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SUBJECT: Forwards results of diesel generator load study, "Emergency Diesel Generator Static & Dynamic Analysis."

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H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261/LICENSE NO. DPR-23
RESULTS OF DIESEL GENERATOR LOAD STUDY

Gentlemen:

In accordance with your letter of October 31, 1988, this submittal provides Carolina Power & Light Company's (CP&L) response to the information requested regarding the adequacy of the Emergency Diesel Generator (EDG) capacity at the H. B. Robinson Steam Electric Plant, Unit No. 2. The enclosure to this letter provides the results of the Emergency Diesel Generator Static and Dynamic Analysis (calculation RNP-E-8.016) performed to demonstrate the following:

A. Adequate EDG capacity for supplying the emergency loads under determined worst-case EDG loading conditions.

B. Adequate bus and equipment transient voltages during motor starting to ensure (a) safety-related starting motors develop sufficient torque to accelerate their loads, (b) safety-related running motors have sufficient torque to "ride through" the transients without stalling, (c) safety-related equipment feeder breakers do not trip during the minimum voltage transients resulting from items a and b, and (d) safety-related energized contactors on Motor Control Centers (MCCs) do not drop out.

The electrical design basis reconstitution effort includes the continuing reconstitution of selected electrical calculations in support of the design basis. The results of the analysis submitted herein are based on the reconstituted design basis, data base, and information available at this time. As this program continues and additional calculations are completed, the analysis will be revised accordingly if required. Furthermore, the analysis will be modified when changes are warranted based on future plant modifications.

The EDG capacity issue was reviewed during the NRC's November 1991 Electrical Distribution System Functional Inspection (EDSFI) at H. B. Robinson. The analysis presented to the inspection team has since been updated. No significant changes to the results presented at the EDSFI have occurred.

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The Emergency Diesel Generator Static and Dynamic Analysis is maintained at the CP&L Corporate Office. If the NRC staff wishes to perform an in-depth review, CP&L believes that a working meeting at the Corporate Office, similar to the one held in January 1992 to review the AC System Voltage Studies, would be the most effective mechanism. If you have any questions regarding this matter or desire a meeting, you may contact Mr. R. W. Prunty at (919) 546-7318.

Yours very truly,

David C. McCarthy
Manager
Nuclear Licensing Section

JSK/jbw

Enclosure

cc: Mr. S. D. Ebneter
Mr. L. W. Garner
Ms. B. L. Mozafari

ENCLOSURE

A. EMERGENCY DIESEL GENERATOR STATIC ANALYSIS

This section of the analysis was performed to determine the EDG's maximum loading under postulated design basis events. The following scenarios were analyzed to determine the worst-case loading:

a. Large-Break Loss-of-Coolant Accident (LOCA)
b. Small-Break Loss-of-Coolant Accident (LOCA)
c. Main Steam Line Break
d. Loss of Off-Site Power (LOOP)

Each of the above events was reviewed individually and in combination where applicable (e.g., LOCA with LOOP). It was determined that large-break LOCA with LOOP and one diesel generator unavailable would result in maximum EDG loading.

In addition to the above events, the following postulated events were considered to establish maximum EDG loading:

e. AOP-027 operation followed by LOCA[1]
f. Mechanical binding of a large motor during LOCA[2]
g. One Service Water Pump (SWP) unavailable with LOOP[3]

(1) Operating procedure AOP-027 is invoked whenever the switchyard voltage falls below the minimum operating schedule. Under such conditions, the operators are required to monitor the emergency bus voltage and manually transfer the busses to their associated diesel generators, should the voltage continue to decline to levels approaching analyzed limits. Should a LOCA occur subsequent to bus transfer, the EDGs are required to supply, in addition to the accident mitigating loads, those loads which were operating prior to the accident (these are the loads that would normally drop out on undervoltage conditions and remain de-energized following bus voltage restoration).

(2) During a LOCA concurrent with either a LOOP or AOP-027 operation, one large motor, normally lightly loaded, is conservatively assumed to be mechanically bound such that it operates at nameplate horsepower. The Containment Fan Cooler (HVH-1 or HVH-3) is used for this scenario. This is a 350-hp motor which operates at 244 hp under LOCA (worst-case) conditions.

(3) Following a LOOP, the automatic blackout sequence loading logic provides a start signal to one SWP per train. Failure of one pump results in operation of both EDGs with only one SWP. It has been determined that this scenario is more limiting than a single SWP failure under LOCA/LOOP conditions since, under such conditions, all four SWPs receive a start signal by the LOCA-initiated safety injection sequence loading logic. This operating scenario is procedurally limited to a maximum duration of 10 minutes.

