UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

ENCLOSURE

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

EMERGENCY DIESEL GENERATOR LOADING ANALYSIS

SECTION III.4.1 OF THE BROWNS FERRY NUCLEAR PERFORMANCE PLAN

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT, UNIT 2

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) submitted its systematic assessment of licensee performance (SALP) by letter dated September 17, 1985, to the Tennessee Valley Authority (TVA) and requested TVA to furnish specific information pursuant to 10 CFR 50.54(f). TVA responded to this request with the Browns Ferry Nuclear Performance Plan (BFNPP), Volume 3, which described the measures TVA was taking to improve its nuclear program for the Browns Ferry Nuclear (BFN) Plant and identified specific electrical issues that required resolution. Special Programs, Section III.4.1 of the BFNPP, Volume 3, addressed deficiencies associated with electrical calculations, including the emergency diesel generators (EDGs) performance.

2.0 EVALUATION

2.1 Background

The emergency diesel generators (EDGs) at the Browns Ferry Nuclear Plant (BFN) are designed and tested by TVA for use in the onsite, Class 1E electrical auxiliary power system (APS). Each EDG is able to

1. Start and be at rated voltage and frequency in 10 seconds.

2. In ten seconds, connect to the APS to start and accelerate 460-volt loads and the designed sequence of large 4160-volt motors.

3. Sustain the loss of all or part of such loads and maintain voltage and frequency within acceptable limits.

4. Supply power continuously to the equipment needed to maintain the plant in a safe condition for a complete loss-of-offsite-power event.

The EDGs provide electrical power to the APS for the following postulated plant operating conditions:

1. A total loss of offsite power (LOOP)

2. A loss-of-coolant accident (LOCA) with concurrent LOOP

Upon a LOOP, all the loads required for either a safe shutdown or for reducing the LOCA effects are isolated (load shed) from the Class 1E shutdown boards. These loads automatically sequence back onto the shutdown boards after the EDG attains rated voltage and frequency. The 4160/480-V shutdown transformer loads do not load shed and are the initial load supplied by the EDG. Additional loads automatically sequence on at time intervals of 1, 7, 14, and 40 seconds.

There are eight EDGs at BFN. Four EDGs (A, B, C, and D) supply power to Units 1 and 2. Four additional EDGs (3EA, 3EB, 3AC, and 3ED) supply power to Unit 3. However, the reactors share some mechanical systems. The present Unit 2 technical specifications (TS) require that EDGs A, B, C, and D be operable before startup. There are electrical ties between EDGs (A and 3EA, B and 3EB, C and 3EC, and D and 3ED). Unit 2 TS will require revisions before restart to include operability requirements for Unit 3 EDGs because the following mechanical systems required to be operable for Unit 2 are powered from Unit 3 EDGs:

1. The standby gas treatment system C train is powered from EDG 3ED

2. The control room emergency ventilation system B train is powered from EDG 3EC

TVA has tested the EDGs as part of its restart test program which included EDG response to a Unit 2 LOOP/LOCA-loads application. Voltage and frequency responses were analyzed for acceptability based on transient and steady-state voltage and frequency not exceeding the electrical equipment design.

By letter dated January 10, 1989, TVA submitted the results of its EDG load analysis and tests to the NRC for review. The staff also received the "Diesel Load Study DNE Calculation ED-Q2000-87071," Revision 2, for review.

2.2 Discussion

2.2.1 EDG Ratings

Engine thermal stress is not expected to decrease the EDG's lifetime if the APS transient and steady-state electrical loads do not exceed the EDG ratings. Four limiting load ratings affecting the EDG's performance rating are associated with the diesel engine rather than with the generator. As indicated below, two of the ratings are transient and two are steady-state:

1. Transient

zero to three minutes	2815 kW
greater than three minutes	3025 kW

2. Steady State

zero to two hours	2800 kW
greater than two hours	2550 kW

The transient loads are the combined running and starting loads that are connected to the EDG at any time during the loading sequence. The transient limitation for the first three minutes is imposed because the engine's turbocharger is not effective during this time period. The greater-than-three minute transient load of 3025 kW can be maintained for 30 minutes but would require special maintenance after shutdown.

