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MEMORANDUM FOR: Thomas E. Murley, Director
Office of Nuclear Reactor Regulation

FROM: Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER NUMBER 158:
OPERATIONAL SAFETY RELIABILITY PROGRAM

References:

1. NUREG-0600, "NRC Action Plan Developed as a result of the TMI Accident," Action Item II.C.4, Reliability Engineering, August 1980.

2. Memorandum from Harold R. Denton to Robert B. Minogue, "NRR User Research Request: Assessment of NRR Reliability Program (RR-NRR-83-01)," February 14, 1983.

3. NUREG-1154, "Loss of Main and Auxiliary Feedwater Event at the Davis-Besse Plant on June 9, 1985."

4. Kepner, Charles H. and Benjamin B. Tregoe, "The New Rational Manager," Princeton Research Press, 1981.

5. M. A. Azarm, E. V. Lofgren, et al., "Evaluation of Reliability Technology Applicable to LWR Operational Safety," NUREG/CR-4618, August 1988.

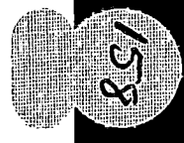
6. INPO paper on "Safety System Performance," enclosed with letter from T. J. Sullivan, INPO, to E. L. Jordan, NRC, April 15, 1988.

7. EPRI paper by John P. Gaertner, "A Review of Research Projects in the EPRI Nuclear Power Division Systems Reliability Analysis Program," presented at IEEE meeting in San Francisco, July 14, 1987.

8. IEEE P933, Draft 7, "Guide for the Definition of Reliability Program Plans," March 1988.

9. "Final Commission Policy Statement on Maintenance of Nuclear Power Plants," Federal Register Vol. 53, No. 56, March 23, 1988.

10. NRC Announcement No. 30, "Guidance on The Use of Performance Indicators," February 5, 1988.



11. NRC Five-Year Plan, March 1988.

12. SECY-88-103, "Status of Performance Indicator Program," April 15, 1988.

13. E. V. Lofgren, et al., "A Reliability Program for Emergency Diesel Generators at Nuclear Power Plants," NUREG/CR-5078, April 1988.

14. Temporary Instruction 2515/97, "Maintenance Inspection," June 1988.

15. J. Vora & J. Burns, "Understanding and Managing Aging and Maintenance," International Nuclear Power Plant Aging Symposium, Bethesda, Maryland, August 30-Sept. 1, 1988.

This Research Information Letter identifies the elements and process of a reliability program that can help to maintain the safety of operating reactors. This process is being used in several NRC and industry initiatives, particularly regarding maintenance and managing the effects of plant aging, performance indicators, and technical specifications.

Regulatory Issue

In 1980, the TMI Action Plan (Item II.C.4, Reliability Engineering) said that NRC would require licensees to develop reliability programs for NRC approval and implementation (Reference 1). Subsequently, however, NRC did not mandate a reliability program because of both technical and institutional problems.

The technical problem was that the essential elements and process of a reliability program applicable to operational safety had not yet been identified. Although NRC requirements, such as Appendices A and B of 10CFR50 strongly reflect reliability principles (i.e., safety margins, redundancy, diversity, and corrective action); nevertheless these principles had been applied primarily to nuclear power plants in the design phase, and not in the operations phase. Reliability engineering practices at nuclear power plants had not yet been developed with strategies to help achieve and maintain the designed-in capability for reliable operation during 40 years of nuclear power plant operating life. Therefore, NRR asked RES to identify the elements of such an operational reliability program (Reference 2). This technical problem is now resolved, mainly through the research reported here and related work by industry.

The institutional problem, i.e., the difficulty of incorporating a reliability program into regulatory requirements, still persists. Prescriptive implementation would be counter-productive because it could encourage a licensee to focus on producing a "paper trail" for subsequent NRC inspections instead of focussing on maintaining plant performance. One way to encourage reliable plant performance without a prescriptive requirement for a reliability

program is to require licensees to set availability/reliability/safety targets for overall plant performance or for selected systems, and to measure performance compared to the targets. Then NRC can focus on improvement programs for flagging performers. This approach is planned for diesel generator reliability (Generic Issue B-56) in support of the station blackout rule.

Conclusions

In resolving the technical problem, this research surveyed the potential usefulness of a reliability program to help resolve generic issues and to prevent precursors. In the course of the study, RES visited 5 utilities; reviewed practices in other industries and other countries; and conducted a very limited trial application.

