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P.O. Box 14000, Juno Beach, FL 33408-0420

MARCH 2 0 1989

L-89-107

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

Gentlemen:

Re: Turkey Point Units 3 and 4
Docket Nos. 50-250 and 50-251
Request for Additional Information on
Emergency Power System Enhancement Project
NRC TAC Nos. 69023 and 69024

Attached are the remaining Florida Power & Light Company (FPL) responses to your January 6, 1989 request for additional information regarding the Emergency Power System Enhancement Project. The responses to questions 1, 2, 32, 33, 34, 35, 37, 38, 39, 47, and the questions relating to the emergency diesel generator qualification testing are included. This submittal supplements the responses provided in FPL letter L-89-54 dated February 21, 1989.

Should there be any questions, please contact us.

Very truly yours,

W. F. Conway
Senior Vice President - Nuclear

WFC/TCG/cm

Attachment

cc: Stewart D. Ebneter, Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant

A001
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RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
EMERGENCY POWER SYSTEM ENHANCEMENT PROJECT

The following are the remaining Florida Power & Light Company responses to the NRC's January 6, 1989 Request for Additional Information (RAI) regarding the Emergency Power System (EPS) Enhancement Project. For your convenience, the response to each question immediately follows the duplicated RAI. Also for tracking purposes, the questions related to EDG qualification testing per Enclosure 2 of the January 6, 1989 request, have been numbered RAI 52 through RAI 60.

RAI 1

Identify the applicable Codes, Standards, Regulatory Guides, NUREGs, General Design Criteria, Generic Letters, and other documentation (hereafter "Standards") that are to be applied to the system enhancement. For each Standard identified, indicate to which part or parts of the system enhancement that the Standard will apply.

Response to RAI 1

1) Civil/Structural Design

The new EDG building, all internal structures, and all new exterior structures (i.e., ductbanks and manholes) as shown on Figure 1-1 will be designed in accordance with the following criteria. Modifications and additions to existing structures will be designed in accordance with the criteria specified in the FSAR.

a. Structural Analysis

1. The load combinations and structural acceptance criteria to be used in the design will be in accordance with NUREG 0800 (Standard Review Plan - SRP) Section 3.8.4.

2. Seismic

Maximum horizontal ground accelerations will be 0.15 g (Maximum Earthquake E' in FSAR) and 0.05 g for OBE (Design Earthquake E in FSAR). Maximum vertical ground accelerations will be two-thirds of the maximum horizontal ground acceleration values. Ground response spectra will be developed enveloping the Newmark curves in accordance with Regulatory Guide (RG) 1.60 "Design Response Spectra for Seismic Design of Nuclear Power Plants".

Damping values used in the design and analysis will be those presented in RG 1.61 "Damping Values for Seismic Design of Nuclear Power Plants". Combination of modes in maximum response analysis will be done using the "square-root-of-the-sum-of-the-squares" method in accordance with RG 1.92 "Combining Modal Responses and Spatial Components in Seismic Response Analysis". Orthogonal earthquake components will be combined using the SRSS method to determine maximum response as presented in RG 1.92. Building floor response spectra curves will be developed from synthetic time-histories using the methods described in RG 1.122 "Development of Floor Design Response Spectra for Seismic Design of Floor Supported Equipment or Components". The building mathematical model to be used in the dynamic analysis will consist of a lumped mass cantilever coupled to the acceleration time-history input by soil springs.

3. Wind Analysis

Wind velocity pressures will be calculated in accordance with ANSI 58.1 "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures". ASCE Paper No. 3269 "Wind Forces on Structures" will be used to obtain effective wind pressure for cases which ANSI A58.1 does not cover. This wind load criteria conforms to the SRP Section 3.3.1. In addition, the South Florida Building Code wind load criteria will be reviewed and used if it yields governing results.

4. Tornado Winds and Missiles

Tornado wind velocities and differential pressure drop will be in accordance with RG 1.76 "Design Basis Tornado for Nuclear Power Plants" and SRP Section 3.3.2. The velocity pressure will be calculated in accordance with ANSI 58.1 with no variation taken for height of the structure or exposure and a gust factor of unity.

The building will be designed to resist the impactive forces of tornado generated missiles combined with the velocity pressure and differential pressure in accordance with SRP Section 3.3.2. The tornado missile spectrum will be that given in SRP 3.5.1.

b. Missile Protection

Missile protection will be provided for the new EDG building and new exterior ductbanks and manholes shown on Figure 1-1. Missile barriers will be designed to resist penetration and impactive dynamic loading in accordance with the criteria provided in SRP 3.5.3. The following missiles will be considered in barrier design.

1. Tornado generated missiles in accordance with SRP 3.5.1
2. Internally generated missiles from the diesel generator.

Protection of the new EDG building from a turbine missile is achieved by its physical location and the low probability of occurrence as described in the FSAR.

c. Flood Design

The new EDG building will be protected from flooding by barriers designed in accordance with RG 1.102 "Flood Protection". The maximum flood and wave run-up elevations will be in accordance with the FSAR.

d. Concrete and Steel Design

Reinforced concrete design will be in accordance with the latest edition of ACI 349 "Code Requirements for Nuclear Safety Related Structures" as modified by RG 1.142 "Safety Related Concrete Structures".

Structural steel design will meet the requirements of the latest edition of AISC "Manual of Steel Construction."

e. Soil Properties

Allowable bearing capacity values and foundation design concepts will be based upon soil data contained in Dames and Moore report "Foundation Investigation, Proposed Nuclear Units, Turkey Point, Florida", dated February 5, 1965, and additional data obtained from testing following the guidelines of RG 1.132 "Site Investigation for Foundations" and RG 1.138 "Laboratory Investigation of Soils".