The EDG ratings listed above include derating in agreement with the vendor's recommendation. This derating is included because the calculated BFN site-specific temperature of 97°F exceeds the EDG vendor design temperature of 90°F. Also, the engine jacket water temperature exceeds the engine design temperature of 190°F. Therefore, the EDGs derating is 1.2 percent for the first three minutes of operation and two percent for all other operating conditions. The staff finds that the ratings as derated are applicable to the BFN EDGs.

2.2.2 EDG Load Analysis

The staff's review of TVA's load analysis indicates that all transient and steady-state loads are within the EDG's ratings with the following two exceptions:

1. The EDG A 3197-kW load at 40 seconds exceeded the 2815-kW transient rating. This load dropped back to within the rating 20 seconds later. The staff finds this condition acceptable because

   - The time duration of this load was short.

   - The residual heat removal service water (RHRSW) pump motor, which is the load applied at 40 seconds, accelerated in 0.939 seconds, and this time was less than the acceleration time for RHRSW pump motors on the other EDGs.

2. The EDG A 2767-kw load at two hours exceeded the greater-than-two hour steady-state rating of 2550 kW. The staff finds this condition unacceptable as discussed below.

TVA proposed to take no operator action to shed loads on EDG A after two hours for a LOOP/LOCA (2767-kW) load. TVA took this position because the engine has a vendor-guaranteed capability of successfully supplying up to a 3025-kw load for 1/2 hour or a 2900-kW load for 200 hours.

In the current BFN technical specifications, Surveillance Requirement 4.9.A states: "Each diesel generator shall be manually started and loaded to demonstrate operational readiness....The test shall continue for at least a one hour period at 75 percent of rated load or greater..." Therefore, each EDG is tested at one-month intervals at a minimum load of 1913 kW. There is no present requirement to test at 18 months (refueling) to the continuous rating of 2550 kW for 22 hours and 2800 kW for two hours. The staff finds that since TVA does not test to the 2900-kW rating, TVA should not take credit for this rating to preclude manual-load shed. TVA should revise its procedure (e.g., abnormal operating procedures and/or emergency operating procedures) to direct the operator to load shed or per Technical Specification provide routine testing of EDG A for 24 hours at the 2900 kW rating.

The staff concludes, from the review of the load study, that EDGs have adequate capacity to perform their safety function with the exception of EDG A loads which exceed the EDG rating after two hours.

2.2.3 EDG Voltage Analysis

The EDGs must provide sufficient voltage during load application to ensure that:

1. The motors develop adequate torque and acceleration.

2. The contactors of the 480-V motor control centers close and do not reopen. If they do reopen, they must reclose with no effect upon the contactors or the motors.

3. The contactor control circuit fuses must not open.

TVA performed a voltage analysis to determine the voltage transients experienced during the restart test program's (RTP's) load-acceptance testing. The EDG's terminal voltage, load (kW), line current, and frequency were recorded during the RTP load-acceptance testing. The analysis used a composite voltage profile consisting of the worst-case transients of the four EDGs for each load sequence step. This approach ensured that the analyzed voltage profile would bound the actual voltage profile experienced by any of the four EDGs during a design-basis event.

The worst-case voltage drop was on EDG C at time 0.2 seconds when the residual heat removal (RHR) pump motor (2000 HP) was started. The voltage dropped to 47.2 percent, then recovered to 90 percent in 3.5 seconds. TVA contacted the manufacturer of the RHR pump motor concerning the effect of this voltage condition upon the motor. The manufacturer advised TVA that the motor would have sufficient starting torque with the voltage as low as 40.5 percent, and the safe stall time, at locked rotor current, is 14 seconds. The restart special test (ST 88-26) for EDG C indicated that the bus voltage was at 80 percent of normal voltage two seconds after the pump started. The RHR pump motor acceleration time was 4.2 seconds; at 4.2 seconds, the voltage was above 100 percent. The staff's review of the 4160-V motor load application on the EDGs finds that the motors developed torque and accelerated adequately.

