UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION



Before the Atomic Safety and Licensing Board



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

TESTIMONY OF G. DENNIS ELEY, C. JOHN SMITH, GREGORY C. MINOR AND DALE G. BRIDENBAUGH ON BEHALF OF SUFFOLK COUNTY REGARDING EMD DIESEL GENERATORS AND 20 MW GAS TURBINE

Introduction and Qualifications

Q. Please state your names and positions and describe your professional qualifications.

A. My name is G. Dennis Eley. My business address is 1301 Metropolitan Avenue, Thorofare, New Jersey 08086. I am a Technical Manager with Ocean Fleets Consultancy Service, Ltd. I have a combined First Class Department of Trade and Industry Certificate of Competency (Steam and Diesel), and a Higher National Certificate in Mechanical Engineering. I also am an Associate Member of the Institute of Marine Engineers, and a Member of the Institute of Port Engineers. Since 1959 I have held various engineering and consulting positions with concerns engaged in the design, manufacture and operation of ships and related machinery, including diesel engines and generators. In these positions I have been responsible for the efficient operation of various diesel engines, boilers, air compressors and refrigeration systems. My qualifications are set forth more fully in my resume which is Attachment 1 hereto.

My name is C. John Smith, and I am an Assistant Technical Manager with Ocean Fleets Consultancy Service, Ltd. My business address is 1301 Metropolitan Avenue, Thorofare, New Jersey 08086. I have worked as a Marine Engineer with Ocean Fleets for the past 22 years, after joining them as an Engineer Cadet in 1962. I hold a Department of Trade and Industry First Class Certificate of Competency (Diesel). During my employment with Ocean Fleets I have had experience in the operation, maintenance and repair of a wide variety of makes of diesels, including Allen, Burmeister & Wain, Deutz, Diahatsu, Doxford, General Motors, Mak, Mitsubishi, Paxman, Petters, Rustonk, Sulzer, and Volvo, in applications both as generators and prime movers onboard ships. As part of my employment I have been required to attend two fire fighting and prevention courses given by the fire departments of the cities of Liverpool and Leith, England. In recent years I have been actively involved in the design and implementation of fire and safety procedures onboard ships. I also have attended the building commissionings and delivery of four new ships, requiring the inspection of machinery and systems for correct operation and compliance with statutory regulations. My resume is Attachment 2 hereto.

My name is Gregory C. Minor. I am a founder of and currently am a Vice President of MHB Technical Associates. My business address is 1723 Hamilton Avenue, San Jose, California 95125. I have 24 years of experience in the nuclear industry including design and testing of systems for use in nuclear power plants. For 16 years I was employed by General Electric Company as a design engineer and manager of engineering design organizations. My responsibilities have included the design and qualification testing and preoperational testing of safety systems to meet safety criteria applicable to nuclear power plants. I have also worked 8 years as a consultant with MHB Technical Associates. These consulting activities have included work on nuclear plant safety features and designs for governmental and private organizations as well as public interest groups. My education is in electrical engineering (with a power systems option) resulting in a B.S. degree from the University of California at Berkeley and an M.S. degree from Stanford. My qualifications are set forth more fully in my resume which has been submitted with the Testimony of Dr. Christian Meyer, Dr. Jose Roesset, and Gregory C. Minor on Behalf of Suffolk County.

My name is Dale G. Bridenbaugh. I am President of MHB Technical Associates, and I serve as a Principal Consultant in the performance of my firm's consulting activities. My business address is 1723 Hamilton Avenue, San Jose, California 95125. I am a Mechanical Engineer by education, having received a BSME in 1953. I am also a registered professional Nuclear Engineer in the State of California. I have more than 30 years experience in the engineering field, primarily in the areas of power plant analysis, construction, maintenance, and operations. A substantial portion of my experience was as a field engineer supervising the installation, operation, and maintenance of central station power plant equipment, including steam turbines, gas turbines, and emergency power generators. Further details of my experience and training are contained in my resume which is Attachment 3 hereto.1/

Purposes and Conclusions

Q. What is the purpose of this testimony?

A. The Long Island Lighting Company ("LILCO") has requested an exemption from the requirements of 10 CFR Part 50,

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1/ Unless otherwise indicated, all answers in this testimony are sponsored by all witnesses.

Appendix A, GDC 17. LILCO proposes that it be allowed to operate the Shoreham Nuclear Power Station ("Shoreham"), at up to five percent of rated power, without a fully qualified emergency, onsite AC power source, that has been designed, procured, manufactured, installed, and tested in compliance with all applicable NRC licensing regulations, and that has been adjudged to meet these requirements ("qualified onsite emergency AC power system").

Instead, LILCO proposes to operate Shoreham using a configuration which enhances LILCO's offsite AC power system, consisting of a set of four mobile diesel generators manufactured by the Electro-Motive Division of General Motors Corporation (the "EMDs") and a 20 MW Pratt and Whitney gas turbine.

This testimony addresses the question whether operating Shoreham at up to five percent of rated power relying on LILCO's proposed, alternate sources of emergency AC power would be as safe as operation at up to five percent power relying on a qualified onsite emergency AC power system. In particular, this testimony addresses the reliability of the EMDs and gas turbine starting and running, and their overall availability, compared with a fully qualified onsite emergency

AC power system. For purposes of this evaluation this testimony compares the EMDs and 20 MW gas turbine to LILCO's originally proposed onsite AC power system (the three diesels procured from Transamerica Delaval, Inc. ("TDI"), as it was envisioned by the FSAR.

Q. Describe briefly the onsite emergency AC power sources described in the Shoreham FSAR.

A. The orginally proposed onsite AC power sources consist of three TDI diesel-generator sets ("EDG's") rated at 3500 KW each. Each of these units is housed in a separate reinforced concrete compartment which is designed to withstand the Shoreham safe shutdown earthquake. Each unit is designed to start automatically and to supply power sequentially to necessary engineered safeguards systems that are needed to assure safe shutdown and maintenance of reactor cooling and containment integrity in the event of a loss of coolant accident coincident with a loss of offsite power (a "LOOP-LOCA"). All appropriate design criteria, such as protection from fire and missiles, separation and single-failure, and other criteria necessary to assure on-site power reliability are committed to be followed in the design, procurement, installation, and operation of these units. This includes a commitment to a

Quality Assurance program in compliance with the requirements of 10 CFR 50, Appendix B.

Q. What is your conclusion?

A. Our conclusion is that low power operation of the Shoreham plant at up to five percent power relying on LILCO's proposed alternate AC power system would not be as safe as such operation with onsite emergency AC power sources that were fully qualified and satisfied all applicable regulatory requirements.

Low power operation in reliance on the proposed, alternate AC power system would not be as safe as such operation in reliance on a fully qualified set of onsite AC power sources, because the EMDs are not as reliable as the latter. First, unlike fully qualified generators, the EMDs have a number of common features that make them vulnerable to single failures. Second, the EMDs have no fire detection or fixed fire suppression systems, and therefore fire in one of the EMDs would be much more likely to incapacitate it and make operation of the other EMDs difficult if not impossible, than a fire in a qualified diesel generator. And, because the starter battery is inadequately ventilated and isolated from potential ignition sources, the threat of explosion or fire in EMD 402, where the battery is housed, is greater than would be true of a qualified diesel generator.

Third, the alarms and monitors of the EMDs are not indicated in the control room, and all but one of them are annunciated only when the diesel shuts down. Consequently, unlike the case with qualified diesels, the EMD alarms are unlikely to lead to human intervention to remedy a developing problem before it causes the unit to stop or otherwise become inoperable. Even at the local control panel the EMD alarms are not specific enough to facilitate timely diagnosis and repair of failures with the machines.

Fourth, LILCO's proposed procedure for testing the EMDs does not provide adequate assurance that the EMDs will function as expected in an emergency. The proposed procedure does not test the automatic elements of the EMDs, and the procedure, as designed, is not likely to reveal significant, developing mechanical problems. Fifth, unlike a fully qualified AC power source, the processes for starting the EMDs and connecting them to the safety loads in the plant are not fully automatic. Consequently, the EMDs are more vulnerable to failure due to human error, and are less reliable than a completely automatic, qualified generator set. Sixth, the maintenance and repair histories of the EMDs indicate that the EMDs have experienced both component failures and the need for overhaul much too frequently. Mechanical failures of the sorts experienced by these machines cast doubt on their reliability.

(Minor and Bridenbaugh) Low power operation in reliance on the proposed, alternate AC power system also would be less safe than such operation would be in reliance on a fully qualified set of onsite AC power sources, because the gas turbine is not as reliable as the latter. First, LILCO has not developed an effective surveillance testing program that provides adequate verification of the reliability of the gas turbine. Second, the alarm and control systems of the gas turbine are insufficient. Third, the gas turbine and its fuel system are susceptible to seismic and missile damage, and the gas turbine is vulnerable to single failures. Finally, the gas turbine is essentially a new installation due to modifications in its control and starting systems. None of these vulnerabilities or inadequacies is a characteristic of the originally proposed onsite AC power system, and consequently the gas turbine is less reliable than that system.

(Minor) In addition, the proposed alternate emergency onsite AC power system is less reliable than the originally proposed AC power system, because it is more complex and therefore more susceptible to equipment failure and human error.

The EMD Diesel Generators

Q. What are the common features shared by the EMDs that render them susceptible to single failures?

A. (All Witnesses) The EMDs share (1) a single electrical output circuit from the EMD control cubicle[2/] to Emergency Bus 11 in the plant; (2) a single starter system consisting of one battery array, one battery charger, and one starter control mechanism; and (3) a single fuel supply system. In addition, all the breakers connecting the individual EMD generators to their common bus are located in the EMD control cubicle.

Q. Describe the single electrical output line from the EMD control cubicle to Emergency Bus 11.

A. The electrical output of each EMD is carried by buried cable to the EMD control cubicle, where it is connected through an electrical breaker to a single three phase bus.[3/] The

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2/ The EMD "control cubicle" is a small, enclosed structure located next to EMD 401. The control cubicle houses the electrical and mechanical control equipment for the EMDs.

3/ An electrical bus typically is a copper or aluminum bar or plate housed in an electrical cabinet or enclosure. Be-

(Footnote cont'd next page)

output of all four EMDs is then carried by two three-conductor cables in a single raceway, which runs approximately 100 yards from the control cubicle to the switchgear room, and a quarter of the length of which is covered by sand and stucco.

Q. How does this single output line compare with LILCO's originally proposed onsite AC power source?

A. The power output of the three qualified diesel generators intended to be provided at Shoreham are completely separate and independent. Not only are the diesel generators themselves housed in separate compartments designed to withstand all design basis loads and phenomena, but each unit also is provided with all necessary auxiliaries and controls for independent operation. The power generated by each of the units is distributed by electrical systems provided with "physical and electrical separation of bus sections, switchgear, interconnections, feeders, load centers, motor control centers, and other system components." (FSAR 8.3.1.1.1).

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(Footnote cont'd from previous page)

cause it is enclosed, it normally is not insulated. It is used to facilitate the interconnection of power supplies and associated branch circuits.

Q. How does the single output circuit affect the reliability of the EMDs when compared with a fully qualified emergency onsite AC power source?

A. If the single output circuit became inoperable due, for example, to any electrical malfunction or mechanical failure in the control cubicle, it would be impossible to transmit power from any of the EMDs to the plant. By contrast, because the power produced by each of the three qualified diesels is transmitted independently, the failure of one output line would affect only one generator. The other two would remain capable of generating and transmitting power. Consequently, the EMDs are less reliable, because a single failure in the output line would make all four EMDs unable to supply emergency AC power.