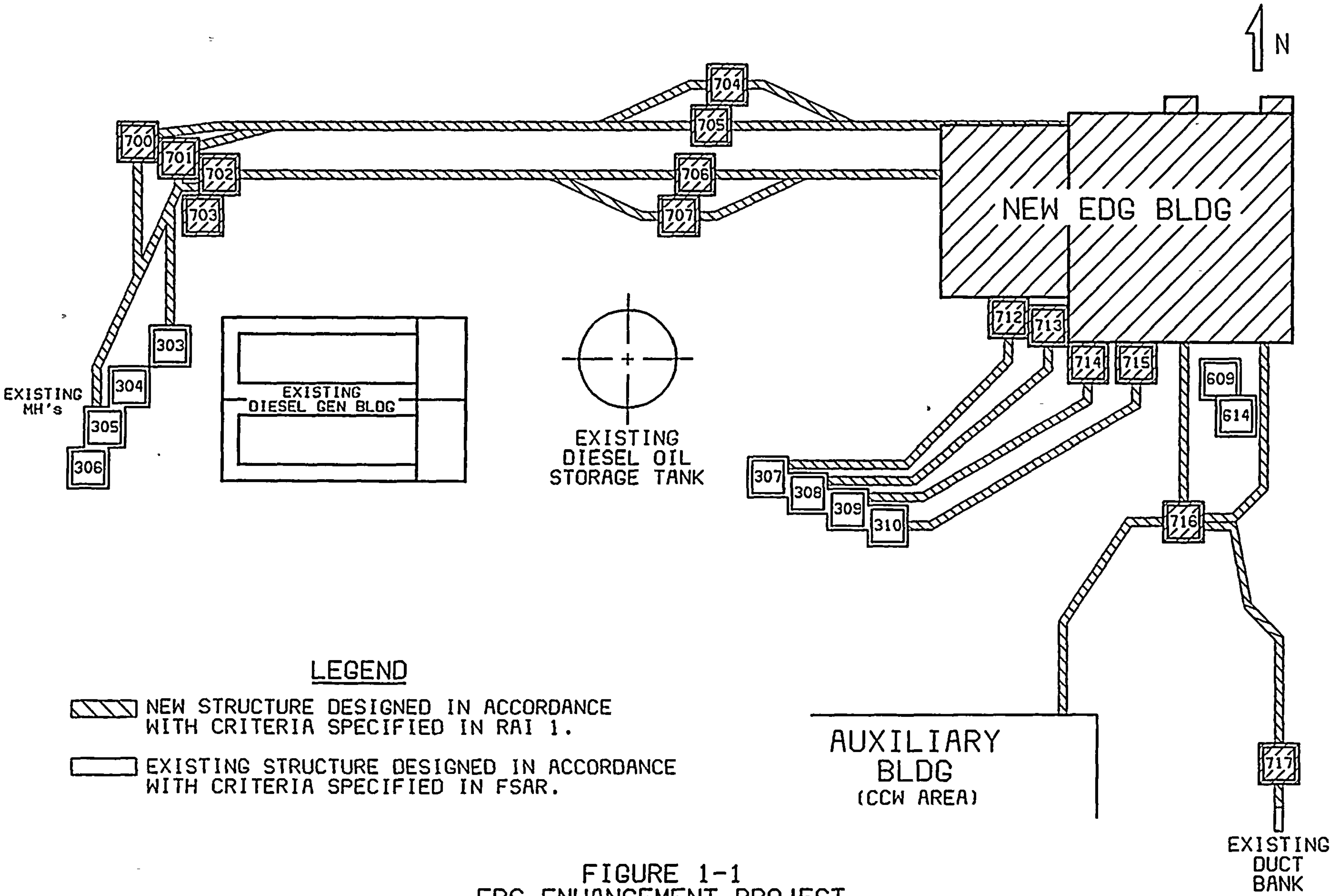


FIGURE 1-1
EPS ENHANCEMENT PROJECT
CIVIL/STRUCTURAL CRITERIA
(NOT TO SCALE)

2) Mechanical System Design

a. Diesel Oil Storage and Transfer System

The new diesel oil storage and transfer system up to the tie-in with the existing oil transfer system will be designed in accordance with Regulatory Guide 1.9 and ANSI Standard N195-1976, as endorsed by Regulatory Guide 1.137. In addition, the system will meet the performance requirements of SRP 9.5.4 as follows:

1. Safety related portions of the diesel oil storage and transfer system will be located inside Seismic Category I structures or otherwise protected from the effects of natural phenomena and external missiles.

2. The failure of non-seismic Category I structures and components will not affect the safety related function of the diesel oil storage and transfer system.

3. The design will ensure that a minimum of seven days of fuel oil is available for each new EDG to meet the engineered safety feature load requirements following a loss of offsite power and design basis accident.

Specific design standards for system components include the following:

- Diesel Oil Storage Tanks

  The diesel oil storage tanks will be designed in accordance with ASME Section VIII and will meet Seismic Category I requirements.

  Sample connection to the tanks will be provided in accordance with ASTM-D270. Connections to non-safety related piping will be provided with ASME Section III, Class 3, isolation valves.

- Diesel Oil Transfer Pumps

  The diesel oil transfer pumps will meet ASME Section III, for Class 3 components and Seismic Category I requirements. In service testing capability for these pumps will be provided in accordance with ASME Section XI.

- Diesel Oil Transfer System Piping

  The diesel oil transfer system piping, external to the engine skid, will be designed in accordance with ASME Section III, for Class 3 components and will meet Seismic Category I requirements.

All two inch and smaller valves will be ANSI Class 600 minimum. Two and one-half inch and larger valves will be ANSI Class 150 minimum.

The engine mounted piping, as a minimum, will be designed and analyzed to ANSI B31.1 and meet Seismic Category I requirements.

As stated in our response to RAI 26, an exception to ANSI N195 was taken for each day tank overflow line. The overflow lines do not go to the fuel oil supply tank, but go to a waste sump located outside the EDG building. Justification for this exception is based upon the use of instrumentation and controls which would prevent or alarm an overflow condition.

b. Diesel Engine Cooling Water System

The diesel engine cooling water system will be designed in accordance with RG 1.9. The system, except for the engine skid piping, the surge tank and radiator, will be designed to ASME Section III, for Class 3 components and will meet Seismic Category I requirements. The engine mounted piping, as a minimum, will be designed to ANSI B31.1 and meet Seismic Category I requirements. The radiators and surge tank will be designed in accordance with ASME Section VIII and will meet Seismic Category I requirements.

The design of the diesel engine cooling water system will meet the performance requirements of SRP 9.5.5 as follows:

1. System components and piping will have sufficient physical separation or shielding to protect the system from externally generated missiles. In addition, since each EDG and its associated cooling water system is independent and physically separated from the other via concrete wall, an internally generated missile (i.e., EDG missile), will not result in failure of the other EDG or its associated cooling water system.

2. The system will be protected from the effects of pipe cracks and breaks in piping since there are no high- or moderate-energy lines in the new EDG building.

3. The system will be housed in structures designed to seismic Category I requirements.

4. Failures of non-seismic Category I structures and components will not affect the safety-related function of the diesel engine cooling water system.

5. Functional capability of the diesel engine cooling water system will not be adversely affected during periods of abnormally high water levels (i.e., the maximum probable flood).

6. The design of an independent cooling water system for each EDG ensures that the failure of a cooling system due to excessive leakage or malfunction will not affect the performance capability of the other EDG. In addition, the capability to detect system leakage will be provided.

7. The system material will be compatible with the corrosion inhibitors or antifreeze compounds used as a coolant.

8. The capacity of the cooling system will be sufficient to ensure proper diesel engine operation under all loading conditions.

9. Proper instrumentation will be provided to permit operational testing of the system.

10. The system design will include provisions to assure that normal protective interlocks do not preclude engine operation during emergency conditions.

c. Diesel Engine Starting System

The diesel engine starting system will be designed in accordance with Regulatory Guide 1.9. The system including air receivers and system piping external to the engine skid will be designed to ASME Section III for Class 3 components. System piping will meet Seismic Category I requirements.

The engine mounted piping, as a minimum, will be designed to ANSI B31.1 and meet Seismic Category I requirements.

All 2 inch and smaller valves will be ANSI Class 600 minimum. Two and one-half inch and larger valves will be ANSI Class 150 minimum. The design of the diesel engine starting system will meet the performance requirements of SRP 9.5.6 as follows:

1. Each diesel engine will be provided with a dedicated air starting system consisting of an air compressor, an air dryer, one or more air receiver(s), piping, injection lines and valves, and devices to crank the engine as recommended by the engine manufacturer.

