U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
PROPOSED REVISION
STANDARD REVIEW PLAN
PSRP-3.9.6 (Rev. 2)

SECTION 3.9.6 INSERVICE TESTING OF PUMPS AND VALVES

REVIEW RESPONSIBILITIES

Primary - Mechanical Engineering Branch (MEB)

Secondary - Reactor Systems Branch (RSB)
Auxiliary Systems Branch (ASB)
Containment Systems Branch (CSB)

I. AREAS OF REVIEW

The MEB reviews the following areas of the applicant's safety analysis report (SAR) that cover the inservice testing of certain safety related pumps and valves typically designated as Class 1, 2, or 3 under Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (hereafter "the Code"), to assure conformance with 10 CFR 50 Appendix A, General Design Criteria 37, 40, 43, and 46 and 10 CFR 50.55a(g):

1. Inservice Testing of Pumps

a. The descriptive information in the SAR covering the inservice test program is reviewed for those ASME Code Class 1, 2, and 3 system pumps ~~provided with an emergency power source~~ whose function is required for safety and system pressure tests. Upon request the ASB ~~Auxiliary Systems Branch~~ verifies the code class designations for each listed pump and the completeness of the list.

b. Procedures ~~Reference values~~ for testing for speed, pressure, flow rate, vibration, and bearing temperature at normal pump operating conditions are reviewed.

c. The pump test schedule, ~~included in the plant technical specifications~~, is reviewed.

d. The methods described in the SAR for measuring the reference values and inservice values for the pump parameters above are reviewed.

This proposed revision of the Standard Review Plan and the supporting value/impact statement have not received a complete staff review and approval and do not represent an official NRC staff position. Public comments are being solicited on both the revision and the value/impact statement (including any implementation schedules) prior to a review and decision by the Office of Nuclear Regulation as to whether this revision should be approved. Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch. All comments received by August 1, 1980, will be considered and all of the associated documents and comments considered will be made publicly available prior to a decision by the Director, Office of Nuclear Reactor Regulation, on whether to implement this revision.

2. Inservice Testing of Valves

The descriptive information in the SAR covering the inservice test program ~~of all~~ is reviewed for those ASME Code Class 1, 2, and 3 valves ~~is reviewed~~ whose function is required for safety and system pressure tests. This review does not include those non-safety related valves exempted by ~~defined in~~ IWV-1200 of Section XI of the Code. Upon request the ASB ~~Auxiliary Systems Branch~~ verifies the classification of each listed valve and the completeness of the list. Upon request, the RSB assists in reviewing compliance with Appendix A to this SRP section.

3. Relief Requests

10 CFR 50.55a(g) requires a nuclear power facility to periodically update its inservice testing program to meet the requirements of future revisions of Section XI of the ASME Code. However, if it proves impractical to implement these criteria, the applicant is allowed to submit requests for relief from Section XI requirements on a case-by-case basis. Accordingly, any requests for relief are reviewed by the staff to determine if the proposed exceptions to Section XI will degrade the overall plant safety. Due consideration is given to the burden upon the applicant that could result if the criteria of Section XI were imposed on the facility. Upon request, the ASB reviews RSB; ~~ASB; and ESB review~~ the system aspects of these relief requests.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in subsection I are as follows. Compliance with these criteria constitutes an acceptable basis for satisfying the applicable portions of General Design Criteria 37, 40, 43, 46 and 10 CFR 50.55a(g).

For those areas of review identified in subsection I as being the responsibility of other branches, the acceptance criteria and their methods of application are contained in the SRP sections corresponding to those branches.

