LETTERS TO THE EDITOR

ZION DIESEL GENERATOR RELIABILITY

The Crooks and Vising report[1] provides a statistical analysis of diesel generator (DG) reliability in emergency service at U.S. nuclear power plants. The report assesses an extremely high point failure probability of 0.411/demand (D) for the Zion DGs (Ref. 1, Table VI). This was obtained from seven failures to start and load in 17 assumed monthly tests. In actuality, the many more tests that occurred invalidate this result. Unfortunately, this value is reflected in subsequent analyses making use of these data.[2,3]

The purpose of this Letter is to make known further data on the Zion DGs that correct this datum and to make clear that no emergency power plants only have a 50-50 chance of working when needed.

Zion plants 1 and 2 use five DGs: Two are assigned to each plant, and the fifth is an automatically transferred "swing diesel." Each DG is a Cooper-Bessemer type KSV-16 rated at 5000 KVA. The utility required that the DGs demonstrate a 0.99 reliability at a 95% confidence level. This requires 298 successful tests without failure or 474 tests with only one failure. Before installation, 110 tests were performed; the remaining 188 tests were performed after installation, primarily on DGs 1A and 1B. Thus, 298 tests were performed without failure, but the first failure occurred only $3\frac{1}{2}$ months after the initial criticality of Zion 1.

The File of Evaluated and Event Data (FEED) program[4] was used to retrieve the data for this analysis. The data in FEED are obtained by abstracting the information reported by the utilities under the requirements of *Regulatory Guide 1.16*.

From October 1, 1973 to January 11, 1975, 41 failures occurred. During this time, there were 1162 tests, but the U.S. Nuclear Regulatory Commission (NCR) conservatively rejected the 110 factory tests and 402 single DG startups that accompanied main turbine startup and coastdown because of weak documentation and lack of loading. Thus, 650 tests were accepted as valid. This gives a point failure probability of 0.035/D or 0.063/D, depending on assumptions of the number of valid tests.

The Zion DG reliability was discussed at length during the December 1974 Advisory Commission on Reactor Safeguards meeting[5] and was the subject of a meeting held with the NRC staff, the licensee, and the diesel vendor. In March 1975, Commonwealth Edison proposed a new well-defined test program performed in accordance with the May 1975 revised Zion Technical Specifications. The licensee performed at least 23 tests on each DG, for a total of 170 start and load tests without a valid failure. The NRC interpreted the data as 170 tests but 2 failures.

TABLE I

Zion Diesel Generator Reliability at a 50% Confidence Level

Tests	Reliability
Pre-1975	
1162 tests, 41 failures	0.960
650 tests, 41 failures	0.929
Post-1975	
170 tests, 0 failures	0.996
170 tests, 2 failures	0.984
79 tests, 0 failures	0.991

The proposed *Regulatory Guide 1.08*, "Periodic Testing of Diesel Generators Used as Onsite Power Systems at Nuclear Power Plants," requires preoperational testing to demonstrate a 0.99/D reliability at a 50% confidence level. This corresponds to 69 consecutive tests without failure. In the test program just described, the last 79 tests were successful; hence, this criterion is satisfied. Table I summarizes the data just discussed in terms of a 50% chi-squared confidence limit. Even the pre-1975 data, interpreted conservatively, give a failure probability of 0.07/D, and the last test results give 0.01/D. It is hoped that future DG assessments will consider these later data.

R. R. Fullwood
W. S. Loell

Science Applications, Inc.
2680 Hanover Street
Palo Alto, California 94304

October 25, 1976

ACKNOWLEDGMENT

This work was supported by the Electric Power Research Institute.

REFERENCES

1. J. L. CROOKS and G. S. VISING, "Diesel Generator Operating Experience at Nuclear Power Plants," USAGC report OOE-ES-002 (June 1974).

2. E. W. HAGEN, "Standby Emergency Power System Part 2–The Later Plants," *Nucl. Safety*, **16**, *2*, 162 (Mar.-Apr. 1975).

3. W. E. VESELY and G. T. MERREN, "Analysis of Component Reliability Data," *IEEE Trans. Reliability*, **R-25**, *3*, 158 (Aug. 1976).

4. W. LOELL, R. FULLWOOD, and H. KIRCH, "Development of an Operational Nuclear Data Base Extracted from Actual Plant Experience," SAI/SR-114-PA, Science Applications, Inc. (Sep. 1975).

5. "Safety Evaluation by the Office of Nuclear Reactor Regulation USNRC in the Matter of Commonwealth Edison Company Removal of License Condition Limiting Operation to 85% of Rated Thermal Power for the Zion Station, Units 1 and 2," Docket numbers 50-295 and 50-304 (May 20, 1976).