2. As a minimum, the air starting system will be capable of cranking a cold diesel engine five times without recharging the receiver(s).

3. Alarms will be provided which alert operating personnel if the air receiver pressure falls below the minimum allowable value.

4. Provisions will be made for the periodic or automatic blowdown of accumulated moisture and foreign material in the air receiver(s), and other critical points of the system.

5. Starting air will be dried to a dew point of not more the 50°F when installed in a normally controlled 70°F environment, otherwise the starting air dew point will be controlled to at least 10°F less than the lowest expected ambient temperature.

6. System components and piping will have sufficient physical separation or barriers to protect the system from externally generated missiles. In addition, since each EDG and its associated starting air system is independent and physically separated from the other via concrete wall, an internally generated missile (i.e., EDG missile), will not result in failure of the other EDG or its associated starting air system.

7. The system will be protected from the effects of pipe cracks and breaks in piping since there are no high- or moderate-energy lines in the new EDG Building.

8. The system will be housed in structures designed to seismic Category I requirements.

9. Failure of nonseismic Category I structures or components will not affect the safety-related functions of the system.

10. Functional capability of the starting air system will not be adversely affected during abnormally high site water levels (i.e., maximum probable flood).

d. Diesel Engine Lubrication System

The diesel engine lubrication system will be designed in accordance with RG 1.9.

All engine lube oil piping will be designed to ANSI B31.1 and will meet Seismic Category I requirements.

The design of the diesel engine lubrication system will meet the performance requirements of SRP 9.5.7 as follows:

1. System components and piping will have sufficient physical separation or barriers to protect the system from externally generated missiles. In addition, since each EDG and its associated lube oil system is independent and physically separated from the other via concrete wall, an internally generated missile (i.e., EDG missile), will not result in failure of the other EDG or its associated lube oil system.

2. The system will be protected from the effects of pipe cracks or breaks in piping since there are no high- or moderate-energy lines in the new EDG building.

3. The system will be housed in structures designed to seismic Category I requirements.

4. Failure of nonseismic Category I structures or components will not affect the safety-related functions of the system.

5. Functional capability of the lube oil system will not be adversely affected during abnormally high site water levels (i.e., maximum probable flood).

6. The design of an independent lube oil system for each EDG ensures that the failure of a lube oil system due to excessive leakage or malfunction will not affect the performance capability of the other EDG. In addition, the capability to detect system leakage will be provided.

7. Measures to assure the quality of the lubricating oil will be provided.

8. Instrumentation and control features will be provided to permit operational testing of the system and to assure that normal protective interlocks do not preclude engine operation during emergency conditions.

9. Measures will be provided for cooling the system and removing system heat load.

10. Protective measures (such as relief ports) will be utilized to prevent unacceptable crankcase explosions and to mitigate the consequences of such an event. (See response to RAI 47.)

11. The temperature of the lubricating oil will be automatically maintained above a minimum value by means of an independent recirculation loop including its own pump and heater, to enhance the "first-try" starting reliability of the engine in the standby condition.

12. The diesel engine will be provided with a dedicated lube oil system design which includes measures to provide lubrication to the diesel engine wearing parts during standby conditions and/or normal and emergency starts.

e. Diesel Engine Combustion Air Intake and Exhaust Systems

The diesel engine combustion air intake and exhaust systems will be designed in accordance with RG 1.9.

As a mimumum, all system piping will be designed and analyzed to ANSI B 31.1 requirements. The analysis will consider dead weight, pressure, thermal and seismic loads.

These systems will also be designed to meet the performance requirements of SRP 9.5.8 as follows:

1. Each new diesel engine will be provided with an independent and reliable combustion air intake and exhaust system. The systems will be sized and physically arranged such that no degradation of engine function will be experienced when the diesel generator set is required to operate continuously at the maximum power output.

2. The combustion air intake system will be provided with a means of reducing airborne particulate material over the entire time period that emergency power is required assuming the maximum airborne particulate concentration of the combustion air intake.

3. Design precautions will be taken to preclude degradation of the diesel engine power output due to exhaust gases and other dilutents that could reduce the oxygen content below acceptable levels.

f. Diesel Generator Building Ventilation System

The ventilation associated with the EDG control panel rooms and 4kV switchgear rooms will be designed safety related and meet Seismic Category I requirements.

The design of these systems will meet the performance requirements of SRP 9.4.5 as follows:

1. A single active failure will not result in loss of the system functional performance capabilities. Specifically, since each EDG control panel room is equipped with a dedicated ventilation system, a single active failure resulting in loss of one ventilation system will not affect the performance capability of the other ventilation system. For each 4kV switchgear room, a dedicated ventilation system consisting of redundant fans (i.e., one fan connected to an "A" train power source and the other connected to a "B" train power source), is provided. Therefore, a single active failure will not result in the loss of both fans to either switchgear room.

2. Failure of nonseismic Category I equipment or components will not result in damage to essential portions of the ventilation system.

3. The ventilation system will be designed to maintain a suitable ambient temperature range in the areas serviced.

4. The ability of the safety features equipment in the areas being serviced by the ventilation system to function under the worst anticipated degraded ventilation system performance will be assured.

5. The capability of the system to automatically actuate components not operating during normal conditions, or to actuate standby components (redundant equipment) in the event of a failure or malfunction, as needed will be provided.

6. The capability of the system to control airborne particulate material (dust) accumulation will be provided.

7. Functional capability of the ventilation system will not be adversely affected during periods of abnormally high water levels (i.e., maximum probable flood).

8. Ventilation system components will have sufficient physical separation or shielding to protect the system from internally or externally generated missiles.

9. The system components will be protected from the effects of pipe cracks and breaks in piping since there are no high- or moderate-energy lines in the new EDG building.

3) Electrical/Control System Design

Under the EPS Enhancement Project, two new emergency diesel generators and associated electrical equipment will be installed and integrated into the existing Turkey Point EPS. The electrical modifications required to implement the EPS enhancements will take place throughout existing plant areas and inside the new EDG building, with the majority of work occurring inside the new EDG building.

It is FPL's intent under the EPS Enhancement Project to comply with the latest standards for electrical design inside the new EDG building. Outside the new EDG building, electrical design will as a minimum, meet the criteria specified in the FSAR, or the latest standards wherever practical. This approach to the application of electrical design standards is considered acceptable and appropriate for the following reasons:

- Due to the physical configuration and vintage of Turkey Point's existing EPS, compliance with the latest standards outside the new EDG building would not be possible without the redesign and rework of numerous existing EPS structures/components including manholes, ductbanks, raceway and electrical enclosures throughout the plant. The effort to redesign and rework existing EPS structures/components to achieve compliance with latest standards would be prohibitive and is considered beyond the intent of the EPS Enhancement Project.

- From a human factors standpoint, we believe it is important to maintain a consistent design approach inside the existing plant. The application of latest standards for electrical design outside the new EDG building would introduce physical configuration differences with the surrounding systems and components. The application of FSAR criteria will ensure that a consistent design approach is maintained throughout the existing plant.