Q. Describe the common starting system for the EMDs.

A. The common starting system for the EMDs is comprised of a number of components. Included is a battery array housed in EMD 402. This array consists of a number of individual lead acid batteries connected in series, which provide a total available voltage of 125v. The battery array is connected to a stepping switch located in the EMD control cubicle. The stepping switch is necessary, because the battery array is capable of starting only one EMD at a time. When a start signal is given, the stepping switch directs the battery power to one machine at a time, moving to the next machine when the first machine starts or fails to start after 15 seconds. Also included in the starting system is a battery charger located in EMD 402. It is connected to the battery array, and is intended to maintain it in a fully charged state.

Q. Describe the starter system for a set of qualified onsite AC power sources.

A. The starting systems described in the FSAR that were to be provided for the fully qualified EDGs were substantially more reliable than the system provided for the EMDs. The FSAR states:

> Each diesel generator set has a separate air starting system designed to be capable of starting the diesel engine without external power and also to meet the single failure criterion. The air storage tanks and piping between tanks and the air start distributors are designed to ASME Boiler and Pressure Vessel Code Section III, Class 3. All other portions of this system are designed to manufacturer's standards and Seismic Category I requirements."

(FSAR 9.5.6.1) Further:

> Each [qualified] diesel generator is provided with two independent, redundant starting systems. Each independent starting system includes the following:
>
> 1. One ac motor-driven air compressor with intake filter

2. One air compressor after cooler

3. One refrigerant air drier with moisture trap

4. Two check valves

5. Two air storage tanks with relief valves and drain valves

6. One manual shutoff valve

7. One strainer

8. Instrumentation and control systems

9. Air starter distributor system

> Each independent redundant air starting system is of sufficient volume to be capable of cranking the engine for a minimum of five starts, without recharging the tanks.
>
> Each motor-driven air compressor has the capacity to recharge the air storage system in 30 min to provide for a minimum of five starts. Its motor is furnished with automatic start and stop control on pressure signals from the air storage tanks.

(FSAR 9.5.6.2).

Q. How does the common starter system affect the reliability of the EMDs relative to a qualified set of onsite power sources?

A. The EMDs are less reliable than qualified onsite generators, because, unlike the latter, the failure of the single starter system could make it impossible to start any of the

EMDs. The failure of the battery array and/or charger could render the starting system inoperable. Similarly, if the starter control mechanism in the EMD control cubicle failed, although electricity would be available to power the EMD starter motors, that electricity would not be transmitted to them, and none of the EMDs would be started. Therefore, the set of three qualified onsite generators described in the FSAR would be more reliable than the EMDs. As noted above, each TDI diesel generator is provided with two independent, redundant starting systems. (FSAR §9.5.6.2.) Thus, the failure of one starting system would not incapacitate even one qualified generator, and failure of two systems could only prevent the starting of one generator. The other generators still would be able to supply emergency power to the plant. By contrast, the failure of one starter component could prevent the entire EMD set from starting and from transmitting any power at all to the plant.

Q. Describe the EMD fuel supply system.

A. The EMD fuel supply system also consists of several components. They include individual 130 gallon "day" tanks in each individual unit, which are joined together by an equalizing pipe. Fuel from all four day tanks flows through the equalizing pipe in a manner which keeps the fuel in all four day tanks at the same level. Fuel is supplied to the day tanks by two transfer pumps located in EMD 402. Normally, only one of these two pumps operates; the second pump will run if the fuel level in the day tanks drops to an abnormally low level. These pumps draw the fuel through a single above ground pipe line.4/ This pipe runs next to the EMDs at the foot of a steep embankment. It passes under a temporary ramp constructed to allow vehicles to drive up the embankment, and ends at a fueling station. At that point, the pipeline is connected to a flexible hose which in turn is connected to a 9,000 gallon tank truck. Fuel from the truck is drawn by the pumps through the hose and supply pipe line, into the day tank in EMD 402. From there it flows to the other day tanks through the equalizing pipe. The EMD fuel supply system is illustrated in Attachments 4, 5 and 6.

Q. Describe the fuel supply system for a set of qualified onsite diesel generators.

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4/ We understand that LILCO has now committed to put this pipe underground. When data are available regarding the new pipe design, it may be necessary to amend this testimony.

A. Each of the three TDI diesel generators described in the FSAR has its own fuel system, which is physically isolated from the fuel systems for the other two generators. Each system consists of a completely buried tank and two fuel supply pumps housed in their own concrete block house. All components are designed to withstand the credible seismic events that may occur. Each system also has its own fuel supply line, which is buried. Thus the tanks, pumps and supply lines are protected from common fires and missile events. In addition, each generator also has its own "day" tank, which is isolated from the other generators' day tanks.

Q. How does the design of the EMD fuel supply system affect the reliability of the EMDs relative to a set of qualified onsite AC power sources?

A. The fuel system for the EMDs presents another single failure vulnerability that is absent from the qualified emergency AC power source described in the FSAR, and as a result, the EMDs are less reliable than qualified AC power sources. In the case of qualified generators, if a failure rendered a fuel supply system inoperable, because each qualified generator has an independent fuel supply system, only one of the three generators would be affected; the other two generators could continue to produce power. By contrast, if the EMD fuel supply system failed, all four EMDs would be affected, because they all receive their fuel through that single system.

For example, because all the fuel for all the EMDs flows through the pumps and day tank in EMD 402, an interruption of the fuel supply in that unit would interrupt the flow of fuel to all four EMDs. Thus, if a fire occurred in EMD 402, or if the pumps or float switches in EMD 402 failed, fuel would not be transferred from the single supply pipe to the day tanks of any of the EMDs. Similarly, because all the day tanks are interconnected by the equalizing line, any single failure, such as a rupture due to a seismic event, could adversely affect all four EMDs.

The single failure vulnerability created by the EMD fuel supply system is heightened by two features that are particularly susceptible to the kind of failure that could affect all the EMDs.

First, fuel for the EMDs is transferred from the tank truck into the supply line through a hose running from the truck. This hose apparently just lies on the ground as it runs from the tank truck to the connection with the supply line. (See Attachment 7.) The area in which the tank truck and hose are located is an area with significant construction activity,[5] and consequently it is quite possible that the hose could be damaged by construction activicies or equipment. Because the fuel for all four EMDs flows through this one piece of equipment, damage to it could terminate the flow of fuel from the tank truck to all four EMDs.

Second, the single supply line that carries fuel from the hose to EMD 402 is susceptible to failure due to both ground motion and missile impact. As other witnesses for Suffolk County have testified, a seismic event with ground acceleration of 0.2g's could cause the pipeline to rupture. (See Testimony of Dr. Christian Meyer, Dr. Jose Roesset and Gregory C. Minor on Behalf of Suffolk County.) The supply line is also susceptible to damage from missile impact. For example, at the point at which the pipe issues from under the south side of the ramp (See Attachment 4) there is no protection from the possibility of a vehicle, such as an articulated truck, striking and rupturing the pipe. Again because fuel for all four EMDs flows through this pipeline, damage to it would interrupt the flow of fuel from the tank truck to all the EMDs.

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5/ Completion of the Colt diesel addition program (through preoperational testing) is not expected until mid-1985, well after LILCO's proposed low power test program would likely be completed.

Q. How is the reliability of the EMDs affected by the location of the breakers for all four EMDs in the EMD control cubicle?

A. The reliability of the EMDs is reduced, because a single event, such as an electrical fire in the control cubicle, or missile damage, could disable all four breakers and make it impossible to transmit emergency power from the EMDs to Emergency Bus 11.

Q. What fire protection systems were included in the onsite AC power system originally proposed for Shoreham?

A. The onsite emergency generator system originally proposed for Shoreham contained both fixed fire detection and fixed fire extinguishing systems. These fire protection systems, as described in the FSAR (Section 9.5), contain permanent and automated detectors and fire suppression devices in each EDG compartment. These systems are designed to automatically activate $CO_2$ fire suppression systems which flood the compartments with $CO_2$ gas. The fire protection systems also provide immediate alarms in the main control room to assure that followup operator action is initiated. Because each of the three TDI EDGs is in its own separate compartment, these systems operate independently to enhance the reliability of each unit.

Q. What fire protection systems exist for the EMDs?

A. The EMDs contain no fire detection equipment and no fixed, remotely operated fire extinguishing system. The only fire extinguishing equipment associated with the EMDs is a small number of hand-held fire extinguishers stored inside the EMD units and two fire hydrants located in their vicinity.

Q. How does this lack of fixed fire detection and suppression systems affect the reliability of the EMDs relative to a set of fully qualified onsite AC power sources?

A. It makes the EMDs less reliable than the qualified sources. First, it is unlikely that a fire in one of the EMDs would be discovered until it was too late to extinguish it expiditiously. Because the EMDs are not fitted with a fire detection system, the first indication of a fire would be smoke or flames escaping from the housing of an EMD. Even then detection would only occur when someone happened to see the smoke or flames.

By the time a fire in an EMD is sufficiently well established to cause smoke or flames to issue from the housing, it may be so well established that it will be impossible to enter the EMD housing and apply an extinguishing medium to the seat of the fire. Without the ability to direct hoses and extinguishers at the seat of the fire, it is very unlikely that the fire could be extinguished before the EMD was rendered inoperable. Consequently, personnel responding to the fire would have to be content with containing it.

In addition, the vulnerability of the EMDs is increased by the fact that it is unlikely the other three EMDs could be kept running if one EMD were burning. Fire fighters responding to such a fire would almost certainly want to isolate sources of fuel from the fire. This would mean stopping the flow of fuel from the tank truck as well as isolating the day tank of the burning unit. Consequently, the other three EMDs would have only the fuel that was in their day tanks when the burning unit was isolated. Also, operating EMDs draw large amounts of air. Therefore running them while a neighboring unit is burning creates the risk of drawing flames into the non-burning machine through the air intakes. Similarly, because the fire fighters almost certainly would spray large amounts of water on the non-burning EMDs to cool them, there is a risk that water could be drawn into the running EMD through its air intakes. Finally, a fire in EMDs 401 or 402 could result in water being sprayed on the nearby EMD control cubicle. To eliminate the risk of electrical injury to the fire fighters, the flow of electricity through the switchgear in the control cubicle probably would have to be stopped, thereby preventing the operation of any of the EMDs.

This situation makes the EMDs less reliable than qualified, onsite generators, because they are more vulnerable to fires. By way of example, with LILCO's originally proposed diesel generators, any fire would be detected quickly; indeed the precursers to the fire, such as hot gases, might even be detected before the fire actually began. And once a fire was detected, the fixed mitigation system could quickly attempt to extinguish it. A fire in an EMD almost certainly would incapacitate the EMD, whereas one of the originally proposed diesel generators would have a much better chance of surviving a fire; and while a fire in one qualified diesel would not affect the others, a fire in one EMD would make it very difficult to continue to run the others.

Q. Is the EMD arrangement more vulnerable to fire hazards in any other ways?

A. Yes. The absence of fire detection and fixed fire suppression equipment is a serious shortcoming in any diesel configuration, because operating diesel engines always present a potential for fire. But this shortcoming is especially serious with respect to the EMDs, because they are more vulnerable to common fire damage than the diesel configuration originally proposed by LILCO. Unlike a set of qualified diesel generators, the EMDs are not separated by approved, fire barrier walls. The EMDs are simply sitting in a row, with each unit approximately 8 to 12 feet from the next one. (See Attachment 4.) Consequently, there is a greater potential that a fire in one EMD could spread to the other EMDs and prevent the entire set from supplying emergency power to the plant.

