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JUN 12 1985

MEMORANDUM FOR: Robert M. Bernero, Director
Division of Systems Integration

FROM: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

SUBJECT: SCHEDULE FOR RESOLVING AND COMPLETING GENERIC ISSUE NO. B-59 - (N-1) LOOP OPERATION IN BWRs AND PWRs

Generic Issue No. B-59, "(N-1) Loop Operation in BWRs and PWRs" has been prioritized as a "Regulatory Impact" issue that is resolved for BWRs and PWRs as explained in the enclosed evaluation. Beaver Valley's SER (MPA E-05) is the basis for resolution for PWRs. For BWRs, the issue is resolved on the basis that Generic Issue B-19, "Thermal Hydraulic Stability" is resolved, the plant-specific tests at Browns Ferry and the review of licensee submittals for MPA E-04, "BWR Single-Loop Operations." Since the issue was resolved by several different means, you should work with the Division of Licensing to develop a generic letter to inform licensees and applicants of the resolution.

In accordance with NRR Office Letter No. 40, "Management of Proposed Generic Issues," there is no resolution to this issue to be monitored by the Generic Issue Management Control System (GIMCS). However, the attached prioritization evaluation will be incorporated into NUREG-0933, "Prioritization of Generic Safety Issues," and is being sent to other NRC offices, the ACRS, and PDR for comments on the technical accuracy and completeness of the prioritization evaluation. Any changes as a result of comments will be coordinated with you.

Should you have any questions pertaining to the contents of this memorandum, please contact Louis Riani (24563).

Original Signed By
H. R. Denton

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosure:
Prioritization Evaluation

cc: See next page

6/4/85

Note: See previous concurrences.*

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ENCLOSURE

PRIORITIZATION EVALUATION

Generic Issue No. B-59

"(N-1) LOOP OPERATION IN BWRs AND PWRs"

ISSUE NO. B-59: (N-1) LOOP OPERATION IN BWRs AND PWRs

DESCRIPTION

Historical Background

The majority of the presently operating BWRs and PWRs are designed to operate with less than full reactor coolant flow. If a PWR reactor coolant pump or a BWR recirculation pump becomes inoperative, the flow provided by the remaining (N-1) loops is sufficient for steady state operation at a power level less than full power. Although the FSARs for the licensed BWRs and PWRs present (N-1) loop calculations showing allowable power and protective system trip set-points, the NRC staff has disallowed this mode of operation for most plants primarily due to insufficient analyses. At present BWR and PWR licensees have Technical Specifications which require shutdown within a fairly short time if one of the reactor coolant loops becomes inoperable.

Allowing (N-1) loop operation gives utility operators more flexibility in deciding whether to shut down a plant or let it operate at a reduced power level. In this issue, (N-1) loop operation is restricted to that resulting from a single reactor coolant pump failure. When fixing an out-of-service pump becomes a major task, it is not expected that the pumps will be repaired while the plant is on-line. By continuing operation in the N-1 mode, the repair work may be postponed until a scheduled refueling time.

In connection with multi-plant action (MPA) E-05 a safety evaluation report (SER) was completed in July 1984 (reference G) for the request by Beaver Valley Unit No. 1 (BV-1) for N-1 loop operation. Based on that SER, it is expected that BV-1 will be authorized to operate with N-1 loops when the Technical Specifications are revised and updated appropriately in the near future. The SER for BV-1 represents the resolution of this issue for PWRs so

that this issue is resolved for PWRs. For PWRs the program manager recently requested the Director of DL to close out MPA E-05 on the basis that there are no other active PWR applications for N-1 operation and, further, that none are expected in the foreseeable future (reference H). On the other hand, MPA E-04, "BWR Single Loop Operation," covers ten licensing actions on BWR submittals for N-1 or single loop operation (SOL) for seven licensees. The staff has reviewed the requests and submittals from the BWR licensees and has approved them such that N-1 loop operation for BWRs would be authorized if the licensees submit the appropriate changes to their Technical Specifications. The question of potential thermal-hydraulic instability problems during single loop operation for BWRs and how restrictive the Technical Specification changes would have to be was raised in References I and J, but this issue was resolved in Generic Issue B-19. However, in an effort to resolve certain plant-specific concerns about thermal-hydraulic instability in the Browns Ferry plant, TVA completed tests at the Browns Ferry plant on February 9, 1985, and those concerns have been resolved. The tests demonstrated that technical specifications based on GE SIL380, which have been proposed for some BWRs and approved by the staff, are unlikely to result in any limitation on the achievable power level in SLO. They also indicated (pending verification by data analyses) that SLO is not significantly less stable than two loop operation under similar power/flow operating conditions.