- By referring to Figure 1 of our June 23, 1988 submittal, it can be seen that most of the existing EPS is unchanged by the EPS enhancement modifications. Therefore, considering the capability of the EPS as a whole, it is our position that an appreciable increase in safety would not be achieved through the application of latest standards outside the new EDG building.

Specific standards which will be applied to electrical design inside the new EDG building are identified below. The use of these standards in conjunction with the FSAR criteria for the work outside the new EDG building will ensure that the capability of the enhanced EPS to comply with the Turkey Point General Design Criteria as specified in the FSAR, remains valid.

a. Protection Against Natural Phenomena

The new EDG's and safety related power distribution system components will be located in Seismic Category I structures which provide protection from the effects of earthquakes, tornadoes, hurricanes and floods. Also, see response to RAI 4 and RAI 5.

b. Environment and Missiles

See response to RAI 4 and RAI 5.

c. Sharing of Power System

See response to RAI 5.

d. Independence Between Redundant Load Groups

For electrical design in the new EDG building, the enhanced EPS will comply with the requirements of Regulatory Guide 1.6 for independence between redundant load groups.

e. Design of Diesel Generator Units

The selection, design and qualification of the new EDG's and associated auxiliary systems will comply with the requirements of Regulatory Guide 1.9 with the following exceptions.

1. FPL has requested exemption from the 300 Start and Load Acceptance Test provisions of IEEE Standard 387-1984 (Reference FPL letter L-88-454 dated October 19, 1988). In lieu of a 300 Start and Load Acceptance Test, FPL has proposed that a 30 Start and Load Acceptance Test be performed.

2. Physical independence of the new EDG's, equipment and circuits within the new EDG building is discussed in Item g below.

f. Bypassed and Inoperable Status Indication

The EPS Enhancement Project will provide for the installation of two (2) additional emergency diesels generators, two additional battery chargers and reconfiguration or addition of 4160V switchgears and 480V load centers, and 480V MCC's, but does not encompass all other safety systems such as containment isolation, safety injection and other systems which are required for the mitigation of the DBA or safe shutdown. Presently, Turkey Point Units 3 and 4 does not employ a Bypassed and Inoperable Status Indication System. Therefore, a Bypassed and Inoperable Status Indication System is not provided with the EPS Enhancement Project modifications. Status indication for the new EDG's and associated auxiliaries is discussed in our responses to RAI's 15, 20, 36, 43, 48 and 49.

g. Physical Independence

Physical independence of the new EDG's, equipment and circuits within the new EDG building will comply with the requirements of RG 1.75 and IEEE 384-1981 except as follows:

1) Non-Class 1E circuits which are associated with Class 1E circuits via electrical connection to a Class 1E power supply without the use of an isolation device, and/or proximity to Class 1E circuits and equipment without the required physical separation or barriers, will comply with the requirements of associated circuits except as follows:

   a. Identification - Associated circuits will not be uniquely identified as such. The terminology "associated" is not presently in use at Turkey Point. From a human factors standpoint, we believe it is important to maintain a consistent design approach throughout the plant. The introduction of this new terminology would create inconsistency in the plant, especially where cables originating in the new EDG building interface with the existing plant.

   b. Qualification Requirements

      1. Connected non-Class 1E circuits (except those noted in b.2 below), comply with the requirements placed on Class 1E circuits such as derating, environmental qualification (mild environment), flame retardance, splicing restrictions and raceway fill, except that connected non-Class 1E loads are seismically supported, not seismically qualified.

      2. Miscellaneous 120 VAC circuits (i.e., lighting and receptacles) which are routed in independent conduit systems and located within Class 1E enclosures will meet the flame retardance requirements of UL 83 in lieu of IEEE-383.

2) Consistent with current plant criteria, dry contacts of relays and control switches are considered isolation devices for instrumentation and control circuits. In the enclosure where these relays and switches are located, the wiring associated with the contacts are routed in the same wireways as the wiring associated with the redundant or non-Class 1E circuits. Once the cables exit the enclosure, control circuits to redundant equipment are routed in separate raceways per current plant criteria, ensuring that any physical damage affecting one circuit will not affect the redundant circuit.

3) Identification of Class 1E Cable - IEEE 384 requires that cables installed in exposed Class 1E raceways be marked at intervals of approximately five feet to facilitate initial verification that the installation is in conformance with the separation criteria. In accordance with current Turkey Point criteria, this marking will not be provided.

4) For Class 1E control panels, boards and racks, IEEE Standard 420-1982 requires that non-Class 1E equipment and circuits located within the same control panel be separated consistent with the criteria of IEEE 384. For the EPS Enhancement Project, the separation criteria of IEEE 384 as noted above will apply.

h. Application of Single Failure Criteria

Single failure criteria as specified in Regulatory Guide 1.53 will be applied to the modifications implemented under the EPS Enhancement Project.

<u>RAI 2</u>

Identify and provide justification or the reasons for deviations that are known at this time from these Standards. As work progresses, periodically update any further deviations from the Standards and the reasons for such deviations. Also, identify any additional Standards that become applicable as work progresses.

<u>Response to RAI 2</u>

FPL's approach to the application of codes and standards for the EPS Enhancement Project along with justification for identified exceptions is provided in response to RAI 1.

The control of applicable standards will be performed in accordance with FPL's Plant Change/Modification (PC/M) process. Under this process, the specific standards being applied to the detailed design will be specified in each PC/M. Any changes in design criteria from that specified in RAI 1 will be documented and justified. As PC/M's are developed, finalized and issued, they can be made available for NRC review, as necessary.

RAI 32

Provide a tabulation showing the individual and total heat removal rates for each major component and subsystem of the diesel generator cooling water system. Discuss the design margin (excess heat removal capability) included in the design of major components and subsystems.

Response to RAI 32

The attached Figure 32-1 identifies the total and individual heat removal rates for the diesel generator cooling water system at 110 percent rated load. The cooling system is designed to maintain a top tank (water leaving the engine) temperature of 190°F at 110 percent rated load and radiator cooling air entering the radiator coils at 122°F. Since the engine is typically not operated at 110 percent rated load, the actual heat removal requirements are lower. The lower actual heat load constitutes design margin for the system.