Moreover, the EMD starting battery array poses a threat of explosion and fire. When the EMDs are started, the starter battery is partially depleted, and it must be replenished by the battery charger. While they are being charged, batteries generate both oxygen and hydrogen gases. The hydrogen gas is a potential source of explosion. Safe operating practice dictates that batteries should be housed in a compartment with no potential sources of ignition, and which is ventilated to outside air either naturally or mechanically in a manner which prevents the accumulation of explosive gases.

Neither of these practices is followed with the EMDs. The starter battery array for all four EMDs is stored beneath the floor of the engine compartment of EMD 402. Instead of ventilation that carries potentially explosive gases to the outside air, gases generated by this starter battery are vented into the enclosed engine compartment of EMD 402. There those gases are exposed to electrical devices, such as lights, light switches and relays, all of which could create sparks and ignite an explosion and possibly a fire. (See Attachments 8 and 9).

An explosion or fire could incapacitate EMD 402. But it also could disable the common starting system for all four EMDs by destroying the battery. It also could incapacitate the fuel supply system for all four EMDs, which runs through EMD 402. Consequently, the threat of explosion or fire resulting from the improper ventilation of the starting battery array is a potential single failure that could prevent the operation of the entire EMD set.

There is no comparable threat of explosion associated with the originally proposed diesel generators, because their starting systems utilize no batteries and therefore there is no source of hydrogen. (FSAR 9.5.6.2)

Q. What are LILCO's proposals for testing the EMDs?

A. LILCO proposes to conduct bi-weekly surveillance testing of the EMDs. The details of this plan are described in Temporary Procedure TP 24.307.04. Rev. 0, June 7, 1984. By this procedure, LILCO will manually start the EMDs one at a time to be sure that three of the four mobile diesels "can be manually started and operated at rated speed." This process is deficient in that it does not provide for regular testing of the automatic starting, synchronizing, and load sharing mechanisms as these devices would be required to operate during the LOOP-LOCA scenario. Consequently, LILCO's proposed testing would not identify potential problems with key automatic elements of the EMD configuration, and as a result that testing does not provide an accurate indication of the reliability of the EMD system. The need for regular testing of these systems is demonstrated by the fact that during an electrical function test performed on July 2, 1984, one EMD failed to synchronize; and during attempts to restart this machine, two of the other EMDs tripped off.

In addition, there are specific deficiencies in the proposed test procedure aside from the failure to test the entire EMD system. (See Attachment 10, which is an appendix to

Procedure TP 24.307.04 that sets forth the steps to be followed in the manual starting and loading of the EMDs). First, the procedure does not provide for a visual inspection of each EMD prior to starting the engine. Such an inspection is good operating practice. It permits the operators to ensure that the required amount of vital fluids is present, and that equipment failures or human errors have not left the engine mechanically unsound. Starting the engine without a visual inspection increases the risk that the machine will be damaged and rendered inoperable.

Second, although the General Motors manual for the EMDs states that prelubrication of the EMD engine is a "necessary and important practice for any engine which has been inoperative for more than 48 hours" (See Operating Manual, MU-20E Power Plants for Peaking, Reserve, and Base Load Operation (the "EMD Operating Manual"), at 9-17), the LILCO test procedure does not require the "necessary and important" prelubrication.

Third, the LILCO test procedure does not indicate how long an EMD should be run once it has been started and connected to electrical loads. Consequently, it is possible that the EMDs will not be run long enough at their normal operating temperature to allow temperatures to stabilize in individual components. Stopping an engine before this occurs reduces component life and operating reliability.

Fourth, the LILCO test procedure does not call for a visual inspection of the machines while they are running. Such an inspection is important, because many developing mechanical problems can only be detected while the engine is running. If no one inspects the machine while it is operating, such problems could go undetected. As a result, the operators would not have the opportunity to repair the problem before it became serious enough to make the machine inoperable.

Finally, the LILCO test procedure does not call for a visual inspection after completion of the test. Thus, LILCO passes up another opportunity to discover developing problems with the machines. Moreover, a post-test visual inspection serves to verify that the soak back lube oil pump for the turbocharger is operating properly. Failing to verify that the soak back pump is functioning increases the risk of damage to the turbocharger.

Q. How do the deficiencies you have identified in LILCO's test procedure relate to the reliability of the EMDs?

A. Each of these deficiences results in a missed opportunity to discover developing problems with the units, increased risk of damage to components, or reduced operating life of components. Consequently, all of these deficiencies reduce the reliability of the EMDs.

Q. How does the alarm monitoring present in the EMD configuration affect its reliability when compared with qualified diesel generators?

A. Inadequacies in the EMDs' alarm system make it less likely that they will operate reliably than would a set of qualified diesel generators. When qualified onsite diesels are operating, personnel in the control room are informed of deviation of the diesel systems from design parameters (e.g., cooling, fuel, lubrication) by alarm systems that are displayed in the control room. Early detection of an abnormal condition gives the control room personnel the ability to take corrective action before the condition deteriorates to the point at which the diesel(s) automatically stops. Thus, the operating reliability of the diesels is enhanced by adequate alarms.

The EMDs do have alarm systems, but all the alarm signals except one ("Abnormal Fuel Tank Level") are given only when a problem becomes serious enough to initiate an engine shutdown. That is, all but one of the alar go off only when it is too late for human intervention to correct an abnormal condition prior to shutdown. In addition, the EMD alarm system is not sufficiently precise to facilitate the prompt diagnostic and repair actions that would be needed to restore to service a failed EMD. Indeed, four of the alarm lights on the EMD annunciator panel cover 17 separate shutdown causes. For example, if the "Engine Stop" light and the "Generator Breaker" light come on simultaneously, the problem could be low engine lubricating oil pressure, low engine cooling water level, excessive crankcase pressure, engine overspeed, or an open breaker. Consequently, when faced with those two alarms, the operators would have to check a long list of potential problems in order quickly to repair the EMD.

By contrast, the description of the alarm system contained in the Shoreham FSAR sets forth the comprehensive instrumentation provided for operation and monitoring of a typical qualified onsite AC power system.

> Surveillance instrumentation is provided to monitor the status of the diesel generator. Provisions for surveillance are an essential requirement in the design, manufacture, installation, testing, operation, and maintenance of the diesel generators. Such surveillance not only provides continuous monitoring of the status of the emergency generators so as to indicate their readiness to perform their intended function, but also serves to facilitate

testing and maintenance of the equipment. Conditions which can adversely affect performance of the emergency diesel generators are annunciated locally and in the main control room. The following list shows the important functions that are annunciated:

| | Function | Alarm Local | Alarm Control Room |
|---|---|---|---|
| 1. | Low Pressure Lube Oil | x | x |
| 2. | High Temperature Lube Oil | x | |
| 3. | Low Pressure Turbo Oil | x | |
| 4. | High & Low Temperature Jacket Water | x | |
| 5. | Low Pressure Jacket Water | x | |
| 6. | Low Level Jacket Water | x | |
| 7. | Low Level Fuel Day Tank | x | |
| 8. | Low Level Lube Oil | x | |
| 9. | Low Pressure Starting Air | x | |
| 10. | Aux. Pump Switches Off | x | |
| 11. | Low Pressure Lube Oil Shutdown | x | |
| 12. | High Temperature Lube Oil Shutdown | x | |
| 13. | Low Pressure Turbo Oil Shutdown | x | |
| 14. | High Temperature Hacket Water Shutdown | x | |
| 15. | High Pressure Crankcase Shutdown | x | |
| 16. | Overspeed Shutdown | x | x |
| 17. | Low Pressure Fuel Oil | x | |
| 18. | High Level Fuel Day Tank | x | |
| 19. | Low Flow Service Water | x | |
| 20. | Fail to Start | x | |
| 21. | Unit Unavailable | x | |
| 22. | Diesel System Degraded | | x |
| 23. | Diesel System Inoperative | | x |
| 24. | Diesel Engine Trouble | | x |
| 25. | Emergency Bus Supply or Feeder Breaker Auto Trip | | x |
| 26. | Generator Neutral Ground Overcurrent | | x |
| 27. | Low Level Fuel Storage Tank | x | |
| 28. | Generator Field Manual Shutdown | x | |
| 29. | Generator PT Blown Fuse | | x |
| 30. | Generator Voltage Regulator Power Failure | | x |
| 31. | Main Board Control Disabled | x | x |
| 32. | Generator Heater Loss of Control | x | |
| 33. | F.O. Suction Strainer High Differential Pressure | x | |
| 34. | Jacket Water Conductivity High | x | |
| 35. | Motor Driven Fuel Pump Running | x | |
| 36. | Field Flash Inoperative | x | |
| 37. | Fuel Oil Transfer Pump Locked Out | x | |
| 38. | Fuel Oil Booster Pump Strainer High Differential Pressure | x | |

NOTE: Alarm No. 24 includes Local Alarm Nos. 2 through 10, 17, 18, 19, 20, 27, 28 and 34 Alarm No. 23 includes Local Alarm No. 21 and 36. Alarm No. 22 includes Local Alarm No. 32.

(FSAR 8.3.1.1.5)

Moreover, the EMD alarm indications are only given on an annunciator panel in each EMD unit. This means that during operation the EMD alarms cannot be read from the control room, but instead can only be read if operating personnel actually monitor the individual annuciator panels in each EMD unit. LILCO's procedures do not provide for operators to be in the EMD units during their operation. The only indication in the control room of the status of the EMDs is an indication of whether any voltage is being supplied by the EMDs. There is no indication in the control room of how many EMD units are operating, how they are sharing the load, or if one or more are in difficulty and/or about to shut down. Consequently, it is possible, for example, for only one EMD to be operating, without control room personnel knowing that the other three have shut down. In contrast to the situation with the originally proposed diesel generators, in such circumstances the operators of the EMDs would not know how close they were to losing all their EMD-supplied power. Thus, the operators would be unable to attempt to head off developing operating problems before those problems forced the EMDs to cease operation. Consequently, the reliability of the EMDs is less than that of a set of qualified diesels that can be monitored in the control room.

Q. Are the EMDs started and loaded in the same manner as qualified, onsite AC power sources?

A. No. The normal design of safety-related onsite emergency AC generators is to have power available within 10 seconds of a loss of offsite power. (FSAR 8.3.1.1.8) All the starting and loading functions are performed automatically without operator assistance. LILCO's originally proposed onsite AC power systems were designed to meet this standard.

By contrast, starting and loading of the EMDs is a multiple step process. The starting sequence is automatic, but a total of at least 18 manual operations, performed by operators under the potential stress of an emergency situation, are required to connect the necessary electrical loads for the engineered safeguard systems to the EMDs. (See procedure TP 85.84042.3, Rev. 1, pages 6, 7.) A start signal is given simultaneously to all the EMDs by the EMD autostart system upon loss of voltage on the EMD bus. However, because only one cranking battery is provided for all four units, electricity is provided to each unit's starter motors serially. The starter control mechanism in the EMD control cubicle supplies starting power to each EMD, one at a time, for cranking. After the first unit has started, or has cranked for a timed period, the control mechanism switches power to the next EMD. After a 90 second warmup period at idle speed, each engine goes to full speed as soon as engine oil pressure is satisfactory. The first engine to reach full speed has its speed adjusted to give the correct frequency and is then connected to the EMD bus. As the other machines come up to speed, they are sychronized with the first machine and then connected to the EMD bus. When all the running EMDs are synchronized and connected to the EMD bus, they can be manually connected to Emergency Bus 11.