1. Inservice Testing of Pumps

a. The scope of the applicant's test program is acceptable if it is in agreement with IWP-1000 of Section XI of the Code. Since the pump test program is based on the detection of changes in the hydraulic and mechanical condition of a pump relative to a reference test specified in IWP-3000, the establishment of a reference set of parameters and a consistent test method is a basic criterion of the program.

b. The pump test program is acceptable if it meets the requirements for establishing reference values and the periodic testing schedule of IWP-3000 of Section XI of the Code. The allowable ranges of inservice test quantities, corrective actions, and bearing temperature tests are established by IWP-3000 and IWP-4000. The pump test schedule ~~in the plant technical specification~~ is required to comply with these rules.

c. The test frequencies and durations ~~in the plant technical specifications~~ are acceptable if the provisions of IWP-3000 of Section XI of the Code are met. If a pump is normally operated more frequently than once a month, and at the reference conditions, it need not be specially tested. Otherwise, pumps must be tested each month during plant operation, and during shutdown periods if practical. The pumps must be run for at least five minutes under conditions as stable as the system permits. Bearing temperatures must be measured once a year for the duration specified in IWP-3000.

d. The methods of measurement are acceptable if the test program meets the requirements of IWP-4000 of Section XI of the Code with regard to instruments, pressure measurements, temperature measurements, rotational speed, vibration measurement, and flow measurements.

2. Inservice Testing of Valves

a. To be acceptable, the SAR valve test list must contain all safety related Code Class 1, 2, and 3 valves required by IWV-1100 except those non-safety related valves ~~defined in~~ exempted by IWV-1200. The SAR valve list must include a valve categorization which complies with the provisions of IWV-2000 of Section XI of the Code and Appendix A to this SRP section. Each specific valve to be tested by the rules of Subsection IWV is listed in the SAR by type, valve identification number, code class, and IWV-2000 valve category.

b. The valve test procedures ~~in the plant technical specifications~~ are acceptable if the provisions of IWV-3000 of Section XI of the Code and Appendix A to this SRP section are met with regard to preservice and periodic inservice valve testing.

3. Information Required for Review of Relief Requests

a. Identify component for which relief is requested:
   (1) Name and number as given in FSAR
   (2) Function
   (3) ASME Section III Code Class
   (4) For valve testing, also specify the ASME Section XI valve category as defined in IWV-2000

b. Specifically identify the ASME Code requirement that has been determined to be impractical for each component.

c. Provide information to support the determination that the requirement in (b) is impractical; i.e., state and explain the basis for requesting relief.

d. Specify the inservice testing that will be performed in lieu of the ASME Code Section XI requirements.

e. Provide an explanation as to why the proposed inservice testing will provide an acceptable level of quality and safety and not endanger the public health and safety.

f. Provide the schedule for implementation of the procedure(s) in (d).

Requests for relief from Section XI requirements will be granted by the staff if the applicant has adequately demonstrated either of the following:

a. Compliance with the code requirements would result in hardships or unusual difficulties without a compensating increase in the level of safety, and noncompliance will provide an acceptable level of quality and safety.

b. Proposed alternatives to the code requirements or portions thereof will provide an acceptable level of quality and safety.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from the procedures described below as may be appropriate for a particular case. For each area of review, the following review procedures are followed:

1. Inservice Testing of Pumps

a. The scope of the applicant's program is reviewed for agreement with subsection II.1.a. The program is acceptable if a preservice test program is used to established reference values. The periodic inservice program must verify the reference values within acceptable limits. Upon request the ASB verifies the acceptability of the pump list.

b. The pump test program procedures must agree with the requirements of subsection II.1.b. The program is best presented in tabular form. ~~in the plant technical specifications~~

c. The inservice test frequencies and test durations ~~in the plant technical specifications~~ are reviewed for agreement with subsection II.1.c.

d. The test procedures ~~results~~ described in the SAR are reviewed for agreement with subsection II.1.d. The SAR need only provide the necessary information to permit a conclusion that the methods of measurement and the data acquisition system will provide the needed data. The reviewer does not approve or disapprove the instruments or methods proposed or used.

2. Inservice Testing of Valves

a. The SAR valve test list and categorization are reviewed for agreement with subsection II.2.a. Upon request the ASB verifies the acceptability of the valve test list and categorization.

b. The valve test program is acceptable if the procedures follow the rules of subsection II.2.b for preservice and periodic inservice testing.

c. Upon request, the RSB will assist in reviewing the inservice valve test program for compliance with Appendix A to this SRP section.