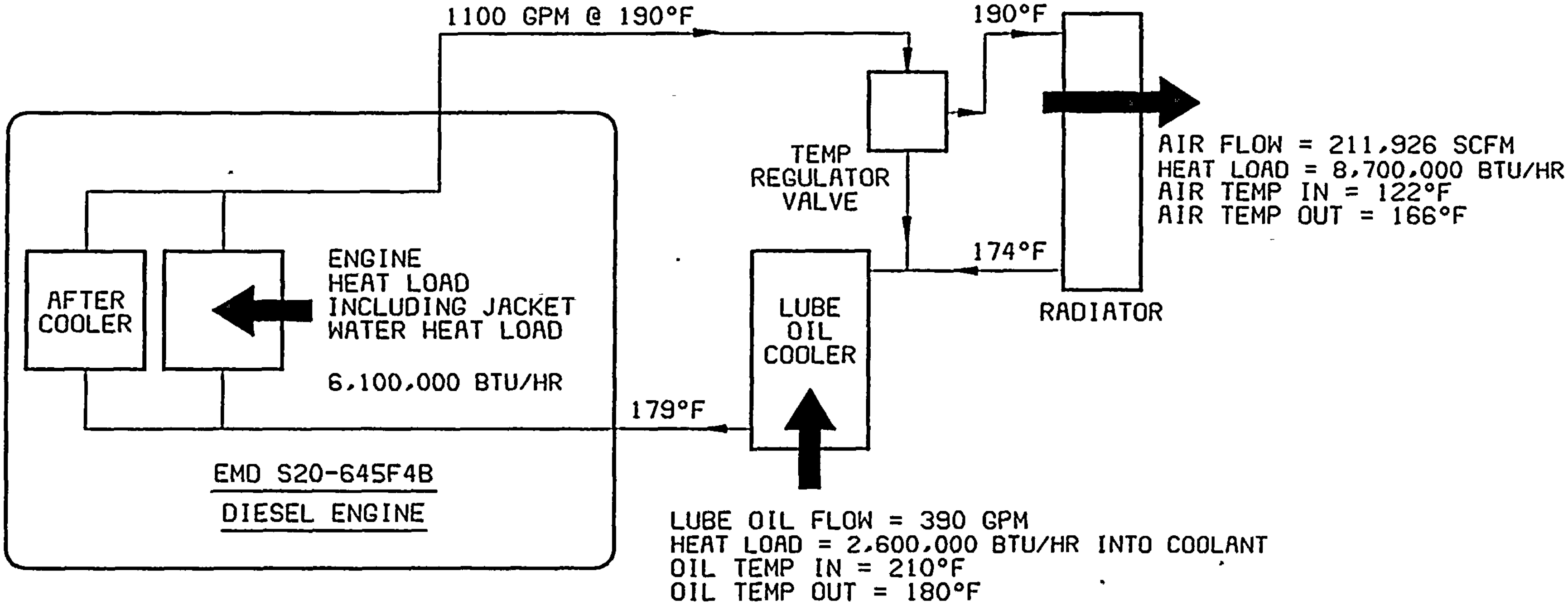


FIGURE 32-1
COOLING SYSTEM HEAT TRANSFER CAPABILITY
(AT 110% RATED LOAD)

RAI 33

Provide the results of a failure mode and effects analysis to show that failure of a piping connection between subsystems (engine water jacket, lube oil cooler, governor lube oil cooler, and engine air inter-cooler) does not cause total degradation of the diesel generator cooling water system.

Response to RAI 33

In the event of a cooling system piping connection failure, the resultant loss of cooling system fluid would eventually force the affected EDG out of service. However, the possibility for this event is considered highly unlikely for the following reasons:

1) The cooling system normally operates at relatively low pressure and temperature (less than 30 psig and 190°F) respectively and meets the criteria for a low energy system per SRP 3.6.1.

2) The entire cooling system is analyzed for all normal and postulated loads including dead weight, thermal and seismic conditions and designed accordingly.

3) The cooling system design is consistent with the manufacturers standard practice which historically has proven to be very reliable with respect to cooling system piping failures.

Although considered highly unlikely, should such a failure occur, available alarms and indication (see response to RAI 36) would alert plant operators of possible degradation in cooling system performance so that appropriate action could be taken. In addition, as stated in response to RAI 32, during non-emergency use, automatic EDG shutdown would occur when cooling temperatures reached 215°F.

In the event that a cooling system piping connection failure would lead to shutdown of the affected EDG, safe plant operation would not be affected since the redundant EDG with completely independent cooling water system would still be available.

RAI 34

Indicate the measures to preclude long-term corrosion and organic fouling in the diesel engine cooling water system that would degrade system cooling performance, and the compatibility of any corrosion inhibitors or antifreeze compounds used with the materials of the system. Indicate if the water chemistry is in conformance with the engine manufacturer's recommendations.

Response to RAI 34

Control of corrosion and organic fouling for the existing Turkey Point diesels is assured per procedure based upon the use of a borate-nitrate type inhibitor and treated water.

For the new EDG's, EMD has identified four basic requirements for the coolant solution.

1) It must adequately transfer heat energy through the cooling system.

2) It must not form scale or sludge deposits in the cooling system.

3) It must not cause corrosion within the cooling system.

4) It must no deteriorate any of the cooling system seal materials.

In addition, specific requirements for water quality and the use of various inhibitors are also included in the EMD Maintenance Instruction. For the new EDG's, the above requirements of EMD Maintenance Instruction for engine coolant will be considered and incorporated into plant procedures as appropriate.

RAI 35

Provide details of your proposed diesel engine cooling water system chemical treatment, and discuss how your proposed treatment complies with the engine manufacturer's recommendations.

Response to RAI 35

See Response to RAI 34.

RAI 37

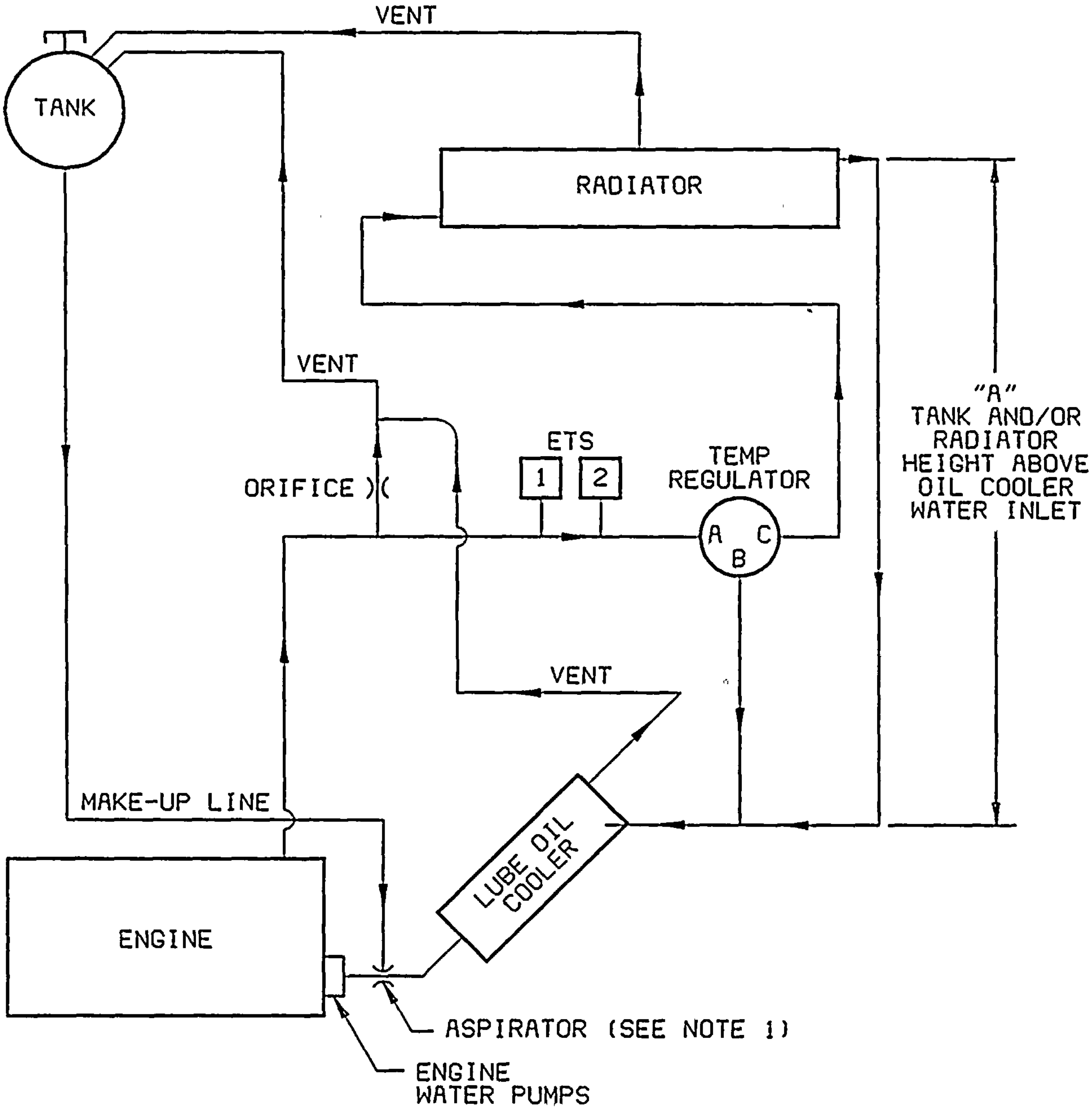
Describe the provisions made in the design of the diesel engine cooling water system to assure that all components and piping are filled with water.