The EMD Operating Manual estimates that for deadline start it will take approximately 2 minutes for one unit to start, idle, accelerate and be ready to receive load. However, loading is not done until the last unit is synchronized with the other units and all units are ready to be loaded. This means that for four units it will take between 2 minutes 20 seconds and 2 minutes 50 seconds to have them synchronized and ready to accept load, in contrast to the 10 seconds required by the FSAR.

In addition, in contrast to the fully automated operation of qualified onsite AC power sources, operation of the EMDs depends on the actions of human operators. Consequently, the risk of human error is greater with the EMDs, and this additional risk reduces their reliability. Before the breaker from the EMD bus to Emergency Bus 11 can be closed, supplying power to the emergency loads, field operators must manually (1) remove three undervoltage program fuses in the service water pump cubicle; (2) open the gas turbine feeder breaker, the feedwater pump feeder breaker, and the 480V substation feeder breaker, in the normal switchgear room; and (3) go outside to the Normal Station Service Transformer ("NSST") and open three disconnect switches on the low side of the NSST. Those disconnect switches and the NSST are depicted in Attachment 11. LILCO's procedures call for an operator to be dispatched to perform these actions. (See Procedure TP 85.84042.3, Rev. 1, Step 8.5.1) In order for an operator to leave the control room and complete those necessary tasks, he must travel nine flights of stairs, pass through approximately 15 doors (6 of which are locked, security doors, and require a credit card-like key to open), and he must pass one security station. The large number of stairways and doors involved in this process increases the chances that the operator will be unable to complete his assigned tasks in a timely manner.

In addition, step (3) above requires the operator to leave the building, climb over the EMD cable raceway, and open three switches on the NSST. In order to open the switches, the operator has to use an approximately twenty foot long fiberglass pole, with a hook at the end. The difficulty involved in performing this task increases the risk of delay. Moreover, the difficulty of opening these switches under adverse weather or lighting conditions is significantly increased, especially because there is no emergency lighting in the vicinity of the NSST.

In addition, the impact of human error potential in the operation of the EMDs is further increased, because it is necessary for operators manually to manage the load of the EMDs from the EMD control cubicles.

(Smith) LILCO personnel have acknowledged during a recent demonstration that manual control of the loads placed on the EMDs could be necessary to ensure that the engines do not run at loads low enough to be detrimental to the machines.

(All witnesses) This necessary local management increases the risk of human error, especially because the EMD control cubicle contains only one set of current and power meters; monitoring the load on each EMD is consequently a cumbersome process. Because this management increases the risk of human failure, the reliability of the EDGs relative to that of fully automated power sources is decreased.

Q. What information relating to the reliability of the EDGs is contained in the records of their maintenance and repair histories?

A. (Eley and Smith) The maintenance records for the EDGs for the period 1974 through 1983 show that exclusive of replacement of parts at scheduled maintenance periods the following components have had to be replaced:

- 17 cylinder heads
- 21 power assemblies (a power assembly consists of complete cylinder, piston and cylinder head)
- 3 turbochargers
- 13 starter motors

The failure of this number of major components over an average of 2,255 hours per machine is greater than expected for reliable diesels.6/

Furthermore, although the EDG Operating Manual states that repowering7/ should take place at 12,000 hours and Power

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6/ Salient events from the maintenance and repair histories of the EDGs are set forth in Attachments 12 through 15.

7/ In a "repowering" the cylinder assemblies (piston, piston rod, cylinder and cylinder head), and the fuel injectors

(Footnote cont'd next page)

Systems (LILCO's agent for maintaining the EMDs) states in its maintenance agreement with LILCO that repowering should take place after 15,000 hours, the maintenance records show that EMDs 401 and 403 only ran 6,900 hours before requiring repowering. EMDs 402 and 404 have only 6,300 and 6,000 hours, respectively, since they were fitted with Utex Engines.3/ Nonetheless, after their installation inspection at Shoreham, Power Systems had concerns about the mechanical condition of EMDs 402 and 404 and stated in its installation inspection report that the "[e]ngine components are used and approaching overhaul." Copies of the relevant pages of the installation inspection report are attached to this testimony as Attachment 16.

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(Footnote cont'd from previous page)

are replaced, and the following parts are checked and changed or adjusted as needed:

connecting rod bearings
piston cooling tubes
rocker arms, rocker arm bushings
and cam followers
lash adjusters
exhaust valve timing
water pumps

3/ A Utex Engine is a factory rebuilt engine brought up to as new standards.

Some additional, specific incidents documented in the maintenance histories of the EMDs which give rise to our concern about their reliability are described below.

At 12,932 hours (i.e., only 6,900 hours after having been fitted with a Utex engine), the engine in EMD 401 was repowered. Eighty-seven hours later power units[2/] 4, 6, 10, 11, 13 and 18 had to be changed again because of damage to the cylinders and pistons that had occurred in the short time after the repowering. After a further 15 minutes of running, Power Unit No. 11 was again changed because of cylinder/piston damage. For this number of components to be changed so soon after overhaul (when they would be expected to last approximately 12,000 hours) indicates that either the maintenance or components were of poor quality.

The turbocharger on EMD 404 failed at 10,992 hours. The normal expected life of a turbocharger is 32,000 hours. A mere 734 hours later the new turbocharger failed in such a fashion that pieces of the broken turbocharger pierced the aftercoolers, requiring them to be changed also. These two

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2/ A "Power Unit" consists of the cylinder head assembly, cylinder liner, piston assembly, carrier assembly, connecting rod assembly, and all related gaskets and seals.

failures, coupled with the fact that EMD turbochargers have had a history of problems (see Refinement of the Electro-Motive Turbocharger 31 Aug. 1982) indicate that this component has low reliability.

In light of the facts that the EMDs have required the replacement of parts due to failures as well as repowering much more frequently than one would expect, it seems likely that there is some serious deficiency either in some of the machines or in the manner in which they have been maintained. In either event, the risk of mechanical failure seems higher than it should be. This increased risk is made worse by the fact that LILCO's test procedure is not adequate to discover developing mechanical problems. The end result is another factor that reduces the reliability of the EMDs.

<u>The 20 MW Gas Turbine</u>

Q. Has LILCO developed an effective surveillance test program for the gas turbine to assure it will be available when needed?

A. (Minor and Bridenbaugh) We have been provided with only two gas turbine test procedures, SP 24.307.07 (Draft) and TP 24.307.03, Rev 1, July 2, 1984.10/ Our review of these two

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10/ TP 24.307.03 also makes reference to an unidentified "biweekly 13 MWE load test" but we have been unable to determine if such a test procedure in fact exists, or what its purpose may be.

procedures leads us to conclude that they are not an effective surveillance program for the new service assigned to the gas turbine.

Procedure TP 24.307.02 is entitled "Six Month Surveillance on 20 MW Gas Turbine Generator No. 2". The apparent purpose of this procedure is to demonstrate the ability of the unit to start and carry some safety related load in the event of a loss of off-site power. During this test the gas turbine is required to carry the load of only one or two operating RHR pumps from the 103 emergency bus. These two pumps have a total power rating of 1993 KW, so if both are run simultaneously, this would load the gas turbine to approximately only 10% of its rating. The procedure is silent as to how long the load should be carried.

Procedure SP 24.307.07 is entitled "Monthly Black Start Test of the 20 MW Gas Turbine." It calls for the gas turbine to be started, loaded and operated for at least one hour every two weeks, and to be black started monthly. ("Black start" is the term used to define a component which has the ability to start and operate with no external power being supplied to it.) The specific test included as an appendix to this procedure is identified as a "Monthly Test" but describes in step 23 the performance of a "10 MWe biweekly load test." It is, accordingly, not clear what test requirement is being fulfilled by this procedure, and we conclude that the final details have not yet been developed.

Q. Do you conclude that the surveillance test program for the gas turbine is ineffective?

A. (Minor and Bridenbaugh) Yes. The six month testing of the gas turbine at only 5 to 10 percent of its rated capacity for a non-defined period of time does not sufficiently tax the unit to verify its reliability. The test is too easy. The one month (or perhaps bi-weekly) load test is obviously not yet developed. A test in such a preliminary stage of development does not have well enough defined goals, procedures, or acceptance criteria to provide adequate verification of the reliability of the gas turbine for the service for which it has been proposed. Our position that the proposed test is not sufficient to verify the ability of this unit to supply the necessary loads is supported by the NRC Staff's review of this issue reported in the Safety Evaluation Report (NUREG-0420, Supplement 5, April 1984). In this report, the Staff expressed concern regarding the possible imposition of non-safety loads on the gas turbine that could result in a total of 17 MW on the unit. The Staff has recommended more frequent full load testing and monthly testing to verify that the normal 69 KV and 4.16 KV loads will automatically disconnect. (NUREG-0420, Supplement 5, page 8-2 and 8-3).

Q. Does the Shoreham control room have adequate controls and alarms for monitoring the operation of the 20 MW gas turbine?

A. (Minor and Bridenbaugh) The only indication available in the Shoreham control room from which operation of the gas turbine can be inferred is the indication of voltage on the 69KV line and a light which indicates whether the 20 MW gas turbine breaker is open or closed. Thus, as is the case with the EDGs, the operators in the control room cannot monitor the operation of the gas turbine in the manner made possible by the comprehensive alarm monitoring system associated with the originally proposed onsite AC power system. Consequently, with the gas turbine, the operators do not have the same ability to intervene and rectify developing problems with the unit's operation that they have with respect to the originally proposed onsite AC power system.

Moreover, under most conditions, the gas turbine can only be operated at the local control panel at the gas turbine or by the LILCO system operator in Hicksville, if the control is set up for remote control. If the controls are set for black start operation, then the unit is supposed to start automatically if voltage is lost on the 69KV line. Thus, there is no way to start the 20 MW gas turbine manually from the Shoreham control room, short of artificially creating a loss of power event by isolating the 69 KV line. The control room operator cannot directly start or initiate a restart attempt of the gas turbine as a precautionary or supplemental measure. Consequently, the only way that the gas turbine can serve the needs of Shoreham in a timely manner is if its controls are left in the proper auto start position, and it performs correctly during a loss of offsite power event. If it failed to start properly, the only way to determine the status of the machine and attempt a restart would be to dispatch an operator to the gas turbine, and that would take too long.

Q. Is the gas turbine protected against phenomena such as seismic events, external missiles and other potentially destructive events?

A. (Minor and Bridenbaugh) The gas turbine is not designed to be able to withstand the Shoreham safe shutdown earthquake, nor is its fuel supply tank. The turbine is not enclosed by anything other than a weatherproof enclosure, and therefore, its operation is vulnerable to missiles such as those that could be generated by falling aircraft.

Q. Is the gas turbine designed to satisfy the single failure criterion?

A. (Minor and Bridenbaugh) No, it is not. Because the gas turbine is a single unit, the failure of any one of many critical components could prevent or interrupt its operation. Of particular importance is its reliance on a single starting system and a single fuel supply line routed to it from the fuel tank approximately 40 yards away. This fuel line could be severed by missile impact, such as falling transmission towers or lines, or out-of-control motor vehicles. (See Attachment 17.)

Q. Does the past performance of the gas turbine provide assurance that it will perform reliably in the future?

A. (Minor and Bridenbaugh) No, it does not. Although this unit had several thousand hours of operation in the past, it was moved to Shoreham only in the Spring of 1984. Coincident with this move, the control and starting equipment necessary to provide black start capability was added to this unit. Thus, it is essentially a new installation with the inherent startup "bugs" still to be worked out.