The following categories of loads were considered in establishing the EDG loading for each operating scenario:

1. Continuous Run Loads: Essential loads required for accident mitigation which are started when voltage is available.

2. Auto-Sequenced Loads: Essential loads required for accident mitigation which are started through the safeguards sequencing logic. Sequence starting of these loads is completed within the first minute of the event.

3. Automatic Process-Controlled Loads: Essential loads required for accident mitigation which are started automatically through process parameter signals (pressure, temperature, etc.).

4. Manual Emergency Operating Procedures (EOP) Loads: Accident mitigating loads started manually per applicable plant EOPs.

5. Nonessential Loads: Loads not required for accident mitigation which are not prevented from automatically starting during accident mitigation.

6. Operator Discretionary Loads: Nonessential loads which drop out upon LOOP and require manual operator action for restarting (operator preference loads, should sufficient EDG capacity be available).

7. Motor Operated Valve (MOV) Loads: Essential loads typically associated with auto-sequenced loads.

8. Cable Losses: Losses in cables and bus duct associated with the operation of equipment.

9. Transformer Losses: Core and load losses associated with the operation of transformers connected to the emergency distribution system.

This analysis addresses all loads within categories 1-4 above and conservatively credits no manual load shed of category 5 loads.

Category 6 loads have not been included in the EDG loading since these loads can only be started through procedurally controlled actions of the plant operator, when sufficient EDG capacity is available.

Category 7 loads (MOVs) have not been included in the EDG loading since they are of short duration and small magnitude and do not contribute to the EDG's continuous loading.

Category 8 and 9 loads (cable and transformer losses) have been included in the EDG loading.

With the exception of the Containment Fan Coolers HVH-1 and HVH-3, which are assumed to operate at nameplate horsepower, all loads are considered to operate at design load values (i.e., design break horsepower (bhp), design KVA, design KW, etc.). This most closely represents the anticipated loading on the EDGs and is conservative for the following reasons:

1. No credit has been taken for cyclic/intermittent duty load diversity (i.e., once started, intermittent duty loads are assumed to run continuously for the entire event lacking specific procedural action to secure them).

2. It is conservatively assumed that all motors are operating at their design bhp value at the same time (i.e., no credit has been taken for "system level" diversity).

   Exception: Reduced motor loading during the recirculation phase of some systems has been credited due to substantial reduction of system flow (e.g., Auxiliary Feedwater Pumps).

3. Non-motor (i.e., static) loads have been conservatively assumed to be greater than field measured values (examples: (a) Lighting Panel 29 measured load is 21.4 kVA; load used in analysis is 25.2 kVA. (b) Heat tracing A and B measured load is 24.8 kVA and 16.9 kVA, respectively; load used in analysis is 28.13 kVA for both).

4. The starting of category 4 loads (essential loads started manually by the operator as directed by plant EOPs) is based on plant process parameters. Assumptions relative to the operator decision points were used that assured conservative EDG loading.

5. One Containment Fan Cooler in each safety train is assumed operating at 350 hp (nameplate rating) instead of its design load of 244 hp.

The results of the EDG static analysis indicate that the LOCA/LOOP/HVH BINDING scenario is more limiting than the AOP-027/LOCA/HVH BINDING scenario, in that it results in maximum EDG steady-state loading. The results of the analysis are as follows:

	EDG A	EDG B	EDG RATING
MAXIMUM CONTINUOUS LOAD IN KW:	2,030	2,063	2,500
MAXIMUM SHORT TIME (<2 HRS) LOAD IN KW:	2,639	2,678	2,750

The maximum EDG loading under the LOOP/SINGLE SWP scenario is as follows:

	EDG A	EDG B	EDG RATING
MAXIMUM SHORT TIME[(1)] (≤10 MIN) LOAD IN KW:	1,097	1,112	1,375

(1) Long-time EDG loading and corresponding rating are not applicable to the LOOP/SINGLE SWP scenario since plant operating procedures ensure that this condition cannot last more than 10 minutes (i.e., within 10 minutes of LOOP initiation, the operator is directed to verify that two SWPs are operating and start a second SWP if necessary).

It is evident from the above that each EDG's maximum loading is within its continuous and short-time ratings.

B. EMERGENCY DIESEL GENERATOR DYNAMIC ANALYSIS

This section of the analysis was performed to demonstrate that, with the diesel generator supplying the emergency power distribution system, adequate bus and equipment transient voltages are available during motor starting transients to ensure the following:

a. Starting motors develop sufficient torque to accelerate their loads.

b. Running motors have sufficient torque to "ride through" the transients without stalling.

c. Equipment feeder breakers do not trip during the minimum voltage transients resulting from items a and b above.

d. Energized contactors on MCCs do not drop out.