This research identified the essential elements and process of a reliability program that can help to maintain the safety of nuclear power plants during their operating lifetime. We conclude that an important characteristic of this process is its closed-loop characteristic. This closed-loop process, illustrated in Figure 1, includes monitoring plant safety performance; comparing performance with targets and identifying deviations, i.e., potential problems; prioritizing the deviations; and for the important problems, identifying the causes, taking corrective action, and monitoring plant performance to verify that the corrective action achieved its objectives (Reference 5).

Such a reliability program is directly related to operational safety, as illustrated in Figure 2. For example, applying such an operational reliability program to balance-of-plant and other normally-operating equipment helps to minimize the occurrence of transients. Applying such a reliability program to standby safety systems helps to maintain their availability to respond when challenged. This process, based in part on widely used business principles (Reference 4), can help to focus attention onto important potential problems early on, and help prevent serious problems from occurring. This process integrates information on component failures, aging, and condition monitoring, developed by activities such as NRC's Nuclear Plant Aging Research and INPO's Nuclear Plant Reliability Data System, into a top-down strategy to prevent safety margins from degrading during the operating life of a plant.

Industry applications of this reliability technology to help maintain or improve operational safety have been mixed. On the one hand, one utility recently discharged its reliability engineering group. On the other hand, the industry is supporting several reliability initiatives including: the Institute of Nuclear Power Operation's operation of the Nuclear Plant Reliability Data System, and development of a risk-based Safety System Performance Indicator (Reference 6); the Electric Power Research Institute's adaptation and trial use of reliability-centered maintenance in operating plants (Reference 7); and the Institute of Electrical and Electronics Engineers' development of a guide for the definition of reliability program plans for operating plants (Reference 8).

Regulatory Application

The elements of an operational reliability program are being applied in several NRC and industry initiatives, such as technical-specification improvements, performance indicators, safety goals, nuclear plant aging research, and particularly improved maintenance of nuclear power plants (References 9-11, 15).

For example, NRC's maintenance policy says: "The Commission defines maintenance as the aggregate of those functions required to preserve or restore safety, reliability, and availability of plant structures, systems, and components.... The program should include feedback of specific results to ensure corrective action, provisions for overall program evaluation, and the identification of possible component or system design problems" (Reference 9).

This feedback constitutes the closed-loop process illustrated in Figure 1. Furthermore, the maintenance initiative addresses both the diagnostic evaluation of problems that have occurred and the prognostic identification of important potential problems (Reference 14).

Table 1 shows how an operational reliability program is included in a maintenance program. In Table 1, Column (1) lists the elements of an operational reliability program. Column (2) lists maintenance technical activities identified in the Commission's Policy Statement on Maintenance (Reference 9). Column (3) lists items on NRR's Maintenance Inspection Tree (Reference 14). Three elements of a reliability program, although not mentioned explicitly in Column (2), are understood to be included implicitly in a utility's maintenance program. These three elements are: (1) assessing reliability/safety in design and operations, and setting objectives for the maintenance program, (2) identifying and prioritizing potential problems, and (3) determining the causes of important potential problems. All these elements are included in NRC inspection of maintenance as shown in Column (3).

Thus, NRC's maintenance policy and inspection plan include the elements and closed-loop feedback process of a reliability program. In addition, individual aspects of a reliability program are being included in other NRC and industry initiatives, such as development of risk-based plant performance indicators and improvement of technical specifications (Reference 11, 12). Furthermore, an operational reliability program is part of the proposed resolution of Generic Issue B-56, "Diesel Generator Reliability" (Reference 13).

Restrictions on Applications

An operational reliability program, I believe, can be implemented more effectively in performance-based regulation (where NRC mandates the level of safety performance to be achieved) instead of in a prescriptive manner (where NRC mandates the way to achieve the desired safety performance).

Unresolved Questions and Further Work

Research to evaluate the effectiveness of selected applications of reliability engineering is continuing. In particular, we are evaluating an improved strategy to prevent common-cause failures (a follow-up item from the Davis-Besse loss of feedwater in 1985); i.e., what can be done to help prevent multiple failures? (Reference 3).

In summary, through this research and related NRC and industry programs, the staff understands the elements and process of an operational reliability program. This understanding is being applied in several NRC and industry initiatives.

(S)
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*See previous concurrences.