Q. What is your conclusion as to the reliability of the 20 MW gas turbine as a source of emergency onsite AC power, relative to the originally proposed onsite AC power system?

A. (Minor and Bridenbaugh) The 20 MW gas turbine is not as reliable as the originally proposed onsite AC power system. It does not meet the single failure criterion, it is not qualified to withstand any of the necessary design basis phenomena, and it is not even under the control of the Shoreham control room operators. Moreover, LILCO's proposed test procedures do not adequately assure the reliable operation of the unit, and its alarm monitoring is inadequate. None of these vulnerabilities or inadequacies present in the 20 MW gas turbine configuration are present in the originally proposed onsite AC power system. As a result, the gas turbine is not as reliable as the latter.

Complexity of the Proposed Alternate AC Power System

Q. In what ways is the proposed, alternate AC power system more complex than the originally proposed AC power system?

A. (Minor) The electrical connections associated with the alternate AC power system proposed by LILCO are more complex than those associated with the originally proposed onsite AC power source. The EMDs are not connected directly to the emergency load centers (Buses 101, 102 and 103). To reach those centers, AC power from any EMD must pass through 3 circuit breakers and 2 buses. Output from the 20 MW gas turbine must take an even longer and less certain route in order to reach the safety loads connected to the emergency 4 KV buses. Power from the gas turbine must pass through 3 circuit breakers, 2 switches and 2 transformers. By contrast, AC power produced by one of the originally proposed onsite generators must pass through only 1 intervening device, a single circuit breaker, in order to reach safety loads connected to an emergency 4 KV bus.

Q. How does this increased complexity affect the reliability of the proposed alternate AC power system relative to the originally proposed system?

A. (Minor) The increased complexity of the proposed alternate AC power system reduces its reliability relative to the originally proposed onsite AC power system. In general, the less complex a system is, the more likely it is to be able to perform its assigned task. A less complex system involves lower potential for failure of intervening hardware and less need for coordination of automatic and manual actions; as a result, a less complex system is more reliable. Moreover, because of both the greater number of devices and the increased complexity of necessary procedures involved in the proposed alternate AC power system, it is subject to a greater potential for human error in its design, implementation and operation, than is the originally proposed AC power system.

Q. Does that conclude your testimony?

A. (All witnesses) Yes.

ATTACHMENT 1

CONFIDENTIAL

RESUME

Name: George Dennis Eley

Address: 117 Bortons Road
Marlton, New Jersey 08053

Home Phone: (609) 768-6699

Business Phone: (609) 848-2913

Licenses and Certificates: Combined First Class Certificate of Competency Steamship & Motorship. Higher National Certificate in Mechanical Engineering.

Society Memberships: Associate Member of The Institute of Marine Engineers. Member of the Institute of Port Engineers. Member of the ASTM Task Group on Pollution Abatement Equipment (F25.11).

Employment History

1981 - 1983 Marine Consultant with:-
Head Office:- Ocean Transport and Trading PLC.
India Buildings
Water Street
Liverpool, England L20RB
Telephone No. 011-44-51-236-9292
Address of U.S.A. Office:-
Ocean Fleets Consultancy Service
1501 Grandview Avenue
Midatlantic Corporate Center
Thorofare, New Jersey 08086
Telephone Nos. (609) 435-6457 & (609) 848-2913

1969 - 1981: - Third Assistant, 2nd And Chief
Marine Engineer with above Company.

1966 - 1969: - Estimator and Contracts Engineer for British
Shipbuilders at:-
Austin & Pickersgill Limited
Shipbuilders and Installation
Engineers
P.O. Box 38
Southwick
Sunderland
Tyne & Wear, England
Telephone Nos. 011-44-783-57684

1959 - 1966: - Apprentice Fitter & Turner, then Contracts
Engineer with:-
George Clark & N.E.M., LTD.
P.O. Box 8
Northumberland Engine Works
Wallsend, Northumberlan, England
Telephone No. 011-44-966-623141

Summary of Work Experience & Accomplishments

As a Marine Consultant with Ocean Transport & Trading, my duties have included:-

Negotiation and formation of a joint venture with the American Bureau of Shipping to provide fuel services to the marine industry.
My responsibilities have been to negotiate with Senior Officers of ABS and to formulate operational policy. My duties also include coordination of the various departments and efficient operation of the business. I have implemented the Data Bank System for the above business and control the staff so doing. I also act an an independent consultant on machinery damage investigations and run seminars for the following establishments on fuel technology.

1.) "Kings Point Merchant Marine Academy" on Professor Christenson's "Continuing Education on Diesel Technology" given to chief engineers studying for advanced certification.

2.) Maritime Safety International lecturing to chief and port engineers on poor quality fuel oil.

3.) Marine Engineers Benefit Association to chief and port engineers on poor quality fuel oils.

In addition I advise on system design for ships enginerooms and upgrade existing vessel so that they have full operational capability on lower quality fuel. I have worked in this capacity with major American shipping companies and normally negotiate the contracts for so doing with the vice presidents of those respective companies.

Prior to my employment as a Consultant, I was employed by the same company for 12 years as a Marine Engineer in all capacities up to the rank of Chief Engineer. In this capacity my responsibilities were for the efficient operation and maintenance of various diesel engines, boilers, air compressors, refrigeration systems which encompassed a high degree of automation. Coordination with different marine and hull classification societies was also a requirement as was the effective implementation of planned maintenance scheduling.

Before continuing my career at sea, I was employed by British Shipbuilders as a Contracts Engineer. During this period, my responsibilities were to produce ships specifications for newbuildings to a potential owners requirements, and also to handle all ships contract correspondence. It was also my responsibility to estimate the costs of various building projects and submit these costs for negotiation with the owners representatives.

Prior to my employment with British Shipbuilders, I served an Engineering Apprenticeship with George Clark & N.E.M. LTD., a Marine Enginebuilder. On completion of my apprenticeship I continued as a Draughtsman with this same company in the Engine Design Department until I was promoted to Contracts Engineer with duties similar to those held at British Shipbuilders.

ATTACHMENT 2

# RESUME

NAME: Christopher John Smith

ADDRESS: 33173 Gillette Street
Lake Elsinore, CA 92330

HOME PHONE: 714-678-4278

BUS. PHONE: 609-848-2913

## QUALIFICATIONS

FIRST CLASS CERTIFICATE OF COMPETENCY "MOTOR"

## PERSONAL

Age: 38 years Height: 5'11" Weight: 160 lbs.

## EMPLOYMENT

1983 Marine Consultant with:
Ocean Fleets Services
1301 Metropolitan Avenue
Thorofare, New Jersey 08086

1970-1983 Served as Second Engineer on company vessels. Responsible for the efficient operation of all main and auxiliary machinery.

Resume
Christopher John Smith

1967-1970 Served as Fourth and Third Engineer on company vessels.

1962-1967 Joined Ocean Fleets and trained as an Engineer Cadet.

## WORK EXPERIENCE

During final year of apprenticeship spent several months in the company's engineering department designing engine room modifications for unmanned operation of machinery spaces of two classes of company ships.

Have stood by the building of four of the company's ships in Japanese shipyards. This involved the checking and testing of most systems and machines in the machinery spaces and making modification recommendations where applicable.

Recently as a consultant, I have been advising a major American shipping company on the improved design and operation of their machinery on lower grade fuel.

## INTERESTS

Aircraft maintenance, flying, and sky-diving.

ATTACHMENT 3

# PROFESSIONAL QUALIFICATIONS OF DALE G. BRIDENBAUGH

DALE G. BRIDENBAUGH
1723 Hamilton Avenue
Suite K
San Jose, CA 95125
(408) 266-2716

## EXPERIENCE:

1976 - PRESENT

President - MHB Technical Associates, San Jose, California

Co-founder and partner of technical consulting firm. Specialists in energy consulting to governmental and other groups interested in evaluation of nuclear plant safety and licensing. Consultant in this capacity to state agencies in California, New York, Illinois, New Jersey, Pennsylvania, Oklahoma and Minnesota and to the Norwegian Nuclear Power Committee, Swedish Nuclear Inspectorate, and various other organizations and environmental groups. Performed extensive safety analysis for Swedish Energy Commission and contributed to the Union of Concerned Scientist's Review of WASH-1400. Consultant to the U.S. NRC - LWR Safety Improvement Program, performed Cost Analysis of Spent Fuel Disposal for the Natural Resources Defense Council, and contributed to the Department of Energy LWR Safety Improvement Program for Sandia Laboratories. Served as expert witness in NRC and state utility commission hearings.

1976 - (FEBRUARY - AUGUST)

Consultant, Project Survival, Palo Alto, California

Volunteer work on Nuclear Safeguards Initiative campaigns in California, Oregon, Washington, Arizona, and Colorado. Numerous presentations on nuclear power and alternative energy options to civic, government, and college groups. Also resource person for public service presentations on radio and television.

1973 - 1976

Manager, Performance Evaluation and Improvement, General Electric Company - Nuclear Energy Division, San Jose, California

Managed seventeen technical and seven clerical personnel with responsibility for establishment and management of systems to monitor and measure Boiling Water Reactor equipment and system operational performance. Integrated General Electric resources in customer plant modifications, coordinated correction of causes of forced outages and of efforts to improve reliability and performance of BWR systems. Also responsible for development of Division Master Performance Improvement Plan as well as for numerous Staff special assignments on long-range studies. Was on special assignment for the management of two different ad hoc projects formed to resolve unique technical problems.

1972 - 1973

Manager, Product Service, General Electric Company - Nuclear Energy Division, San Jose, California

Managed group of twenty-one technical and four clerical personnel. Prime responsibility was to direct interface and liaison personnel involved in corrective actions required under contract warranties. Also in charge of refueling and service planning, performance analysis, and service communication functions supporting all completed commercial nuclear power reactors supplied by General Electric, both domestic and overseas (Spain, Germany, Italy, Japan, India, and Switzerland).

1968 - 1972

Manager, Product Service, General Electric Company - Nuclear Energy Division, San Jose, California

Managed sixteen technical and six clerical personnel with the responsibility for all customer contact, planning and execution of work required after the customer acceptance of department-supplied plants and/or equipment. This included quotation, sale and delivery of spare and renewal parts. Sales volume of parts increased from $1,000,000 in 1968 to over $3,000,000 in 1972.

1966 - 1968

Manager, Complaint and Warranty Service, General Electric Company - Nuclear Energy Division, San Jose, California

Managed group of six persons with the responsibility for customer contacts, planning and execution of work required after customer acceptance of department-supplied plants and/or equipment--both domestic and overseas.

1963 - 1966

Field Engineering Supervisor, General Electric Company, Installation and Service Engineering Department, Los Angeles, California

Supervised approximately eight field representatives with responsibility for General Electric steam and gas turbine installation and maintenance work in Southern California, Arizona, and Southern Nevada. During this period was responsible for the installation of eight different central station steam turbine-generator units, plus much maintenance activity. Work included customer contact, preparation of quotations, and contract negotiations.

1956 - 1963

Field Engineer, General Electric Company, Installation and Service Engineering Department, Chicago, Illinois

Supervised installation and maintenance of steam turbines of all sizes. Supervised crews of from ten to more than one hundred men, depending on the job. Worked primarily with large utilities but had significant work with steel, petroleum and other process industries. Had four years of experience at construction, startup, trouble-shooting and refueling of the first large-scale commercial nuclear power unit.

