Item B-56: Diesel Reliability (Rev. 2)

DESCRIPTION

Historical Background

This issue was documented in NUREG-0471[1] and resulted from a review of LERs which indicated that onsite emergency diesel generators (EDGs) at operating plants were demonstrating an average starting reliability of about 0.94/demand. The goal for new plants, as expressed in Regulatory Guide 1.108,[2] was a starting reliability of 0.99/demand. The NRC awarded a contract to the University of Dayton Research Institute to identify the more significant causes of EDG unreliability. The Dayton University study was completed and the significant causes and recommended corrective actions were identified in NUREG/CR-0660.[3]

Safety Significance

Events (offsite and onsite) which result in a loss of offsite power necessitate reliance on the onsite EDGs for successful accident mitigation. Improvement of the starting reliability of onsite EDGs will reduce the probability of events which could escalate into a core-melt accident and thus could effect an overall reduction in public risk.

Possible Solution

The staff proposed a set of interim backfit requirements for operating plants that encompassed elements of Regulatory Guide 1.108[4] and the Dayton University recommendations.[5] These requirements were included in a proposed program[6] to establish a graded set of requirements based on the reliability actually exhibited by EDGs. This program adopted an EDG startup reliability of 0.95/demand as the minimum desired reliability and 0.9/demand as the minimum acceptable level of reliability. At or below the minimum desired level, licensees would be required to improve their EDG reliability and document their program for doing so. Below the minimum acceptable level, licensees would be required to improve or repair EDGs with reliability below the minimum acceptable level and perform a requalification program to demonstrate that the causes of the failures were corrected. The requalification program was intended to pass EDGs only if the reliability had been increased to 0.95/demand or greater.

The proposed interim program imposed a normal surveillance period of no more than 1 month. To increase assurance that a real change in reliability will be detected quickly, an increased test frequency was required when two or more failures had been experienced on an individual EDG in the previous 20 demands. However, the frequency of tests and the anticipated duration of the accelerated test frequency

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[1] NUREG-0471, "Generic Task Problem Descriptions (Categories B, C, and D)," U.S. Nuclear Regulatory Commission, June 1978.
[2] Regulatory Guide 1.108, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, August 1976, (Rev. 1) August 1977. [7907100397]
[3] NUREG/CR-0660, "Enhancement of On-site Emergency Diesel Generator Reliability," U.S. Nuclear Regulatory Commission, February 1979.
[4] Regulatory Guide 1.108, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, August 1976, (Rev. 1) August 1977. [7907100397]
[5] NUREG/CR-0660, "Enhancement of On-site Emergency Diesel Generator Reliability," U.S. Nuclear Regulatory Commission, February 1979.
[6] Memorandum for D. Eisenhut et al. from S. Hanauer, "Diesel Generator Reliability at Operating Plants," May 6, 1982. [8205280490]

were not as restrictive as that recommended in Regulatory Guide 1.108.[7]

An extended out-of-service period could, in many cases, be necessary to allow sufficient time to correct the problems that caused low reliabilities. Therefore, the proposed program would allow out-of-service periods in excess of the existing 72-hour limit, when necessary, while at the same time placing a yearly limit on the cumulative time that a plant may operate in Modes 1 through 4 with one of the EDGs of the power systems inoperable. The cumulative limit would vary depending upon the reliability of the in-service EDG with the lowest reliability.

PRIORITY DETERMINATION

A risk analysis was performed[8] using Oconee 3 and Grand Gulf Unit 1 as representative of PWRs and BWRs, respectively. Since the proposed position was expected to affect only those EDGs that had demonstrated a reliability of less than 0.95/demand, it was assumed that 25% of the EDG population would undergo a reliability improvement from 0.93 to 0.97/demand and 5% would undergo a reliability improvement from 0.9 to 0.97/ demand (requalification).

Frequency Estimate

When the frequency of all core-melt scenarios (including EDG failure) was adjusted to include the above assumptions, it was found that the proposed solution would be expected to result in a significant core-melt frequency reduction for both the 25% EDG population and the 5% EDG population. The 25% EDG population, which was assumed to improve from 0.93/demand to 0.97/demand, would have core-melt frequency reductions of 1.7 x 10^{-5}/RY and 2.3 x 10^{-5}/RY for BWRs and PWRs, respectively. The 5% EDG population, which was assumed to improve from 0.9/demand to 0.97/demand, would have core-melt frequency reductions of 3.7 x 10^{-5}/ RY and 7.5 x 10^{-5}/RY for BWRs and PWRs, respectively.

Consequence Estimate

Base case risk for both PWRs and BWRs was calculated by multiplying the expected frequency of each release category by the dose equivalent value for the category. Adjusted case risk was determined by the same technique using the core-melt frequency reduction calculated for the reliability improvement expected in the respective EDG populations (25% and 5%) for both PWRs and BWRs. The adjusted risk was subtracted from the base case risk and the public risk reduction obtained was multiplied by the appropriate number of PWRs and BWRs. The total public risk reduction calculated was 6.5 x 10^4 man-rem, with an average public risk reduction of about 1.5 x 10^3 man-rem/reactor.