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FIGURE 1

ELEMENTS AND PROCESS OF RELIABILITY PROGRAM

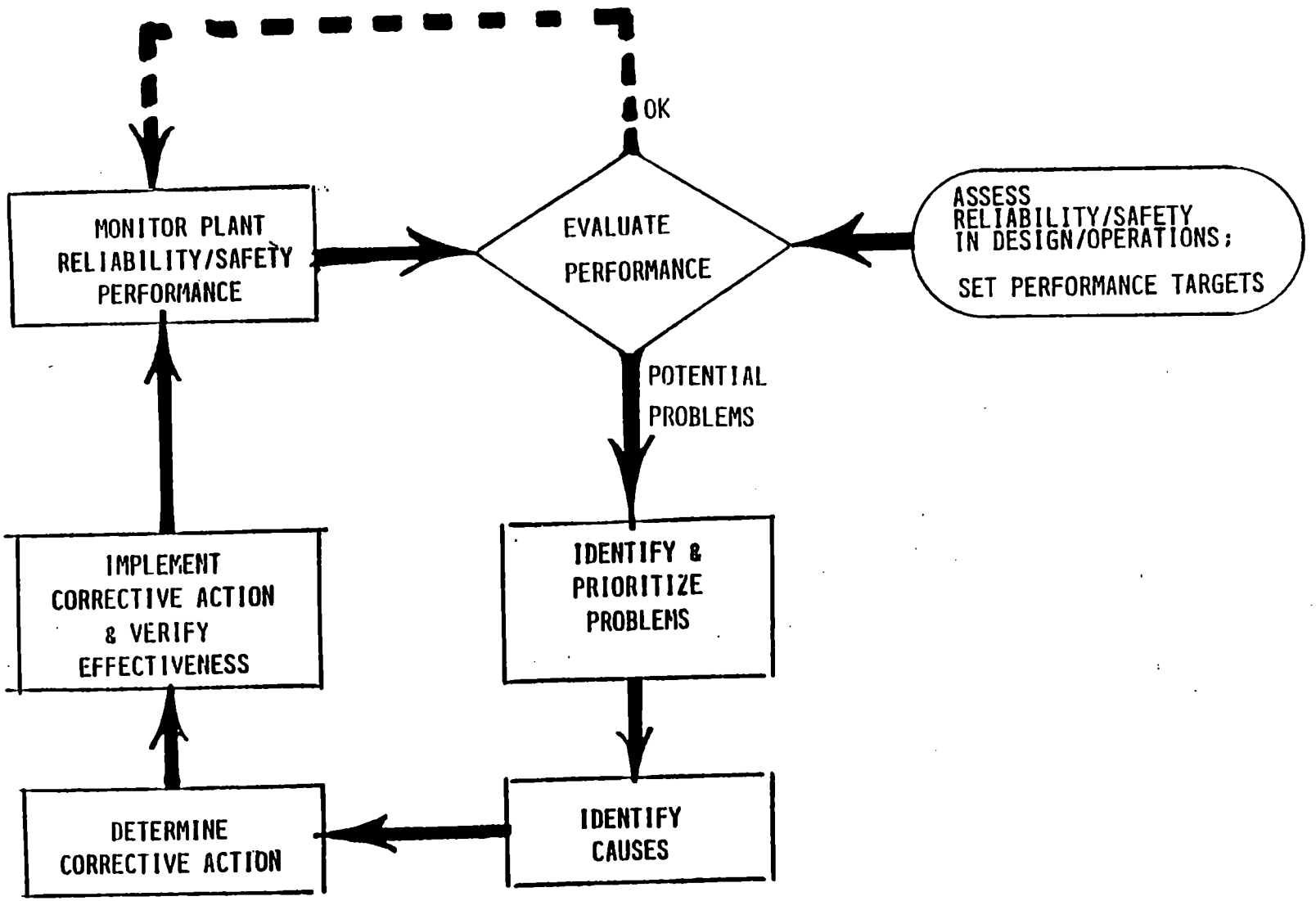

FIGURE 2

HOW RELIABILITY PROGRAM RELATES TO SAFETY

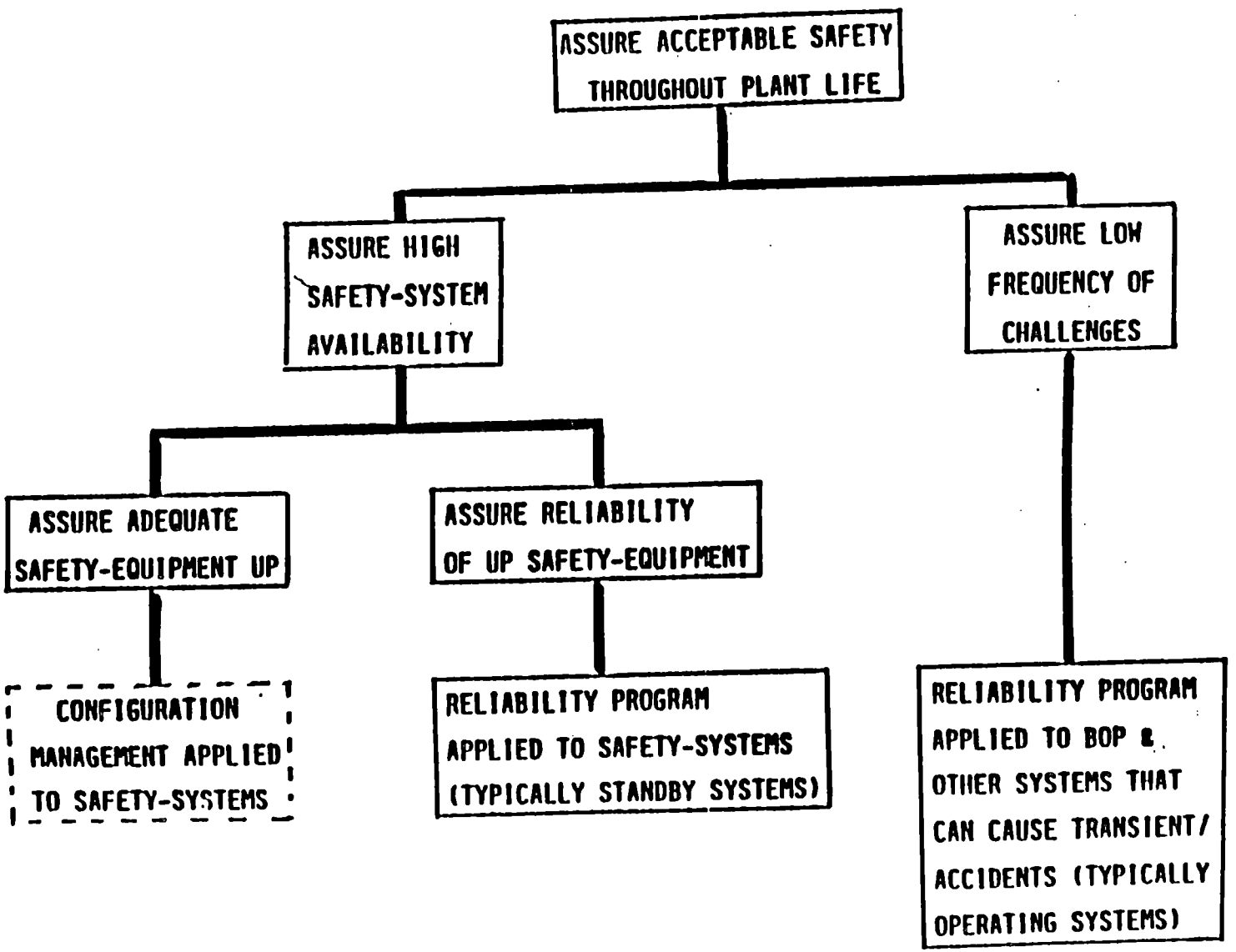

TABLE 1

RELIABILITY PROGRAM ELEMENTS ARE INCLUDED IN

LICENSEE MAINTENANCE ACTIVITIES AND NRC INSPECTION

(1) RELIABILITY PROGRAM ELEMENTS	(2) MAINTENANCE ACTIVITIES	(3) NRC INSPECTION OF MAINTENANCE
°Assess Reliability/ Safety in design & operations; and set targets		°Establish policy, goals & objectives for maintenance °Inspect role of PRA in maintenance program °Identify program coverage for maintenance °Define maintenance requirements
°Monitor performance	°Surveillance °Maintenance records	°Conduct performance measurement °Maintain equipment records & history
°Evaluate performance	°Equipment history & trending °Information feedback °Measures of overall program effectiveness	°Overall plant performance related to maintenance, direct measure °Perform maintenance trending
°Identify & prioritize problems		°Establish deficiency identification & control system °Perform work prioritization
°Identify causes	°Eng. support	°Inspect engineering support
°Determine corrective action		°Maintenance decision process
°Implement corrective action	°CM °PM °Predictive maintenance	°Establish control of plant maintenance activities
°Close-out problem	°Post maintenance testing & return-to-service activities °QA/QC	°Conduct post-maintenance testing °Review completed work documents °Inspect role of QC