This analysis was performed in two steps. First, Colt Industries (Colt), the EDG manufacturer, was provided with the automatic timing sequence for loading of emergency loads onto the EDGs, along with the specific characteristics for each load (i.e., load type (static or motor), horsepower, efficiency, power factor, full-load current, locked rotor current, inertia, etc.). Based on this information and data contained in Colt's files for the engine, generator, and exciter, Colt simulated the EDG response with respect to output terminal voltage and frequency.

The second part of the analysis examined the electrical power distribution system voltage response during motor starting, utilizing as driving voltage the minimum EDG voltage values established by the Colt analysis. The following conservative assumptions were employed in the dynamic analysis:

1. The Containment Spray Pump (CSP), being a random starting load (i.e., starts on containment high-pressure signal and not by the automatic safeguard loading sequence logic), is considered starting concurrently with each of the auto-sequenced loads on the emergency bus (E-Bus).

2. A fictitious margin load of 49 hp and 40 hp for trains A and B, respectively, was assumed starting concurrently with each of the auto-sequenced loads on the E-Bus. The margin load was made part of this analysis in order to account for possible future load additions. The size of this load was selected so as not to exceed the EDG rating and to maintain bus transient voltages at or above the minimum criteria voltages that ensure running motors do not stall and energized contactors do not drop out.

The limiting operating scenario with respect to system transient voltage behavior is the AOP-027/LOCA/HVH BINDING scenario. The results of this analysis are summarized below:

TRANSIENT VOLTAGES IN VOLTS

BUS/MCC	SAFETY TRAIN	MINIMUM TRANSIENT VOLTAGE(1)	MINIMUM BUS TRANSIENT CRITERIA VOLTAGE(2)
EDG A	A	396	-
BUS E1	A	390	363
MCC 5	A	370	353
MCC 16	A	367	351
MCC 10	A	159	159
EDG B	B	396	-
BUS E2	B	386	362
MCC 6	B	368	356
MCC 18	B	363	351
MCC 9	B	158	158

(1) The minimum transient voltages shown are based on the simultaneous starting of the Containment Spray Pump, Service Water Pump, Service Water Booster Pump, and a fictitious margin load of 49 hp and 40 hp for trains A and B, respectively.

(2) The minimum bus transient criteria voltages shown are derived in the AC Auxiliary Electrical Distribution System Voltage/Load Flow/Fault Current Study (calculation RNP-E-8.002). These bus voltages ensure running motors will not stall and energized contactors will not drop out.

(1) The SWP terminal voltages are slightly lower than the minimum allowable starting voltage of 345 V. This undervoltage condition, however, is only momentary, since the EDG voltage recovers rapidly to the level required to achieve 345 V at the motor terminals due to its voltage regulator. The motor terminal voltage remains below 345 V for a maximum duration of 0.4 seconds. This does not challenge the successful starting of the motors because of the following:

a. Once the EDG voltage recovers to the level which allows 345 V at the motor terminals, motor acceleration is assured. Therefore, although unlikely, motor starting can only be delayed by 0.4 seconds.

b. The SWP motors have safe stall times in excess of 16 seconds; thus, motor damage will not occur.

c. The motor feeder breakers will not trip should motor acceleration be prolonged by 0.4 seconds due to momentary stalling.

d. The plant can easily tolerate a delay of 0.4 seconds in SWP accident mitigating response.

(2) The minimum allowable starting voltages shown are based on manufacturer-supplied motor data.

As seen from the above tables, all bus transient voltages are maintained at or above minimum allowable values (208 V MCCs 9 and 10 are limiting) to ensure running motors do not stall and energized contactors do not drop out. All E-Bus-supplied motors receive sufficient voltage to accelerate their driven equipment.

Furthermore, the impact of minimum EDG transient voltages and corresponding bus voltages on motor running and starting currents was determined. The resultant equipment currents were compared with the equipment feeder breaker trip characteristics and found to be within acceptable ranges to prevent breaker trips.

MOTOR MINIMUM STARTING VOLTAGES IN VOLTS

STARTING MOTOR	SAFETY TRAIN	MINIMUM MOTOR TERMINAL VOLTAGE	MINIMUM ALLOWABLE[2] TERMINAL VOLTAGE
CSP A	A	369	345
SIP A	A	377	345
RHR A	A	384	345
SWBP A	A	356	345
SWP A	A	333[1]	345
SWP B	A	345	345
HVH-1	A	373	345
HVH-2	A	377	345
AFW A	A	395	368
CP B	A	412	368
CCW B	A	393	330
CSP B	B	365	345
SIP C	B	375	345
RHR B	B	380	345
SWBP B	B	358	345
SWP C	B	330[1]	345
SWP D	B	343[1]	345
HVH-3	B	378	345
HVH-4	B	367	345
AFW B	B	390	368
CP C	B	408	368
CCW C	B	389	330