Permanent SLO has been approved for Peach Bottom Unit 3, Quad Cities Units 1 & 2, and Dresden Units 2 and 3 and will soon be approved for Duane Arnold. The staff expects to approve permanent SLO for the SLO applicants when appropriate Technical Specification changes have been submitted.

The prioritization analysis will be limited here to N-1 loop operation for BWRs inasmuch as the issue is essentially inactive for PWRs. This

prioritization has been completed with technical assistance from the Pacific Northwest Laboratories (reference F).

SAFETY SIGNIFICANCE

In the event that a loop becomes inoperative in an operating plant, it is not always feasible to place it back in service by the repair of the failed pump while the plant is on-line. The plant operation with the N-1 loops, however, will not differ from operation with all loops except for the requirement to operate at a decreased power level for the lower flow condition and with corresponding instrument/control set-point limitations. The accident sequences would be essentially the same as with all loops in operation and there will be no change in accident initiator frequencies. Moreover, the loss of a loop because of pump malfunction would not impair the function of the ECCS and the other on demand systems should an accident initiator arise. There had been some concern that operation with one loop out of service could result in thermal-hydraulic instabilities and possibly core damage at low flow conditions as well as with jet pump vibration at high flow conditions that could lead to damage to the reactor internals. But this matter has been adequately resolved. Therefore, the safety issue resolution would affect public risk or occupational exposure only slightly and might reduce risk because power and fission product levels would be smaller than at full power. The purpose of this change is to reduce the impact on licensees.

POSSIBLE SOLUTION

The purpose of this task is to develop a set of acceptance criteria, review guidelines and technical specifications changes for the (N-1) loop authorization requests. This set of criteria, guidelines and technical specification changes will encompass accident scenarios (both LOCAs and non-LOCAs) to be analyzed by the licensees, computer models acceptable to NRC

for these analyses and acceptable input parameters in terms of reactor operating conditions (such as allowance for uncertainties in power level and fluid measurement). This has already been accomplished for PWRs by virtue of the completion of the Safety Evaluation Report for Beaver Valley Unit No. 1 (Reference G). In addition, the BWR analyses have been reviewed and accepted by the staff and the appropriate generic Technical Specification changes to allow single loop operation for BWRs have been identified.

PRIORITY DETERMINATION

Frequency/Consequence Estimate

When operating a nuclear plant at a power level proportional to a reduced number of loops, the safety margins are somewhat increased from those at full power, but this increased margin is not regarded as contributing to a significant reduction in risk. Therefore, any potential risk reduction associated with this issue is perceived to be negligible. Moreover, no additional occupational exposure is anticipated for this issue inasmuch as major loop repair is likely to be done during scheduled downtimes.

Cost Estimate

To estimate the cost to industry, it is assumed that the amount of work performed by Duquesne Light for Beaver Valley Power Station No. 1, (BV-1), to analyze plant performance will be comparable to that required for BWR plants (reference B).

BV-1 analyzed a (N-1) loop large break LOCA and 12 non-LOCAs. Accidents involving the partial loss of forced reactor coolant flow, startup of an inactive reactor coolant loop, single reactor coolant pump locked rotor, and complete loss of forced reactor coolant flow were analyzed in the original

FSAR. Therefore, they were not reanalyzed. This leads to 13 transient scenarios to be analyzed.