3. Relief Requests

Requests for relief from Section XI requirements are reviewed to determine that sufficient information has been provided and that the acceptance criteria of subsection II.3 have been met. If necessary, the ~~secondary reviewers are~~ ASB is requested to provide input on the system aspects of the relief requests.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information is provided in accordance with the requirements of this SRP section and that his evaluation supports conclusion of the following type, to be included in the staff's safety evaluation report:

"To ensure that safety related ~~all~~ ASME Code Class 1, 2, and 3 pumps and valves will be in a state of operational readiness to perform necessary safety function throughout the life of the plant, a test program is provided which includes baseline preservice testing and periodic inservice testing. The program provides for both functional testing of the components in the operating state and for visual inspection for leaks and other signs of distress.

"The applicant has stated that the inservice test program for ~~all~~ safety related Code Class 1, 2, and 3 pumps and valves meets the requirements of 10 CFR 50.55a(g).

"Compliance with these requirements constitute an acceptable basis for satisfying the applicable portions of General Design Criteria 37, 40, 43, and 46."

V. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 37, "Testing of Emergency Core Cooling System."

2. 10 CFR Part 50, Appendix A, General Design Criterion 40, "Testing of Containment Heat Removal System."

3. 10 CFR Part 50, Appendix A, General Design Criterion 43, "Testing of Containment Atmosphere Cleanup Systems."

4. 10 CFR Part 50, Appendix A, General Design Criterion 46, "Testing of Cooling Water System."

5. ASME Boiler and Pressure Vessel Code, Section III and Section XI, Subsections IWP and IWV, American Society of Mechanical Engineers.

6. Code of Federal Regulations, Title 10, Section 50.55a, "Codes and Standards."

PROPOSED APPENDIX A TO SRP SECTION 3.9.6
LEAK TESTING OF PRESSURE ISOLATION VALVES

Two or more valves in series at interfaces between high and low pressure systems must be leak tested periodically.

The interfaces of interest are those between the reactor coolant system (RCS) and other systems whose design pressure is less than the rated RCS pressure. This includes systems which are rated at full reactor pressure on the discharge side of pumps, but have pump suction piping rated below RCS design pressure.

These valves will be classified as Category A as described in Section XI Subsection IWV of the ASME Pressure Vessel Code.

The frequency of leak testing of these isolation valves will be:

a) For the RHR, Hot and Cold Leg LPI, LPCS and any other system rated at less than 50% of RCS design pressure, the testing frequency will be each time the valves are disturbed because of flow in the line.

b) For all other systems, once per refueling.

All leak tests will be performed just prior to resuming power operation as the plant is pressurized, and subsequent to the most recent cycling of the valve.

The Class 1 to Class 2 boundary will be considered the isolation point which must be protected by redundant isolation valves.

In cases where pressure isolation is provided by two valves, both will be independently leak tested. When three or more valves provide isolation, only two of the valves need to be leak tested.

The allowable leakage limit will be 1.0 gpm for each valve.

When motor or air-operated valves are proposed as part of the pressure isolation boundary, the staff will evaluate the configuration and may impose operational limitations on these valves based on the probability of valve misalignment due to operator error. In cases where power-operated valves form part of the isolation boundary with a single check valve, the motor valves will not be cycled to meet ASME Section XI operability requirements until the redundant isolation valve has been shown to be providing an isolation function. In all cases where power-operated valves are used in conjunction with check valves, the power valves will be left open as the plant is pressurized until it is demonstrated that pressure is being held by the check valves. This requirement also is in effect for a power valve outside the Class 1/2 interface which is not considered part of the isolation boundary, but which is in series with upstream or downstream check valves.

Compliance with this position is required of all plants before issuance of an operating license or construction permit.

For plants having received operating licenses prior to approval of this revision to SRP 3.9.6, compliance with this position will be required within one year, unless the licensee proposes alternative methods for verifying the integrity of pressure isolation valves, and the staff finds that the proposed alternative methods offer sufficient levels of protection from intersystem LOCA.