Response to RAI 37

General Motors Electro-Motive Division (EMD) has established requirements for cooling water systems to ensure proper performance of the engine mounted cooling water pumps and other system components. These requirements include the following:

1) The minimum height of the expansion tank and radiator relative to the water inlet connection to the lube oil cooler should be 15 feet. Any less height would require the use of aspirators (see Figure 37-1).

2) The maximum height of the expansion tank and radiator relative to the water inlet connection to the lube oil cooler should be 25 feet.



NOTES

1. THIS ARRANGEMENT IS USED IF HEAD "A" AT OIL COOLER INLET EXCEEDS 15 FEET. MAXIMUM ALLOWABLE HEAD "A" IS 25 FEET. (ASPIRATOR MAY ALSO BE USED IF DESIRED.)
2. VENT AND MAKE-UP LINES SHOWN IN SCHEMATIC FOR ILLUSTRATIVE PURPOSES ONLY. ACTUAL VENTING AND MAKE-UP TO SUIT INSTALLATION SO AS TO PROVIDE SMALL VENT FLOW TO TANK FOR REMOVAL OF AIR FROM SYSTEM. FLOW LOSS IN MAKE-UP LINE IS KEPT TO A MINIMUM.

FIGURE 37-1
TYPICAL COOLING SYSTEM SCHEMATIC WITH RADIATOR

3) The total pressure loss of pipe and cooling equipment external to the engine accessory rack should be limited to 8 psi.

4) To assure that the cooling system is kept completely full of water, the high points of any pipe or component shall be vented to the top of the expansion tank (see Figure 37-1).

The new EDG's comply with each of the above requirements.

RAI 38

The diesel generators are required to start automatically on loss of all offsite power and in the event of a LOCA. The diesel generator sets should be capable of operation at less than full load for extended periods without degradation of performance or reliability. Should a LOCA occur with availability of offsite power, discuss the design provisions and other parameters that have been considered in the selection of the diesel generators to enable them to run unloaded (on standby) for extended periods without degradation of engine performance or reliability. Explicitly define the capability of your design with regard to this requirement.

Response to RAI 38

Internal combustion engines including diesel engines operate most reliably at the rating for which they are designed. At extended light load operation, "souping" can be expected to occur with a diesel engine. The term "souping" refers to an accumulation of lube oil in the exhaust system due to light load operation. Depending upon the amount of "souping" that has taken place, an exhaust fire could result when the engine is suddenly loaded.

If long periods of no load operation are required, operation at idle speed (440-560 rpm) is recommended by the manufacturer. Each new EDG has an idle start feature which allows the emergency signal to release the EDG to go to rated speed and frequency and accept load.

In addition, if an engine has been running lightly loaded, the manufacturer has provided the following recommendations for ensuring proper EDG performance:

1) Operation at synchronous speed at loads between 0 and 20 percent: after 4-1/2 hours of operation, the engine should be run at a minimum of 40 percent load for a minimum of 30 minutes to clean out the exhaust stacks.

2) Operation at idle speed (440-560 rpm): After 5 days of operation at a minimum oil into engine temperature of 170°F, the engine should be run at a minimum of 40 percent load for a minimum of 30 minutes to clean out exhaust stacks. In addition, during an extended idle period, the air box drains should be continually drained or opened periodically to purge oil accumulated in the engine air box.

For the new EDG's, the above manufacturer recommendations will be considered in the event that the EDG's are required to operate at light load for extended periods.

RAI 39

You state in Section 5.2.7 of the June 23, 1988 submittal that each diesel engine cooling water system is provided with an expansion tank to provide for system expansion and water makeup. The expansion tank should provide for minor system leaks at pump shafts seals, valve stems and other components, and to maintain required NPSH on the system circulating pump. Provide the size of the expansion tank and location. Demonstrate by analysis that the expansion tank size will be adequate to maintain required pump NPSH and make up water for seven days continuous operation of the diesel engine at full rated load without makeup, or provide a seismic Category I, safety class 3 make up water supply to the expansion tank.

Response to RAI 39

The total cooling water system inventory is approximately as follows:

1)	Engine and accessory rack		- 318 gallons
2)	Radiator		- 365 gallons
3)	6" piping - 1.5 gal/ft - 50 ft		- 75 gallons
		TOTAL	758 gallons

The expansion of water from 40°F to 200°F is approximately 4 percent of total volume therefore, .04 x 758 gal = 30.3 gallons.

The expansion of water from standby temperature 120°F to 200°F is approximately 2.75 percent, therefore, .0275 x 758 gal. = 20.8 gallons.

The expansion tank has a total volume of 100 gallons. It is located at the highest point in the system but not higher than 25 feet above the inlet connection to the lube oil cooler. The equivalent dimension from the bottom of the engine base is 33 feet. The minimum height of the bottom of the expansion tank in conjunction with aspirators is 7 feet from the bottom of the base. To assure that the system is kept completely full of water, the high points of any pipe or component are vented to the top of the expansion tank.

The tank is filled with approximately 60 gallons of water at standby conditions to allow for the 21 gallon expansion when the water is hot.

The water inlet connection to the engine (pump inlet) has a device called an aspirator to assure NPSH at the pump inlet. The bottom expansion tank connection is piped directly to the aspirator.

The jacket water system is a closed system designed to operate at 7 psig pressure. The pumps have mechanical seals and do not leak until they have been worn. Leakage past seals and gaskets at pipe connections should also be non-existent. When properly maintained, there should be no leakage that would require the addition of water during the seven day continuous operation. There is however, a fill connection on the expansion tank to which plant fill piping can be connected to replenish the water level if required.