TVA analyzed the effects of the EDG's 4160-V system low voltage transmitted to the electrical equipment associated with the 480-V system and concluded that there was no adverse effect upon the motors. The starter contactors that are energized will open up the power circuit, and when voltage increases to 80 percent at the contactor coil, the contactor will then close the power circuit. The contactor control fuses will not open, even with an increase in control current because they are designed with sufficient time delay characteristics. This current increase resulted from reduced impedance associated with an open contactor coil and low frequency. The staff finds the low-voltage condition on the 480-V system acceptable.

A maximum voltage of 128 percent occurred on EDG D at 3.5 seconds after the RHR pump start. This voltage is above the 110 percent steady-state design for 1-1/4 seconds. TVA determined that the high voltage transient had no effect upon the RHR pump motor on the 4160-V system or any motor, starter or control fuses on the 480-V system. The staff finds that the overvoltage condition of the 4160-V system and the 480-V system is acceptable.

The voltage transients, high and low, which occur during the sequenced load application, have been verified by test. The staff concludes from the review of the voltage tests and analyses that the electrical equipment will perform its safety function.

2.2.4 EDG Governor and Frequency Analysis

The EDG governor controls the engine speed, generator frequency, or load by adjusting the fuel to the engine. In the initial testing (ST 88-06 series), TVA noted that during heavy load application to the generator, the frequency (speed) generally decreased with no increase in the fuel rack position. This finding indicated no corrective fuel adjustment occurred for a frequency deviation from a load demand setpoint. Further investigation revealed that low voltage input to the governor control affected the control. This situation resulted in improper fuel correction and inconsistent frequency deviation with extended recovery time during the transient condition. TVA, in conjunction with the governor manufacturer, conducted tests at the manufacturer's facility. As a result of these tests, three early electrical governor control panels were modified. The recommendations were also used to:

1. Set the null voltage value to produce an engine fuel correction upon heavy generator load application, thereby reducing the frequency dip.

2. Reduce the mechanical governor full-speed setpoint and incorporate mechanical droop to minimize speed overshoot and improve transient response during EDG startup.

3. Perform additional tests and calibrations at the site to improve the governor response.

The special test results (ST 88-21 through 88-24 and ST 88-27 through 88-30) indicated that the frequency of "hot" engine response of each EDG was significantly improved. The frequency overshoot and dip were both limited and the unit's frequency response curves were closely repetitive with each other. The staff reviewed the "before" and "after" frequency curves and agrees with TVA that the governor response was improved. The staff's review of the EDG "Load Acceptance Test Data Special Test ST 88-32 (EDG A), ST 88-33 (EDG B), ST 88-26 (EDG C), and ST 88-34 (EDG D)" indicated that the EDG B frequency drop represented the worst case. The frequency dropped to 58.9 Hz (98.1 percent) at 3.9 seconds after the RHR pump started. The RHR pump accelerated from zero to full speed in 3.86 seconds. At this time, the frequency was at 100 percent. The next load application did not occur until 2.14 seconds later. The staff concludes from the review of the governor and frequency analysis that the EDGs and connected electrical equipment will perform their safety function.

2.3 Unauthorized changes in the EDG test record

In its EDG load analysis submittal of January 20, 1989, TVA included a condition adverse to quality report (CAQR), BFP 880850 R1. This CAQR indicated that on October 15, 1988, a review of the EDG restart test 2-BFN-RPT-82 revealed possible unauthorized changes to the test package. The review noted discrepancies between the file copies of the change requests that were maintained for the RTP and the original change requests that were maintained in the restart test package. There was a high probability that a portion of the test was not performed on December 12, 1987, and the second-party verification signature did not appear to be authentic. There also were unauthorized changes made to Restart Test Procedure 2-BFN-RTP-57-5, Change No. 7, and four other change notices had improper editorial changes.