Using a resource requirement of 5 man-wk and 15 computer hours for each case leads to a total of 65 man-wk and 195 computer hours. Another 30 man-wk per plant are allowed for preparing technical specification changes, modifying and upgrading procedures and/or systems and familiarizing operations staff with upgrades. Using the industry rate of $2270/man-wk and an estimated computer cost of $1000/hr, the total implementation cost is estimated to be approximately $420,000 per plant for BWRs as well as PWRs. In addition, the plant specific tests run by TVA at the Browns Ferry plant on the weekend of February 9, 1985, required operation at reduced power ranging from 50% to 65% for about 6 hours. On this basis it is estimated that the cost to conduct the test, obtain replacement power, and reduce the data will not exceed $150,000.

The labor and analysis required for operation and maintenance of the resolution of this issue by the licensee is estimated to be negligible.

With the implementation of (N-1) loop operation, plant downtime can be reduced. The results of reference A indicate that the main contributor to (N-1) loop operation are pump seal failures. For Oconee 1, 88% of pump failure events are due to pump seal problems and 99% of pump maintenance time is on seal fixes. Since the non-seal failures only contribute 1% of the total maintenance time in the Oconee case, we ignore them for this analysis and use pump seal failure probability as the probability of losing one loop and operating under (N-1) loop conditions. While the failure frequency of PWR pump seals that contribute significantly to core melt frequency is only 0.02 per plant-year (reference C), seal failures that result in the loss of one loop are estimated to be at a rate of 0.5/py for both PWRs and BWRs. Some

of these are LOCAs or would become LOCAs, but these can be isolated by the BWR recirculation loop valves.

If a plant is base loaded, it is more economical to shut down and repair a seal that fails more than 20 days before the end of a 540 day cycle than continue with one-out-of-two loop reduced power operation. But all plants are not run at full power. Also one loop operation allows flexibility in shutting down to make repairs. Therefore, it is assumed that out of the 0.50/py events, at best only one-third of the events will be continued as (N-1) loop operation, i.e., 0.17/py.

The savings in terms of the avoided outage is estimated from Reference D to be 10 days (average extra outage time per pump seal failure). Therefore, the savings from avoidance of outage per reactor-year is:

(10 days)(1 loop/2 loops)($300,000/day)(0.17/py) = $255,000/py

It is noted that the licensee implementation phase covering the analysis and evaluations of the potential accident sequences have already been submitted to the NRC in many cases for BWRs. Therefore, it will be assumed that the remaining plant analyses and/or re-analysis that may be required by the NRC staff will affect one-half of the total number of reactors. Also, it will be assumed that the cost savings resulting from the avoidance of outages with (N-1) loop operation is the same each year for the industry. Further, assuming an average reactor lifetime of 28 years and 44 BWRs, the total industry costs are estimated to be as follows:

Implementation: (1/2)($420,000)(44 BWRs) = $9,240,000

TVA test at Browns Ferry: $150,000

Operation and Maintenance: Zero

Outage Avoidance: - ($255,000/py)x(44 BWRs) = $11,220,000/yr

The present worth, PW, of the annual savings from outage avoidance over the average reactor lifetime of 28 years at a real discount rate of 5% is:

$$PW_{BWR} = (\$11.22 \times 10^6)\,[(0.05)^{-1}(1 - (1+0.05)^{-28}] = \$168,300,000$$

The cost to NRC of developing a set of acceptance criteria and review guidelines and technical specification changes for the issue are negligible inasmuch as these have already been identified. Some additional effort will be required to revise Chapter 15 of the Standard Review Plan to reflect the criteria needed to review N-1 loop operation. The revision to the SRP may require approximately 4 man-weeks. In addition, NRC labor to support SER implementation should be minimal at about 1 man-wk/plant.

The total costs for the NRC are:

Development of Safety Issue Resolution: Zero
Revision to the SRP: (4 man-wk)($2,270) = $9,080

Implementation: (1 man-wk/plant) ($2270/man-wk) (44 plants)
= $99,800

Total NRC costs are: $110,000 approximately.

CONCLUSION

It is concluded that this is a regulatory impact issue which has been resolved for BWRs and PWRs. For PWRs the issue has been resolved on the basis of the Beaver Valley SER (MPA E-05) and for BWRs the issue has been resolved on the basis of Generic Issue B-19, the plant-specific tests at

Browns Ferry and the review of licensee submittals under MPA E-04, "BWR Single-Loop Operation."

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