1955 - 1956

Engineering Training Program, General Electric Company, Erie, Pennsylvania, and Schenectady, New York

Training assignments in plant facilities design and in steam turbine testing at two General Electric factory locations.

1953 - 1955

United States Army - Ordnance School, Aberdeen, Maryland

Instructor - Heavy Artillery Repair. Taught classroom and shop disassembly of artillery pieces.

1953

Engineering Training Program, General Electric Company, Evendale, Ohio

Training assignment with Aircraft Gas Turbine Department.

EDUCATION & AFFILIATIONS:

BSME - 1953, South Dakota School of Mines and Technology, Rapid City, South Dakota, Upper 1/4 of class.

Professional Nuclear Engineer - California. Certificate No. 0973.

Member - American Nuclear Society

Various Company Training Courses during career including Professional Business Management, Kepner Tregoe Decision Making, Effective Presentation, and numerous technical seminars.

HONORS & AWARDS:

Sigma Tau - Honorary Engineering Fraternity.

General Managers Award, General Electric Company.

PERSONAL DATA:

Born November 20, 1931, Miller, South Dakota.
Married, three children
6'2", 190 lbs., health - excellent
Honorable discharge from United States Army
Hobbies: Skiing, hiking, work with Boy Scout Groups

PUBLICATIONS & TESTIMONY:

1. Operating and Maintenance Experience, presented at Twelfth Annual Seminar for Electric Utility Executives, Pebble Beach, California, October 1972, published in General Electric NEDC-10697, December 1972.

2. Maintenance and In-Service Inspection, presented at IAEA Symposium on Experience From Operating and Fueling of Nuclear Power Plants, Bridenbaugh, Lloyd & Turner, Vienna, Austria, October, 1973.

3. Operating and Maintenance Experience, presented at Thirteenth Annual Seminar for Electric Utility Executives, Pebble Beach, California, November 1973, published in General Electric NEDO-20222, January, 1974.

4. Improving Plant Availability, presented at Thirteenth Annual Seminar for Electric Utility Executives, Pebble Beach, California, November 1973, published in General Electric NEDO-20222, January, 1974.

5. Application of Plant Outage Experience to Improve Plant Performance, Bridenbaugh and Burdsall, American Power Conference, Chicago, Illinois, April 14, 1974.

6. Nuclear Valve Testing Cuts Cost, Time, Electrical World, October 15, 1974.

7. Testimony of D. G. Bridenbaugh, R. B. Hubbard, and G. C. Minor before the United States Congress, Joint Committee on Atomic Energy, February 18, 1976, Washington, D.C. (Published by the Union of Concerned Scientists, Cambridge, Massachusetts.)

8. Testimony of D. G. Bridenbaugh, R. B. Hubbard, G. C. Minor to the California State Assembly Committee on Resources, Land Use, and Energy, March 8, 1976.

9. Testimony by D. G. Bridenbaugh before the California Energy Commission, entitled, Initiation of Catastrophic Accidents at Diablo Canyon, Hearings on Emergency Planning, Avila Beach, California, November 4, 1976.

10. Testimony by D. G. Bridenbaugh before the U. S. Nuclear Regulatory Commission, subject: Diablo Canyon Nuclear Plant Performance, Atomic Safety and Licensing Board Hearings, December, 1976.

11. Testimony by D. G. Bridenbaugh before the California Energy Commission, subject: Interim Spent Fuel Storage Considerations, March 10, 1977.

12. Testimony of D. G. Bridenbaugh before the New York State Public Service Commission Siting Board Hearings concerning the Jamesport Nuclear Power Station, subject: Effect of Technical and Safety Deficiencies on Nuclear Plant Cost and Reliability, April, 1977.

13. Testimony by D. G. Bridenbaugh before the California State Energy Commission, subject: Decommissioning of Pressurized Water Reactors, Sundesert Nuclear Plant Hearings, June 9, 1977.

14. Testimony by D. G. Bridenbaugh before the California State Energy Commission, subject: Economic Relationships of Decommissioning, Sundesert Nuclear Plant, for the Natural Resources Defense Council, July 15, 1977.

15. The Risks of Nuclear Power Reactors: A Review of the NRC Reactor Safety Study WASH-1400, Kendall, Hubbard, Minor & Bridenbaugh, et al, for the Union of Concerned Scientists, August, 1977.

16. Testimony by D. G. Bridenbaugh before the Vermont State Board of Health, subject: Operation of Vermont Yankee Nuclear Plant and Its Impact on Public Health and Safety, October 6, 1977.

17. Testimony by D. G. Bridenbaugh before the U.S. Nuclear Regulatory Commission, Atomic Safety and Licensing Board, subject: Deficiencies in Safety Evaluation of Non-Seismic Issues, Lack of a Definitive Finding of Safety, Diablo Canyon Nuclear Units, October 18, 1977, Avila Beach, California.

18. Testimony by D. G. Bridenbaugh before the Norwegian Commission on Nuclear Power, subject: Reactor Safety/Risk, October 26, 1977.

19. Swedish Reactor Safety Study: Barseback Risk Assessment, MHB Technical Associates, January, 1978. (Published by the Swedish Department of Industry as Document DsI 1978:1)

20. Testimony by D. G. Bridenbaugh before the Louisiana State Legislature Committee on Natural Resources, subject: Nuclear Power Plant Deficiencies Impacting on Safety & Reliability, Baton Rouge, Louisiana, February 13, 1978.

21. Spent Fuel Disposal Costs, report prepared by D. G. Bridenbaugh for the Natural Resources Defense Council (NRDC), August 31, 1978.

22. Testimony of D. G. Bridenbaugh, G. C. Minor, and R. B. Hubbard before the Atomic Safety and Licensing Board, in the matter of the Black Fox Nuclear Power Station Construction Permit Hearings, September 25, 1978, Tulsa, Oklahoma.

23. Testimony of D. G. Bridenbaugh and R. B. Hubbard before the Louisiana Public Service Commission, Nuclear Plant and Power Generation Costs, November 19, 1978, Baton Rouge, Louisiana.

24. Testimony by D. G. Bridenbaugh before the City Council and Electric Utility Commission of Austin, Texas, Design, Construction, and Operating Experience of Nuclear Generating Facilities, December 5, 1978, Austin, Texas.

25. Testimony by D. G. Bridenbaugh for the Commonwealth of Massachusetts, Department of Public Utilities, Impact of Unresolved Safety Issues, Generic Deficiencies, and Three Mile Island-Initiated Modifications on Power Generation Cost at the Proposed Pilgrim-2 Nuclear Plant, June 8, 1979.

26. Improving the Safety of LWR Power Plants, MHB Technical Associates, prepared for U.S. Dept. of Energy, Sandia Laboratories, September 28, 1979.

27. BWR Pipe and Nozzle Cracks, MHB Technical Associates, for the Swedish Nuclear Power Inspectorate (SKI), October, 1979.

28. Uncertainty in Nuclear Risk Assessment Methodology. MHB Technical Associates, for the Swedish Nuclear Power Inspectorate (SKI), January 1980.

29. Testimony of D. G. Bridenbaugh and G. C. Minor before the Atomic Safety and Licensing Board, in the matter of Sacramento Municipal Utility District, Rancho Seco Nuclear Generating Station following TMI-2 accident, subject: Operator Training and Human Factors Engineering, for the California Energy Commission, February 11, 1980.

30. Italian Reactor Safety Study: Caorso Risk Assessment, MHB Technical Associates, for Friends of the Earth, Italy, March, 1980.

31. Decontamination of Krypton-85 from Three Mile Island Nuclear Plant, H. Kendall, R. Pollard, & D. G. Bridenbaugh, et al, The Union of Concerned Scientists, delivered to the Governor of Pennsylvania, May 15, 1980.

32. Testimony by D. G. Bridenbaugh before the New Jersey Board of Public Utilities, on behalf of New Jersey Public Advocate's Office, Division of Rate Counsel, Analysis of 1979 Salem-1 Refueling Outage, August, 1980.

33. Minnesota Nuclear Plants Gaseous Emissions Study, MHB Technical Associates, for Minnesota Pollution Control Agency, September, 1980.

34. Position Statement, Proposed Rulemaking on the Storage and Disposal of Nuclear Waste, Joint Cross-Statement of Position of the New England Coalition on Nuclear Pollution and the Natural Resources Defense Council, September, 1980.

35. Testimony by D. G. Bridenbaugh and G. C. Minor, before the New York State Public Service Commission, In the Matter of Long Island Lighting Company Temporary Rate Case, prepared for the Shoreham Opponents Coalition, September 22, 1980, Shoreham Nuclear Plant Construction Schedule.

36. Supplemental Testimony by D. G. Bridenbaugh before the New Jersey Board of Public Utilities, on behalf of New Jersey Department of the Public Advocate, Division of Rate Counsel, Analysis of 1979 Salem-1 Refueling Outage, December, 1980.

37. Testimony by D. G. Bridenbaugh and G. C. Minor, before the New Jersey Board of Public Utilities, on behalf of New Jersey Department of the Public Advocate, Division of Rate Counsel, Oyster Creek 1980 Refueling Outage Investigation, February 1981.

38. Economic Assessment: Ownership Interest in Palo Verde Nuclear Station, MHB Technical Associates, for the City of Riverside, September 11, 1981.

39. Testimony of D. G. Bridenbaugh before the Public Utilities Commission of Ohio, in the Matter of the Regulation of the Electric Fuel Component Contained Within the Rate Schedules of the Toledo Edison Company and Related Matters, subject: Davis-Besse Nuclear Power Station 1980-81 Outage Review, November, 1981.

40. Supplemental Testimony of D. G. Bridenbaugh before the Public Utilities Commission of Ohio, in the matter of the Regulation of the Electric Fuel Component Contained within the Rate Schedules of the Toledo Edison Company and Related Matters, subject: Davis-Besse Nuclear Power Station 1980-81 Outage Review, November 1981.

41. Systems Interaction and Single Failure Criterion, Phase 2 Report, MHB Technical Associates for the Swedish Nuclear Power Inspectorate (SKI), January, 1982.

42. Testimony of D. G. Bridenbaugh and G. C. Minor on behalf of Governor Edmund G. Brown Jr., before the Atomic Safety and Licensing Board, regarding Contention 10, Pressurizer Heaters, January 11, 1982.

43. Testimony of D. G. Bridenbaugh and G. C. Minor on behalf of Governor Edmund G. Brown Jr., before the Atomic Safety and Licensing Board, regarding Contention 12, Block and Pilot Operated Relief Valves, January 11, 1982.

44. Testimony of D. G. Bridenbaugh before the Commonwealth of Massachusetts, Department of Public Utilities, on behalf of the Massachusetts Attorney General, Pilgrim Nuclear Power Station, 1981-82 Outage Investigation, March 11, 1982.

45. Testimony of D. G. Bridenbaugh before the Pennsylvania Public Utility Commission, on behalf of the Pennsylvania Office of Consumer Advocate, Beaver Valley Outage, March, 1982.

46. Interim testimony of D. G. Bridenbaugh before the Illinois Commerce Commission, on behalf of the Illinois Attorney General's Office, Expected Lifetimes and Performance of Nuclear Power Plants, March, 1982.

47. Testimony of D. G. Bridenbaugh and G. C. Minor before the Atomic Safety and Licensing Board, on behalf of Suffolk County, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 11, Passive Mecnanical Valve Failures, April 13, 1982.