VALUE-IMPACT STATEMENT FOR
PROPOSED APPENDIX A TO SRP 3.9.6
LEAK TESTING OF PRESSURE ISOLATION VALVES

I. Summary of Proposal:

In order to reduce the probability of an intersystem LOCA to acceptable levels, it is necessary to leak test motor-operated and check valves at high to low pressure interfaces in the reactor coolant system. The specific frequency of testing will vary depending on the type of interface configurations in the plant under review. Generally, a leak testing frequency of once per refueling in high to low pressure interfaces will be required. Each plant undergoing license review should be evaluated individually to determine the valves for which testing is required. As discussed in Reference 1to this value-impact statement, it is necessary in some cases to leak test certain check valves whenever the valves are disturbed.

II. Background:

The Reactor Safety Study (WASH-1400) identified the potential intersystem LOCA in a PWR as significant contributor to the risk resulting from core melt. In this scenario, check valves in the injection lines of the RHR or LPI systems fail allowing the high-pressure reactor coolant to communicate with the low-pressure piping outside of containment. Rupture of the low-pressure system would result in loss of reactor coolant outside of containment and subsequent core meltdown. Similar core melt scenarios could also be postulated for BWR's, and the risk levels appear similar.

After the Reactor Safety Study was released, the NRC staff recommended various modifications in the isolation valve configuration protecting low-pressure systems. However, recent work by Science Applications, Inc. (Reference 2) was critical of the NRC recommendations. They suggested that the various alternative options made available to industry by the NRC resulted in widely different levels of risk. Additionally, recent work by the staff has indicated that even with current practice, additional leak testing is warranted.

In addition, recent inservice testing requirements in the ASME Code Section XI have been established which call for periodic leak testing of various valves. There have been considerable differences among applicants regarding categorization of valves for this program. This has resulted in the submittal of leak testing programs which may not provide a sufficient level of protection against the intersystem LOCA event. It appears that guidance from the staff concerning this issue is necessary so that applicants can prepare appropriate inservice testing programs.

III. Value Assessment:

For details of the value assessment see the analysis in Reference 1, "The Probability of Intersystem LOCA: Impact Due to Leak Testing and Operational Changes." The analysis indicates that significant reductions in the probability of intersystem LOCA can be obtained through a systematic program of leak testing isolation valves between high and low pressure systems. Since intersystem LOCA is not a design basis accident, current plant safety systems are not designed to mitigate its consequences. The Reactor Safety Study showed this event to be one of the larger contributors to the probability of core melt.

To arrive at some quantitative estimate of the benefit from this proposed position, a cost benefit analysis can be made.

The intersystem LOCA event is expected to lead to a radiological release, categorized as PWR 2 in the Reactor Safety Study. Consequences of various releases can be calculated by the "CRACK" computer code. For a postulated reactor site and release category, this computer code will provide information on the health and economic consequences. Similar core melt scenarios could also be postulated for BWR plants.

To calculate cost-benefit, we will utilize results from a CRACK analysis done for the Perryman Site. While this location is not representative of all sites, it is general enough to provide valid insights into the cost benefits relationship from the proposed position. Rather than calculate individual effects such as cancer deaths, early fatalities, land contamination costs, and agricultural costs, we will utilize the calculated exposures from the CRACK code and assign an economic cost of $1,000 per man-rem to the exposure resulting from the accident.

In the Reference 1 to this value-impact statement, we have calculated the probability of experiencing an intersystem LOCA both under the assumptions of the "No Testing Case" and with the proposed position. We will calculate the total cost on an intersystem LOCA (present value) by using the equation:

$$C_{PV} = \sum_{n=1}^{40} \frac{P_e \times (M_a R_e) \times \$1000}{(1 + i)^n}$$

C_{PV} = present value cost of accident
P_e = probability of intersystem LOCA per reactor year
$M_a R_e$ = man-rem exposure
i = discount rate

This equation will give the present value discounted cost of the intersystem LOCA accident. This provides only the social cost and does not consider the considerable cost of replacement power which must be purchased for the destroyed plant. The present value costs of the intersystem LOCA is calculated for the "No Testing Case" and for the case with leak testing. The difference in these costs would be the economic benefit for implementing the proposed Appendix A to SRP 3.9.6.