RAI 47

For the diesel engine lubrication system, provide the following information: 1) discuss the measures that will be taken to maintain the required quality of the oil, including the inspection and replacement when oil quality is degraded; 2) describe the protective features (such as blowout panels) provided to prevent an unacceptable crankcase explosion and to mitigate the consequences of such an event; and 3) describe the capability for detection and control of system leakage.

Response to RAI 47

1) EMD's Maintenance Instruction for lubricating oil includes a requirement for monthly lube oil analysis with the results to be trended. In addition, guidance on the interpretation of the lube oil analysis, acceptance criteria and replacement schedule are also specified. For the new EDG's, these requirements will be considered and incorporated into plant procedures as appropriate.

2) Each engine is equipped with a crankcase pressure detector designed to shutdown the engine when operating in the test mode, or to alarm a high pressure condition when operating in the emergency mode. (See RAI 48, Table 48-1). In addition, the engines are equipped with handhole covers which would blowout in the event of excessive crankcase pressure.

3) Detection and control of oil leakage is accomplished in accordance with EMD's recommended maintenance program which calls for periodic visual inspections. During engine operating conditions, excessive leakage would be detected via the installed low oil level/pressure alarms (see RAI 48, Table 48-1).

RAI 52

Provide information which illustrates how the stress margins of the 20 cylinder, single prime mover, F4B model compare to the 20 cylinder, E4 model that has undergone the 300 start and run tests.

Response to RAI 52

The single prime mover configuration does not result in higher crankshaft stresses than the tandem arrangement.

Consider a tandem diesel generator rated 2000 KW. Each engine must furnish 1000 KW. The Woodward 2301A control system positions the governor actuator such that each engine operates at the same fuel rack setting and therefore, each delivers the same amount of power. The inertia of the generator is quite large compared to the inertia of the engine and acts like a single generator looking back to the end connected to its respective end. This shafting between each engine and generator will deliver torque equivalent to one half the total torque. If the shaft on either side of the generator is of equal size, the stresses will be equal. Remove one engine and reduce the size of the generator and the result is the single drive. There is no change in torque between the engine and generator.

A torsional analysis was performed by EMD to verify that stress levels for the Turkey Point model F4B engines are within acceptable limits. However, the torsional analysis is considered proprietary by EMD and was not available for our submittal in this response.

RAI 53

With respect to BMEP and BHP, what tests or other measures are proposed to assure that the F4B series can withstand the additional forces without experiencing fatigue failures over its life?

Response to RAI 53

It is our understanding that the TDI EDG utilized a custom made crankshaft to suit the torsional requirements for the installation. From a statistical point of view, the failure rate of a given component typically follows a "bathtub" curve as shown in Figure 53-1. Therefore, for a customized component, the likelihood of an early failure is greater than for a standard component with significant operating experience.

The EMD Model F4B does not utilize a customized crankshaft to satisfy torsional requirements.

The torsional analysis, combined with significant operating experience as described below, provide a high degree of assurance that the additional forces resulting from the increased BMEP and BHP will not result in fatigue failure.

Operating Experience of Model "F" Engine:

The EMD model "F" engine is produced for stationary, railroad, drill rig and marine service. EMD has produced a total of approximately 861 "F" units.

Those produced for stationary service are used both as standby and base power.

From data provided by EMD, approximately 46 "F" engines were produced for stationary service, but there were also evolutionary engines produced identified as models EB and EC. Figure 53-2 indicates the engine improvements made in each model related to the number of units for that improvement. Only the "F" engines are included for the railroad engines even though the evolutionary models apply to that service also. Marine and Drill Rig applications are not included in the totals.

Stationary service is a constant speed application, whereas railroad service is a variable speed application. Railroad engines once started are seldom stopped but run at idle speed when waiting for an assignment. While the engine is operated at idle when not in use, there are periods of time when the railroad engine is run "full bore" with a BMEP of 153 psi as compared to the rated BMEP of 136 psi for the stationary engine. Locomotive engines typically accumulate 100,000 to 250,000 miles per year. The useful life is 15 to 25 years during which 2 to 5 million miles have been accumulated. In heavy duty mainline freight service, mean time between overhaul is typically 3 to 4 years.

Percent	Duty
17	Full bore
4	Low Load to Full Load
46	Idle
9	Dynamic Brake

Therefore, it is useful to include the engines in railroad service to evaluate the reliability of the improvements to the E4 engine design that finally evolved into the "F" engine design.

For engines in railroad service, 6000 operating hours per year is a conservative estimate. Estimates indicate that the total operating hours approximated 16,806,000 hours or an average of 23,500 hours per unit for railroad service.

The operating hours for stationary service are more difficult to estimate because of the variations between standby power and base power and the evolutionary models that are included in the totals. However, an average of 1000 hours per year appears to be conservative. The estimated total hours of operation of stationary units containing improvements initiated in a particular model are:

Model EB - 414,000 hours
Model EC - 128,000 hours
Model FB - 103,000 hours

Based upon the total number of operating hours, all improvements are on the flat operating portion of the "bathtub" curve, well away from the early failure stage (Figure 53-1).