48. Testimony of D. G. Bridenbaugh and R. B. Hubbard, in the Matter of Jersey Central Power and Light Company For an Increase in Rates for Electrical Service, on behalf of New Jersey Department of the Public Advocate, Division of Rate Counsel, Three Mile Island Units 1 & 2, Cleanup and Modification Programs, May, 1982.

49. Testimony of D. G. Bridenbaugh and G. C. Minor on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 22, SRV Test Program, May 25, 1982.

50. Testimony of D. G. Bridenbaugh and G. C. Minor on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 28(a)(vi) and SOC Contention 7A(6), Reduction of SRV Challenges, June 14, 1982.

51. Testimony of D. G. Bridenbaugh before the Illinois Commerce Commission, on behalf of the Illinois Attorney General's Office, Expected Lifetimes and Performance of Nuclear Power Plants, June 18, 1982.

52. Testimony of D. G. Bridenbaugh and R. B. Hubbard on behalf of the Ohio Consumers Counsel, before the Public Utilities Commission of Ohio, regarding Construction of Perry Nuclear Generating Unit No. 1, October 7, 1982.

53. Issues Affecting the Viabiling and Acceptability of Nuclear Power Usage in the United States, prepared by MHB Technical Associates for Congress of the United States, Office of Technology Assessment for use in conjunction with Workshop on Technological and Regulatory Changes in Nuclear Power, December 8 & 9, 1982.

54. Testimony of D. G. Bridenbaugh on behalf of Rockford League of Women Voters, before the Atomic Safety and Licensing Board, in the matter of Commonwealth Edison Company, Byron Station, Units 1 and 2, regarding Contention 22, Steam Generators, March 1, 1983.

55. Testimony of G. C. Minor and D. G. Bridenbaugh before the Pennsylvania Public Utility Commission, on behalf of the Office of Consumer Advocate, Regarding the Cost of Constructing the Susquehanna Steam Electric Station, Unit I, Re: Pennsylvania Power and Light, March 18, 1983.

56. Surrebuttal Testimony of D. G. Bridenbaugh before the Pennsylvania Public Utility Commission, on behalf of the Office of Consumer Advocate, Regarding the Cost of Constructing the Susquehanna Steam Electric Station, Unit I, Re: Pennsylvania Power and Light, April 20, 1983.

57. Testimony of D. G. Bridenbaugh In the Matter of Public Service Gas & Electric, Base Rate Case, Nuclear Construction Expenditures, on behalf of New Jersey Department of the Public Advocate, Division of Rate Counsel, October 13, 1983

58. Affidavit of D. G. Bridenbaugh, in the Matter of Jersey Central Power and Light, on behalf of New Jersey Department of the Public Advocate, Division of Rate Counsel, TMI Fault Investigation, November 23, 1983.

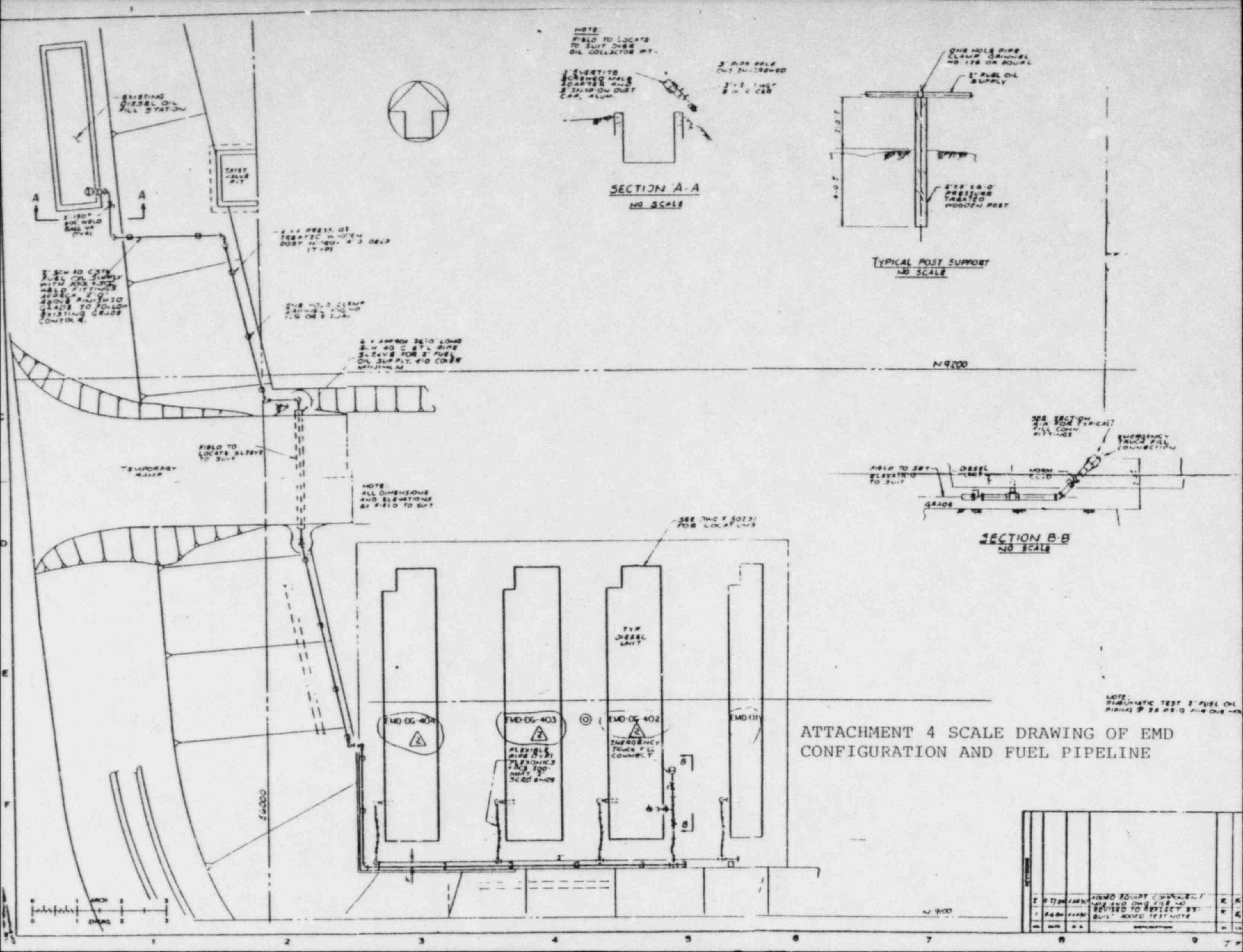
59. Testimony of D. G. Bridenbaugh, in the Matter of Public Service Electric & Gas, on behalf of New Jersey Department of the Public Advocate, Division of Rate Counsel, LEAC Investigation, Salem-1 Outages, December 1, 1983.

60. Rebuttal Testimony of D. G. Bridenbaugh, in the Matter of public Service Electric & Gas, on behalf of New Jersey Department of the Public Advocate, Division of Rate Counsel, LEAC Investigation, Salem-1 Outages, January 18, 1984.

61. Testimony of D. G. Bridenbaugh, L. M. Danielson, R. B. Hubbard and G. C. Minor before the State of New York Public Service Commission, PSC Case No. 27563, in the matter of Long Island Lighting Company Proceeding to Investigate the Cost of the Shoreham Nuclear Generating Facility -- Phase II, on behalf of County of Suffolk, February 10, 1984.

62. Status Report, WJ Zimmer Plant, Assessment of Options, MHB Technical Associates, prepared for The Ohio Office of the Consumer's Counsel, February 23, 1984.

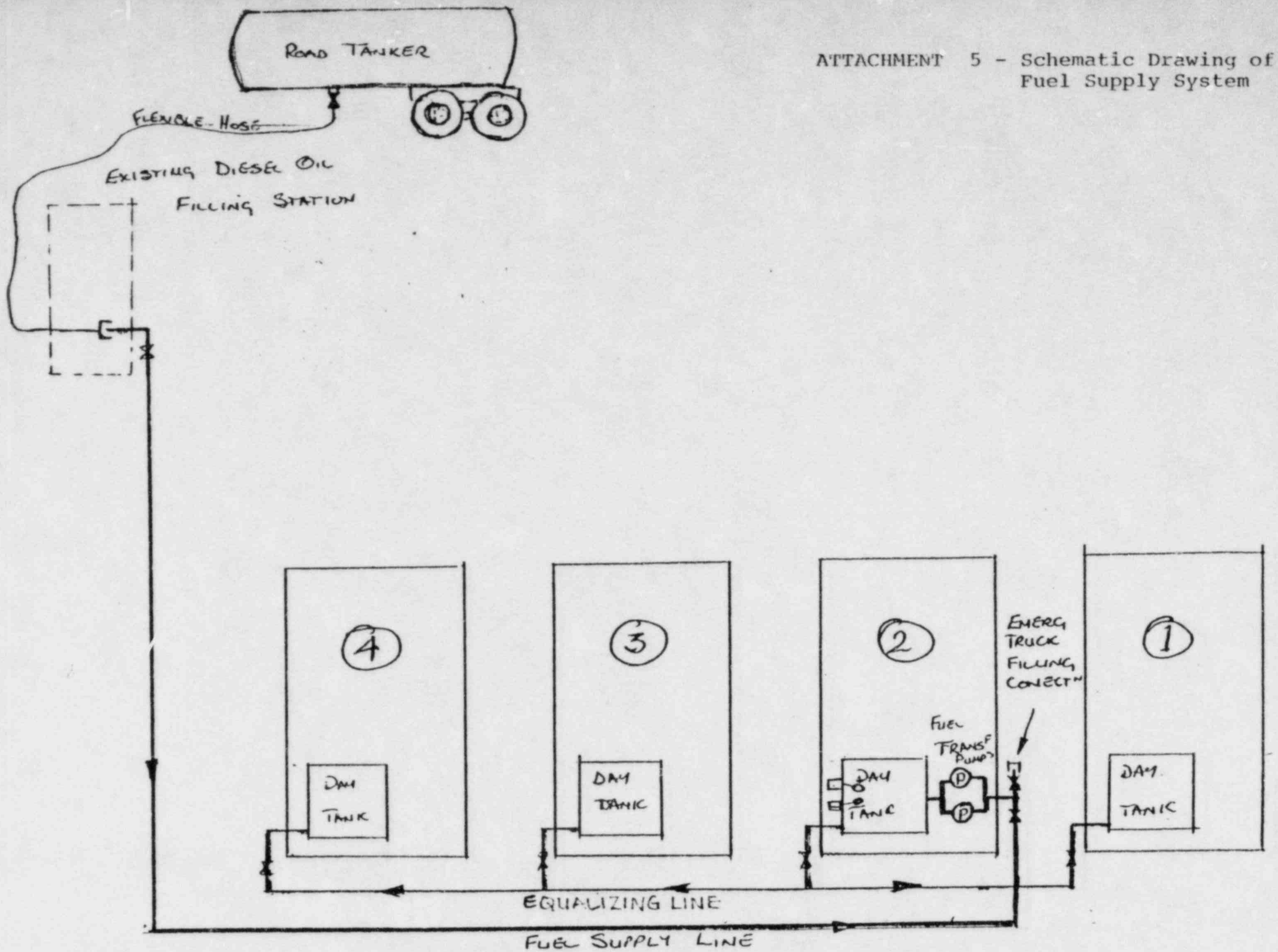
ATTACHMENT 4




ATTACHMENT 4 SCALE DRAWING OF EMD CONFIGURATION AND FUEL PIPELINE

ATTACHMENT 5

ATTACHMENT 5 - Schematic Drawing of EMD Fuel Supply System



ATTACHMENT 6

Attachment 6 is a photograph of facilities within the boundaries of the Shoreham site. Due to concerns of LILCO, circulation of Attachment 6 has been restricted. At the hearing, copies will be provided for the use of the Licensing Board, parties and witnesses.