The root cause of this condition adverse to quality was one test director's failure to follow procedures. This test director is no longer employed by TVA. A corrective action plan was developed and implemented for the purposes of:

1. Identifying the involvement of this individual as a test director in the restart test group.

2. Providing assurance that the unauthorized changes did not reduce the quality of the systems.

For Item 1, TVA reviewed 30 system restart tests. The results showed that only restart tests RTP-82 and RTP-057-5 were involved in the identified problem.

For Item 2, TVA's review indicated that the identified problems were as follows:

1. Procedures had been violated in handling changes.

2. Signatures and dates had been entered and backdated.

3. The second verifier did not initial and date the change.

4. The EDG 3A load rejection test may not have been done. This test was completed per Site Director Standard Procedure (SDSP)-12.1 on November 17, 1988.

CAQR BFP 880850 R1 did not address providing reasonable assurance that the RTP had been functioning effectively. However, 18 additional CAQRs were written against the 170 surveillances performed, with 50 conducted on System 82 (EDG) and six conducted on system 057.5 (4-kV electrical). The resolution of a number of the CAQRs required additional training in testing and procedure requirements. TVA also provided a quality assurance (QA) review consisting of evaluation of the RTP final review process. To measure the process, items found by the QA reviewer were compared with the RTP reviewer's comments to see if these items were mentioned. TVA's QA group concluded that the RTP review process appeared to be adequate for technical reviews. However, the QA group also concluded that more attention should be given to reviewing the RTP test results for adequacy as QA records.

Based upon the above, TVA concluded that the problems identified in CAQR-BFP-880850 appear to be isolated, and the corrective action plan would validate the test results of RTP-82 and RTP-057-5. TVA also concluded that the RTP has been successfully implemented as the result of the QA department's involvement in the resolution of this issue. The staff agrees with these conclusions of TVA.

3.0 CONCLUSION

The staff concludes that the BFN EDG loads are within the EDG ratings with one exception. This exception is for EDG A after two hours for a LOOP/LOCA condition. To resolve this exception, TVA needs to either require manual-load shedding or initiate routine testing of EDG A for 24 hours at the 2900 kW rating (Section 2.2.2). This open item should be resolved before BFN Unit 2 restart. In addition, the Unit 2 Technical Specifications should be revised to include operability requirements for Unit 3 EDGs which are required to support Unit 2 operation (Section 2.1). The voltage and frequency response of the EDGs indicate that the loads will start and accelerate within the required time to meet their intended safety functions. The staff also concludes that TVA's resolution of the restart test record falsification is acceptable.

Principal Contributor: F. Paulitz

Dated: December 21, 1989

December 19, 1989

Docket No. 50-260

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Mr. Oliver D. Kingsley, Jr.
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Dear Mr. Kingsley:

SUBJECT: VOLUME 3, SECTION III.13.2 (CABLE AMPACITY) OF THE NUCLEAR PERFORMANCE PLAN - BROWNS FERRY NUCLEAR PLANT, UNIT 2 (TAC NO. 62260)

Section III.13.2 of Volume 3 of the Nuclear Performance Plan for the Browns Ferry Nuclear Plant outlined inadequacies in the Tennessee Valley Authority's (TVA's) electrical design standards used to size the insulated power cable ampacities, thereby, resulting in the potential undersizing of safety-related cables at the Brown Ferry Nuclear Plant. By letters dated January 25, July 7, September 30, 1988, and March 17, April 18, April 27, and October 6, 1989, TVA submitted detailed information concerning the cable ampacity program at Browns Ferry, Unit 2, to correct these inadequacies.

The staff has completed its evaluation of the proposed corrective action as identified in the TVA submittals and concludes that they are acceptable.

Our Safety Evaluation supporting the above conclusion is enclosed.

If you have questions concerning the above, please call the Browns Ferry Project Manager, Gerald Gears at 301-492-0767.

Sincerely,
Original signed by Gerald E. Gears for

Suzanne C. Black, Assistant Director
for TVA Projects
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Enclosure:
Safety Evaluation

cc w/enclosure:
see next page

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