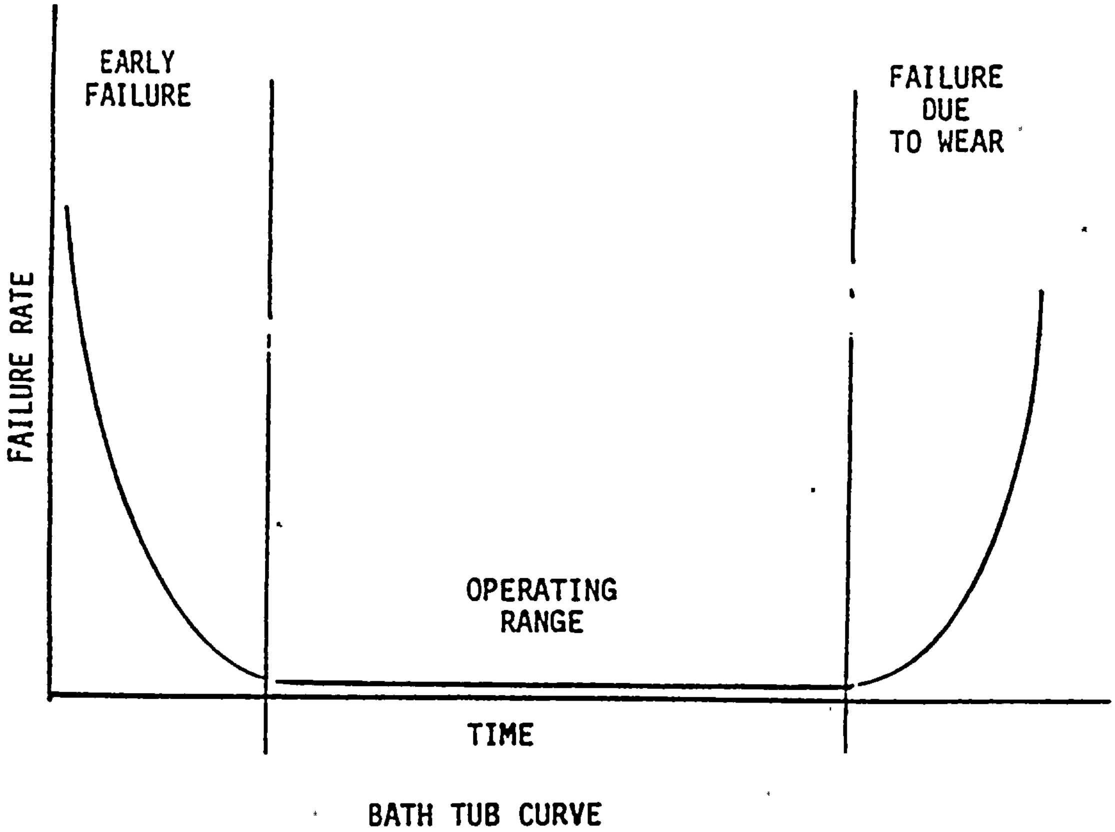

EARLY
FAILURE
FAILURE
DUE
TO WEAR
FAILURE RATE
OPERATING
RANGE
TIME
BATH TUB CURVE

FIGURE 53-1

IMPROVEMENTS		MODEL			UNITS IN SERVICE W/IMPROVEMENTS		
	FB	EB	EC	FB	STAT.	RR	TOTAL
Compression ratio	16:1		—	—	77	714	791
Crankcase	F			—	46	714	760
Liner	Laser Hardened Upper Bore		—	—	77	714	791
Lower Liner Water Seal	Viton		—	—	77	714	791
Water Outlet Seal	Viton	—	—	—	162	714	876
Lower Liner Insert	Nickel			—	46	714	760
Cylinder Head	Thin Deck	—	—	—	162	714	876
Cylinder Head Seat Ring	Aluminum Bronze	—	—	—	162	714	876
Cyl. Crab Retention Sys.	Plate Crab		—	—	77	714	791
Top Piston Ring Location	Fire Ring	—	—	—	162	714	876
Piston Pin Bearing	Bronze	—	—	—	162	714	876
	Rocking Pin	—	—	—	162	714	876
Camshaft Material	1080	—	—	—	162	714	876
Injector Plunger	.500"	—	—	—	162	714	876
Rocker Arm Rollers	Crowned	—	—	—	162	714	876
Exhaust Valve	Heavy Head		—	—	77	714	791
Blade Connecting Rod Matl.	4140		—	—	77	714	791
Turbocharger	FA			—	46	*	46
Turbocharger After Cooler	12 Row			—	46	*	46
Turbocharger Screen	(Reduced - Gradient)				162	714	876
	With Trap	—	—				
	W/Rev.Trap			—			

* A different turbocharger is utilized for locomotive diesel.

FIGURE 53-2

FB IMPROVEMENTS IMPLEMENTED IN PRIOR MODELS

RAI 54

More information is desired as to the similarities and dissimilarities between the proposed Turkey Point EDGs and the "F" engines used for railroad service in order to determine the relevancy of the railroad experience.

Response to RAI 54

Both the railroad service and the "F" engine series are basically a standard 645 model design. They have the same crankcase, crankshaft, power pack (cylinder, head, piston and con rod), main and con rod bearing, accessory and camshaft drive gears, rocker arms, etc.

The differences are:

1) Governor - Railroad has variable speed control, power unit has constant speed control.

2) Turbocharger - The turbine blades and compressor nozzles differ to accommodate variable speed versus constant speed operation. Otherwise, the turbochargers are alike.

3) Injector - The injector tip is different again to accommodate variable speed versus constant speed performances.

Also, see response to RAI 53 for discussion of railroad service experience.

RAI 55

Discuss and analyze the comparative properties of the 4140 Blade Con Rod material of the F4B versus the 1050 material of the E4.

Response to RAI 55

Our previous letter L-88-454, dated October 19, 1988, should have identified the Blade Con Rod material of the E4 as SAE 1046, not 1056.

A comparison of 4140 and 1046 is as follows:

	SAE 4140H*	SAE 1045** Similar to 1046
Tensile Strength	130,000	110,000
Yield Strength	110,000	80,000
Elongation	20%	18%
Reduction Area	58%	50%

This represents an 18% increase in tensile strength and a 37% increase in yield strength.

*Properties based upon the normal hardness range of 28-32 Rockwell "C".
**Properties based upon 3 inch round material being water quenched and tempered at 24-29 Rockwell "C".

RAI 56

Discuss and analyze the comparative properties of the 1080 Camshaft material of the F4B versus the 5046 material of the E4.

Response to RAI 56

The camshaft material was changed to SAE 1080 to provide increased strength and reliability, and to reduce cam lobe wear. Properties of the 1080 camshaft material are dependent on the type of heat treatment which was not available at the time of this response.

RAI 57

Compare the FA Turbocharger of the F4B versus the E Turbocharger of the E4.

Response to RAI 57

The turbine blade and compressor nozzle geometry of the E Turbocharger differ slightly to accommodate variable speed versus constant speed operation. Otherwise, the turbochargers are alike.

RAI 58

Discuss how the F4B obtains a higher compression ratio than the E4 considering that the piston to head clearance or the stroke has not changed.

Response to RAI 58

The increase in compression ratio is accomplished by a reduction in the volume of the piston bowl, involving a slightly narrower and shallower bowl than that of the E4 piston. Despite the higher firing pressure produced, the temperature of the piston crown is actually lower than in previous models due to a new crown structure.

The relocation of the piston fire ring from 1-1/4" to 3/4" from the top of the piston also contributes to the increase in compression ratio.

RAI 59

Discuss and analyze the significance of the 1-1/4 Top Piston Ring Location of the E4 versus the 0.75" Fire Ring for the F4B.

Response to RAI 59

The fire ring was located for the following considerations:

1) To contribute to the increase in compression ratio

2) To decrease blow-by into the engine air box which improves performance at light load operation.

The higher location of the fire ring results in less combustion gas pressure when the fire ring passes by the cylinder liner ports that open into the air box, as the piston is now further down the stroke. Therefore, less exhaust gas enters the air box. This gives a better charge of air into the combustion chamber enhancing the combustion process.

RAI 60

Provide justification for the fact that the standard EMD components are not built in accordance with ASME Section III Class 3.

Response to RAI 60

The Electro-Motive Division of General Motors (EMD) produces a commercial diesel of a standard design. The purpose of a standard design is to ferret out both design and operational problems early in the life of a model series. The varied applications for railroad, oil rig drilling, marine, off-road vehicles and stationary power service, subjects the basic standard design to all types of operational problems.

The Electro-Motive Division has produced approximately 80,000 model 645 diesels of which approximately 26,000 are in stationary power service. This provides a great depth of experience.

The manufacture of the 645 diesel is performed in compliance with the Electro-Motive Division Quality Assurance Program that includes control of the engineering, production and material control processes.

One of a kind designs sometimes lead to problems which are not discovered until a period of service has passed. Therefore, EMD will avoid producing a "one of a kind" design. Changing design and assembly practices to meet the requirements of ASME Section III, Class 3, would introduce the "one of a kind" concept, which is not recommended by EMD.