Cost Estimate

Industry Cost: It was assumed that 30% of the 143 expected plants would institute a reliability improvement program. In addition, 5% of the plants were assumed to incur a major equipment (EDG) replacement and an associated loss of power production. Industry costs were estimated for revision of operating procedures and personnel training, installation of additional equipment (air dryers, dust-tight enclosures for electrical contacts, EDG room ventilation ducting, etc.) and ongoing increases in operation and maintenance costs. Thus, the total industry cost was estimated to be $46M.

NRC Cost: The cost to complete resolution of the issue, review and approve new requirements, and issue implementation orders was estimated to be $130,000. Review of plant responses to orders and periodic reports expected from plants which must develop and initiate EDG reliability improvement

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[7] Regulatory Guide 1.108, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, August 1976, (Rev. 1) August 1977. [7907100397]

[8] NUREG/CR-2800, "Guidelines for Nuclear Power Plant Safety Issue Prioritization Information Development," U.S. Nuclear Regulatory Commission, February 1983, (Supplement 1) May 1983, (Supplement 2) December 1983, (Supplement 3) September 1985, (Supplement 4) July 1986, (Supplement 5) July 1996.

programs and long-term surveillance of the industry was estimated at $1M. Thus, total NRC cost was estimated to be $1.1M.

Total Cost: The total industry and NRC cost associated with the solution to this issue was $(46 + 1.1)M or $47.1M.

Value/Impact Assessment

Based on a potential public risk reduction of 6.5 x 10^4 man-rem and a cost of $47.1M, the value/impact score was given by:

$$S = \frac{6.5 \times 10^4 \text{ man-rem}}{\$47.1\text{M}}$$

$$= 1{,}380 \text{ man-rem}/\$\text{M}$$

Other Considerations

An unusually significant avoided accident cost was calculated for the resolution of this issue. This cost represented the expected savings to the industry from lowering the core-melt probability by implementation of a specific improvement and was calculated by multiplying the expected cost of the loss of a plant (~$3 Billion) by the expected total core-melt frequency reduction. In this instance, the avoided accident cost (savings to the industry) was estimated to be $30M.

CONCLUSION

The calculated value/impact score was indicative of a medium priority assignment; however, other factors prevailed. The very large estimated total public risk reduction (6.5 x 10^4 man-rem) and high expected core- melt frequency reduction (>10^{-5}/RY) elevated the priority of this issue. In addition, if the averted accident cost (industry savings) were subtracted from the total resolution cost, a value/impact score of 3,800 man-rem/$M would result. Therefore, the issue was given a high priority ranking (See Appendix C).

The issue was resolved by the inclusion of guidance on EDG reliability in Regulatory Guide 1.160[9] which was issued as part of the Maintenance Rule (10 CFR 50.65). This guide endorsed NUMARC 93-01, "Industry Guidelines for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," which addressed the optimization of EDG reliability and availability and contained an example of an acceptable means of establishing performance criteria and/or goals for EDGs. In addition, Regulatory Guide 1.9,[10] Rev. 3 was issued to integrate into a single document pertinent guidance previously addressed in the following documents: Regulatory Guide 1.9,[11] Rev. 2; Regulatory Guide 1.108,[12] Rev. 1; and Generic

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[9] Regulatory Guide 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, June 1993 [9306250035], (Rev. 1) January 1995. [9501300137]

[10] Regulatory Guide 1.9, "Selection, Design, and Qualification of Diesel-Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants," March 1971, (Rev. 1) November 1978, (Rev. 2) December 1979 [8001220580], (Rev. 3) July 1993. [9308180045]

[11] Regulatory Guide 1.9, "Selection, Design, and Qualification of Diesel-Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants," March 1971, (Rev. 1) November 1978, (Rev. 2) December 1979 [8001220580], (Rev. 3) July 1993. [9308180045]

[12] Regulatory Guide 1.108, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, August 1976, (Rev. 1) August 1977. [7907100397]

Letter 84-15.[13] As a result, Regulatory Guide 1.108,[14] Rev. 1 was withdrawn.[15] Thus, this issue was RESOLVED and new requirements were established.[16] In an RES evaluation,[17] it was concluded that consideration of a 20-year license renewal period did not affect the resolution.

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[13] Letter to All Licensees of Operating Reactors, Applicants for An Operating License, and Holders of Construction Permits from U.S. Nuclear Regulatory Commission, "Proposed Staff Actions to Improve and Maintain Diesel Generator Reliability (Generic Letter 84-15)," July 2, 1984. [ML031180013]

[14] Regulatory Guide 1.108, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, August 1976, (Rev. 1) August 1977. [7907100397]

[15] Federal Register Notice 58 FR 41813, "Regulatory Guide; Withdrawal," August 5, 1993.

[16] Memorandum for J. Taylor from E. Beckjord, "Resolution of Generic Safety Issue B-56, 'Diesel Generator Reliability,'" June 29, 1993. [9312220205]

[17] Memorandum for W. Russell from E. Beckjord, "License Renewal Implications of Generic Safety Issues (GSIs) Prioritized and/or Resolved Between October 1990 and March 1994," May 5, 1994. [9406170365]