGINE AIR INTAKE FILTERS:

1. Check oil level in oil bath type filters
2. Check indicator of disposable paper elements

C.. VISUALLY CHECK THE FOLLOWING FLUID LEVELS

1. Governor Oil (running)(use 30 weight oil)
2. Engine Oil (idling)
3. Engine Coolant

D. MAKE THE FOLLOWING VISUAL AND AUDIO INSPECTION WITH THE ENGINE OPERATING AT IDLE SPEED

1. Listen for unusual engine and turbine noises
2. Fan and fan drive system for normal operation
3. Check stack damper for proper opening (MP-36 only)

E. CHECK BATTERY CONDITION

1. Check electrolyte level - Add water if required
2. Check electrolyte specific gravity of pilot cell
3. Check cell voltage
4. Inspect connections for corrosion
5. Observe charger operation by manually starting charger
6. Initiate 24-hour equalizing charge

F. CHECK PERFORMANCE OF STANDBY HEATING SYSTEM

1. Note readings of oil and water temperature gauges
2. Check stack damper for proper closure with the engine stopped (MP-36 only)

G. VISUALLY INSPECT ELECTRICAL CABINETS

1. MP Unit generator and engine cabinets for discolored connections and field relay appearance
2. MP Unit starting and solenoid contactors

H. GENERAL UNIT INSPECTION:

1. MC Unit (Control House)

   a. Check all positions of unit and bus metering
   b. Check circuit breaker indicator lights for proper indication
   c. Observe synchronizer of performance during automatic start
   d. Note that breaker trips open between 300 and 600 KW when stopping unit

2. MP Units (Power Unit)

   a. Observe exhaust for proper condition
   b. Note governor rack stop setting (check meter in MC)
   c. Note engine temperature and pressure gauges for proper indication
   d. Note that no unusual noise or vibration exists
   e. Give unit complete operating sequence check by initiating start and stop cycles, using all controls

Every Three Months:

A. Drain condensate from Fuel Tank

B. Change auxiliary turbocharger oil filter element or clean metal auxiliary oil filter element as applicable.

C. Take sample of engine lube oil for customers laboratory analysis

D. Clean and lubricate starters

E. Lubricate door hinges and inspect door seals and locks

F. Lubricate ventilating fan motor bearing on MC unit or outdoor switchgear station

G. Lubricate cooling fan bearings unless 700 hour lubrication occurred first

H. Lubricate shutter linkage and motor

Every Six Months:

A. Check operation of protective devices and annunciators

B. Check inhibitor and add treatment as required (Spring and Fall) "in cooling system".

Every Year:

A. Lube oil system

1. Clean scavenging oil screens
2. Change filters and clean filter housing
3. Remove and clean oil separator
4. Inspect and clean oil filter bypass valve
5. Remove and clean strainer in strainer housing

B. Engine

1. Retorque engine nuts and bolts
   a. Head frame to crankcase bolts
   b. Turbocharger to aftercooler air duct bolts
   c. Turbocharger compressor scroll flange bolts
   d. Engine and generator hold down bolts
   e. Check top deck cover seals

2. Check settings
   a. Overspeed trip by intentionally overspeeding the engine
   b. Lash adjusters by observation with engine idling
   c. Governor rack setting, valve and injector timing

3. Ejector Eductor Tube Assembly
   a. Inspect for carbon deposits and clean

4. Governor oil - flush and change

C. Generator

1. Visually inspect and clean

D. Electrical Cabinets and Compartments

1. Visually inspect and clean

   a. Voltage regulators
   b. Synchronizer
   c. All relays, contactors, and circuit breakers

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Every Year (Cont'd.)

2. Remove Circuit Breakers from Compartments

   a. Clean insulators
   b. Lubricate linkage bearings
   c. Check operation manually and electrically in test position

E. Lube Oil Circulating Pump

   1. Remove and clean check valve

   2. Replace spider

F. Engine Air Intake Filters

   1. Disposable paper elements

      a. Check for deterioration

   2. Oil Bath Type Filters

      a. Change oil and clean sump
      b. Clean filter media

G. Exhaust System

   1. Manifold connections

      a. Inspect for cracks and leaks
      b. Torque manifold base bolts

<u>Every Three Years:</u>

A. Crankcase Pressure Detector

   1. Unit exchange *(See Note 1)

<u>Every Six Years:</u>

A. Cylinder Head Grommets, Outlet and Inlet Seals, Lower Liner Seals

   1. Replace if not already changed at 8000 Hours. *(See Note 1)

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After First 350 Hours:

After first 350 hours of operation, on a replacement engine or a newly installed service part:

A. Engine nut and bolt retorquing

1. Cylinder liner water inlet line nuts and bolts
2. Exhaust manifold flange bolts
3. Cylinder head crab nuts
4. Head frame to crankcase bolts
5. Turbocharger to after cooler air duct bolts

Every 350 Hours of Operation:

A. General Examination

1. Inspect cooling fan belts for defects
2. Visually inspect cylinder head mechanism with engine at idle speed and at operating temperature
3. Add required amount of lube oil
4. Fill oil cups on engine water pumps
5. Check operation of crankcase pressure detector

Every 700 Hours of Operation:

A. Engine

1. Inspect by barring over and observing the following:

   a. Air box drain
   b. Pistons, piston rings and cylinder liners
   c. Piston to head clearance
   d. Engine cooling system for leaks
   e. Engine fuel system for leaks

B. MP45 Units, Lube Oil Filters

1. Change the following:

   a. Engine filter elements
   b. Engine mounted turbocharger filter element
   c. Auxiliary turbocharger filter element

Every 700 Hours (Cont'd.)