The results of the calculations were obtained using a discount rate of 8 percent and were performed using the probabilities developed for the Sequoyah PWR, in Section 4.1, page 22, of the Reference 1 to this value-impact statement. The probabilities were modified slightly to allow credit for the fact that hot leg injection motor operated valves will be locked closed during plant operation. This reduces the probability of intersystem LOCA from 1.8×10^{-3} in the "original case," to 1.7×10^{-4}, since the hot leg injection interface (of two check valves and a locked closed motor valve) provides about the same degree of protection as three check valves in series. The "revised" probability, for the case when leak testing is employed, is still taken to be 4.3×10^{-6}.

Using the probabilities of intersystem LOCA, assuming no leak testing program (1.7×10^{-4}), we obtain an expected present value cost for the accident of just over $102 million. Using the probabilities associated with implementation of the leak testing program, gives an expected cost due to the accident of $2.5 million. The difference between these two accident costs is approximately $100 million, which shows the economic benefit from accepting the proposed leak testing program. This is much larger than the estimated cost for installing the leak testing system, which is discussed in the next section.

IV. Impact Assessment:

Pre-CP Issuance.

There will be very little impact from these proposed requirements at the CP stage of review. The applicant will be informed of the staff requirement for periodic leak testing and will be asked to identify the pressure isolation valves and verify that he has the capability to individually leak test them.

If test connections are not currently planned, they will have to be added to the plant. It is expected that this cost will be minimal. Previous reviews have shown that in most cases, necessary test connections are already included in the plant design. This issue should not result in any schedule delays.

Post -CP.

It is proposed that this position be applied to all plants undergoing OL review. Review of operability and leak testing programs is already required for the Inservice Testing Program of the ASME code. This position provides guidance to the applicants as to the proper categorization of various valves in their submittal to the staff.

If current plant design does not incorporate the necessary test connections to leak test individual isolation valves, hardware modifications would involve the field installation of vent and drain lines in piping where valve leak testing is necessary. The lines required would be quite small, approximately 3/8 inch with a local isolation valve. Discussions with members of the staff and AE firms indicate that field installation of these connections is feasible. Due to the small size of the test lines, only a minimal amount of analysis is required by the ASME code. There would be some initial engineering cost associated with the planning and set up of a program to install leak detection lines. Costs for this preliminary engineering would probably fall in the range of $5,000 - $15,000. There would also be the component and installation costs for the leak testing lines. The lines, associated valves, and weld attachments appear to be standard off-the-shelf components. Costs for installation of the lines should therefore be quite low, a figure of approximately $2,000 per line was suggested by one firm which has done similar work.

Since the majority of locations where leak test lines are required already have these provisions, it should be noted that only a limited number of test connections would have to be field installed. A total cost of $25,000 for the installation of leak testing lines would not appear unrealistic.

V. Proposed Implementation Plans:

It is proposed that this position be approved for immediate use. Plants which are currently undergoing operating license review are submitting plans for compliance with the ASME Inservice Testing Programs. Acceptance of this position will allow for the efficient completion of these submittals by formalizing the staff position on an important element of the inservice testing program.

It is proposed that compliance with this position be required of all plants before issuance of an operating license or construction permit.

For plants having received operating licenses prior to approval of the proposed revision to SRP 3.9.6, it is proposed that compliance with this position be required within one year of such approval, unless the licensee proposes alternative methods for verifying the integrity of pressure isolation valves, and the staff finds that the proposed alternative methods offer sufficient levels of protection from intersystem LOCA.

REFERENCES

1. NUREG-0677, "The Probability of Intersystem LOCA: Impact Due to Leak Testing and Operational Changes," March 1980.

2. PWR Sensitivity to Alterations in the Interfacing-Systems LOCA, Science Applications, Inc., EPRI NP-262, September 1976.

† Available for purchase from the NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, and the National Technical Information Service, Springfield, Virginia 22161.