ATTACHMENT 7

Attachment 7 is a photograph of facilities within the boundaries of the Shoreham site. Due to concerns of LILCO, circulation of Attachment 7 has been restricted. At the hearing, copies will be provided for the use of the Licensing Board, parties and witnesses.

ATTACHMENT 8

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ATTACHMENT 9

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ATTACHMENT 10

Submitted: [signature]

Reviewed/OQA Engr.: [signature]

Approved/Plant Mgr.: [signature]

MC-1

TP Number 24.307.04
Revision 0
Date Eff. 5/11/84
TPC 84-41N - 5-11-84
TPC
TPC

## BI-WEEKLY TESTING OF G. M.
## MOBILE DIESEL GENERATORS

1.0 PURPOSE

To provide detailed steps necessary to perform the required surveillance testing as set forth by LILCO commitments and to provide additional assurances of the highest reliable A.C. power supply for Shoreham.

2.0 RESPONSIBILITY

The Operating Engineer shall be responsible for ensuring proper implementation of this procedure.

SR2-1021.200-6.421

INFORMATION COPY

JUN 07 1984

# BI-WEEKLY TESTING OF GM MOBILE DIESEL GENERATOR UNIT # 4

| | Signature | Initials | Time | Date |
|---|---|---|---|---|
| Authorization for Start | | | | |
| Initiated By | | | | |
| Completed By | | | | |
| Reviewed By | | | | |

| Step Procedure | Initials |
|---|---|
| 1. Verify Prerequisites Have Been Met | |
| 2. Place Selector Switch (ACB 4 Cubicle Door) to Idle Allow Engine to Idle for approx. 90 secs. (90 Sec TD Before High Speed Operation permitted) | |
| NOTE: NEXT STEP STARTS THE DIESEL GENERATOR # 4 | |
| 3. Place Start/Stop Switch to Start | |
| 4. Place Selector Switch to Run Engine will accelerate to 900 rpm | |
| 5. Place Selector Switch to "Excite" Position Observe Generator Volts increase | |
| 6. Adjust Generator Voltage with Voltage Control Switch (Only Generator Voltage indicated, no Bus Voltage Check with C. R. for Bus Voltage) | |
| 7. Adjust Engine Speed with the Governor Control Switch (Set Indicator to 60 Hertz) | |
| 8. Using Synch. Lights on Main Control Cabinet, Close ACB #4 at Point of Complete Darkness | |
| 9. Increase Load to Approximately 225 amps | |
| 10. After Run is complete, Shutdown Diesel by Lowering Load to approx. 40 amps with Governor Control Switch | |
| 11. Open Generator ACB #4 | |
| 12. Place Start/Stop Switch to stop | |
| 13. Place Selector Switch to Auto | |

ATTACHMENT 11

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ATTACHMENT 12

ATTACHMENT 12

EMD 401

(UTEX Engine at 6030 hours)

Hours:

| | |
|---|---|
| 11601 | New Radiator |
| 11618 | New Cylinder Head (9) Crkd |
| 11880 | New Power Pack (4) Head Crkd |
| 12242 | New Cylinder Heads (8.18) Crkd |
| 12274 | New Cylinder Head (2) Crkd |
| 12400 | New Power Assy (20) |
| 12498 | New Clock |
| 12695 | New Power Assy (6, 9, 11, 19) |
| 12932 | Repower |
| 12938 | New Starters |
| 13019 | New Power Assy (4, 6, 10, 11, 13, 18) |
| 13019.25 | New Power Assy (11) |
| 13234 | New Frequency Generator |
| 13290 | New Left Rear Camshaft |
| 13290 | Report of Installation Inspection at Shoreham states that water pumps need replacing. |

ATTACHMENT 13

EMD 402

(UTEX Engine at 6552 hours)

| Hours: | |
|---|---|
| 10834 | New Rear Radiator Core |
| 11279 | New Set Batteries |
| 11727 | New Cylinder Head (6) Crkd |
| 11437 | New Power Assy (19) |
| 12697 | New Stack |
| 12899 | New Cylinder Head |
| 12737 | New Power Assy (1) |
| 12846 | Camshaft Showing Wear |
| 12846 | Report of Installation Inspection at Shoreham states that engine components are used and approaching overnaul. Recommend monthly surveillance to inspect and advise LILCO of any abnormal conditions. |

ATTACHMENT 14

ATTACHMENT 14

# EMD 403

(UTEX Engine at 6163 hours)

| Hours: | |
|---|---|
| 11062 | New Cylinder Head (2) Valve Blow |
| 11310 | New Right Front Camshaft |
| 11306 | New Power Assy (19) |
| 11306 | New Cylinder Head (9) |
| 11563 | New LH Water Pump |
| 11632 | New Cylinder Head (19) |
| 11695 | New Cylinder Head (14) |
| 11822 | New Starting Motors |
| 11868 | New Cylinder Head (4) Crkd |
| 11892 | New Cylinder Head (12) |
| 11980 | New Viscous Damper |
| 11980 | Two New Water Pumps |
| 11980 | New Assy Drive Gear |
| 11980 | New Scavenge Pump Gear |
| 11980 | New Main Bearing Pump Gear |
| 11980 | New Governor Drive Gear |
| 12170 | New Cylinder Head (3.6) Valve Blow |
| 12532 | New Power Assy (17) |
| 12511 | New Cylinder Head (20) |
| 12694 | New Starting Motors |
| 12922 | Replaced Power Assy (1) Used Unit |
| 12952 | New Starting Motors |
| 13074 | Replaced Power Assy (16) Used Unit |
| 13152 | Repower |
| 13152 | New Turbocharger |
| 13152 | New R Cooling Water Pump |
| 13177 | Recommendation for Prelube Before Starting |
| 13286 | New Power Assy (5, 15) Scored |

ATTACHMENT 15

EMD 404

(UTEX Engine at 8070 hours)

| Hours: | |
|---|---|
| 9407 | New Generator and Dust Bin Blower (Failure) |
| 10992 | New Turbocharger (Failed) |
| 11540 | New Starter Motor |
| 11540 | New Frequency Generator |
| 11601 | New Lower Starter Motor |
| 11617 | New Upper Starter Motor |
| 11617 | New Frequency Generator |
| 11617 | New Upper and Lower Starter Motor |
| 11617 | New Power Assy (11, 13) |
| 11696 | New Turbocharger (Failed) |
| 11696 | Two New Aftercoolers (Damaged by Turbo Fail) |
| 11696 | New Cylinder Head (9, 10) Valve Blow |
| 12781 | New Left Water Pump |
| 12781 | New Governor |
| 13047 | New R&L Water Pumps |
| 13047 | Camshaft Showing Wear |
| 13047 | Report of Installation Inspection at Shoreham states that engine components are used and approaching overhaul. Recommend monthly surveillance to inspect and advise LILCO of any abnormal condition. |

ATTACHMENT 16

...ener: Diesel Generator #2

ATTACHMENT 16

## Clearance Readings

| Cylinder # | Auxillary | Gear | Cylinder # | Auxillary | Gear |
|---|---|---|---|---|---|
| 1 | .037 | .041 | 11 | .037 | .038 |
| 2 | .038 | .040 | 12 | .038 | .036 |
| 3 | .030 | .028 | 13 | .032 | .030 |
| 4 | .027 | .028 | 14 | .035 | .032 |
| 5 | .035 | .036 | 15 | .030 | .027 |
| 6 | .039 | .036 | 16 | .028 | .030 |
| 7 | .044 | .047 | 17 | .033 | .030 |
| 8 | .031 | .033 | 18 | .032 | .032 |
| 9 | .040 | .041 | 19 | .028 | .030 |
| 10 | .052 | .048 | 20 | .040 | .040 |

## Cylinder Liner Condition

| Cylinder # | Cylinder # |
|---|---|
| ood | 11 Heavy Picture Framing |
| rbon Drag Light Picture Framing | 12 Picture Framing Port Chipping |
| rt Chipping Carbon Drag + varnish | 13 good |
| iner wear Light Picture Framing (CD) | 14 Heavy Picture Framing |
| icture Framing Carbon Drag (V) | 15 Heavy Picture Framing (CD V) |
| iner wear Heavy Carbon Drag (V) | (16) Liner wear (PF CD) |
| icture Framing Light Port Chipping | 17 Heavy Picture Framing (CD V) |
| arbon Drag Light Port Chipping | 18 Picture Framing Carbon Drag (C |
| iner wear Carbon Drag (V) | 19 Heavy Picture Framing (CD) |
| icture Framing Carbon Drag | 20 Picture Framing Vertical Liner |

All cylinder conditions noted above were reviewed using EID pointers No. 7P-77 January 12, 1977 liner/piston inspection guide as criteria for qualification.

ENGINE COMPONENTS ARE USED AND UPON COMPLETING OVERHAUL FE ... MONTHLY SERVICE ONCE TO INSPECT AND ADVISE LILCO OF ANY ABNORMAL CONDITIONS.

Emergency Diesel Generator 1A

## Clearance Readings

| Cylinder # | Auxillary | Genr | Cylinder # | Auxillary | Genr |
|---|---|---|---|---|---|
| 1 | .045 | [illegible] | 11 | .043 | .044 |
| 2 | .047 | .044 | 12 | .046 | .048 |
| 3 | .048 | .045 | 13 | .038 | .040 |
| 4 | .044 | .044 | 14 | .040 | .040 |
| 5 | .044 | .043 | 15 | .038 | .037 |
| 6 | .050 | .047 | 16 | .039 | .042 |
| 7 | .050 | .048 | 17 | .033 | .033 |
| 8 | .047 | .046 | 18 | .034 | .036 |
| 9 | .048 | .047 | 19 | .041 | .044 |
| 10 | .054 | .054 | 20 | .032 | .034 |

Cylinder Liner Condition

| Cylinder # | | Cylinder # |
|---|---|---|
| 1 | Light Carbon Drag | 11 Heavy Picture Framing Carbon D[illegible] |
| 2 | Carbon Drag Vertical Marks | 12 Light Picture Framing Carbon Drag |
| 3 | Good | (13) Liner wear Heavy Picture Framing |
| 4 | Light Carbon Drag | 14 Light Picture Framing Carbon Drag |
| 5 | Liner wear Vertical marks | (15) Light Liner wear Picture Framing [illegible] |
| 6 | Liner wear | 16 Picture Framing Carbon Drag |
| 7 | Liner wear Vertical marks | 17 Picture Framing Vertical [illegible] |
| 8 | Liner wear Carbon Drag | 18 Light Picture Framing Carbon Drag |
| 9 | Liner wear Carbon Drag | 19 Light Picture Framing Carbon D[illegible] |
| 10 | Liner wear Picture Framing | 20 Light Picture Framing Carbon D[illegible] |

All cylinder conditions noted above were reviewed using EID pointers No. 17-77 January 12, 1977 Liner/piston inspection guide as criteria for qualification. Engine components are used and approaching overhaul, Recommend Monthly Surveillance to inspect and advise L.L.Co of any abnormal conditions

ATTACHMENT 17

Attachment 17 is a photograph of facilities within the boundaries of the Shoreham site. Due to concerns of LILCO, circulation of Attachment 17 has been restricted. At the hearing, copies will be provided for the use of the Licensing Board, parties and witnesses.