C. MP26, MP27, MP36 Units, Lube Oil Filters

1. Change engine lube oil filters
2. Clean turbo oil supply filter

D. Cooling System

1. Check fan belt tension
2. Lubricate cooling fan bearings unless the three months lubrication occurred first

E. Fuel Filters

1. Clean fuel suction strainer
2. Change engine mounted fuel filter elements
3. Change fuel transfer pump filter elements (where used)

Every 1400 Hours of Operation:

A. Engine

1. Check engine speed
2. Remove and clean oil separator element
3. Inspect ejector tube for carbon deposits and clean if necessary

B. Engine Air Intake Filter

1. Disposable paper element

   a. Change elements if required

2. Oil bath type filter

   a. Change oil, clean sump and filter media

C. Engine Aftercoolers (Air bath filter equipped engines only)

1. Take manometer reading across aftercoolers
2. Clean air passages if required *(See Note 1)

Every 2000 Hours of Operation:

A. Lube Oil System

1. Change engine lube oil unless yearly occurred first

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Every 2000 Hours (Cont'd)

B. Engine

1. Remove and clean strainers in strainer housing
2. Clean scavenging oil screens
3. Clean oil pan
4. Clean filter housing
5. Check injector timing and injector rack length
6. Check all external bolts - tighten if necessary

C. Generator

1. Inspect slip rings and brushes
2. Check for heat, noise, or grease purging at bearing

D. Fuel System

1. Check operation of fuel transfer system controls, switches, and alarms

Every 4000 Hours of Operation:

A. Engine

1. Inspect top deck cover seal and latches
2. Retorque cylinder head crab nuts
3. Retorque main lube oil and piston cooling oil pump shaft nuts
4. Retorque rocker arm assemblies
5. Inspect harmonic balancer

B. Exhaust System

1. Remove manifold screen. Check for cracks and clean. Clean the trap (if applies)
2. Inspect manifold connectors for liner cracks and replace if necessary

C. Lube Oil System

1. Remove and clean turbo oil filter check valve in the engine mounted turbocharger filter head
2. Clean and inspect lube oil filter bypass valve

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Every 4000 Hours (Cont'd)

D. Cooling System

1. Check operation and setting of engine water temperature controls
2. Check torque on flexible pipe coupling bolts
   Check for hardened or damaged gaskets
4. Clean and inspect radiators

E. Inertial Filters (MP-45 units only)

1. Take manometer readings across inertial filters. Engine at full speed, no load

Every 8000 Hours of Operation:

A. Engine

1. Replace cylinder head grommets, outlet and inlet seals and lower liner seals. *(See Note 1)
2. Clean top deck, air box, and oil pan
3. Qualify injectors *(See Note 1)
4. Check lash adjusters
5. Check valve timing, reset injector timing and injector racks
6. Unit exchange engine water pumpes *(See Note 1)
7. Inspect engine driven fuel pump
   a. Replace if needed *(See Note 1)

B. Starting Motors

1. Inspect starting motors and renew parts if necessary *(See Note 1)

C. Lube Oil Soak Back System

1. Remove and clean

   a. Soak back check valve
   b. Soak back oil pressure relief valve
   c. Soak back filter bypass valve in soak back filter head
   d. Soak back pump motor (clean with dry air)
   e. Replace coupling spider *(See Note 1)

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Every 8000 Hours (Cont'd)

D. Cooling System

1. Replace cooling system pressure cap

Every 16000 Hours of Operation:

A. Engine Overhaul *(See Note 1)

1. Install new thrust collars
2. Install new lower main bearings
3. Replace cylinder assemblies (power pack change-out)
4. Inspect and qualify connecting rod bearings
5. Inspect and qualify piston cooling tubes
6. Replace water pump seals and all worn parts

B. Turbocharger (Manufactured prior to 71D serial number)

1. Unit exchange *(See Note 1)

C. Soak Back or Lube Oil Circulating Pump and Motor

1. Unit exchange *(See Note 1)

D. Cooling System *(See Note 1)

1. Replace flexible coupling seals (MP26 and MP36 only). Replace internal parts of temperature regulating valve..

Every 16000 Hours of Operation:

A. Turbocharger (Manufactured with 71D or later serial number)

1. Unit exchange *(See Note 1)

B. Flexible drive couplings

1. Inspect flexible drive couplings for torn or split rubber bushings

Every 24000 Hours of Operation:

A. Lube Oil System *(See Note 1)

1. Rebuild lube oil pumps
2. Clean and test lube oil cooler

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Every 24000 Hours (Cont'd)

B. Fuel System

1. Rebuild or replace engine or motor driven fuel pump *(See Note 1)

C. Engine *(See Note 1)

1. Replace crankshaft viscous damper
2. Replace oil pumps
3. Replace lower liner inserts
4. Replace injector control linkage links, seals, and bearings
5. Check camshaft bearings
6. Check rocker level and roller bushings
7. Inspect crankcase
8. Replace crankshaft harmonic balancer (3 pack type, where used)

D. Governor

1. Unit exchange *(See Note 1)

E. Generator Bearing

1. Relubricate *(See Note 1)

F. Cooling Fan

1. Replace drive bearings *(See Note 1)

Every 72000 Hours of Operation:

A. Unit exchange engine *(See Note 1)

B. Unit exchange generator *(See Note 1)

*NOTE 1: Performance of these items subject to additional billing not part of this Maintenance contract. Items under 4000 Hours of Operation. 8000 Hours of Operation, 12000 Hours of Operation, 16000 Hours of Operation, 24000 Hours of Operation and 72000 Hours of Operation are not included as part of this agreement. They are recommendations only. Performance of any part of the aforementioned recommendations will be additional to the agreement and require prior approval to perform and additional billing to the customer.