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INSTRUMENT LINES PENETRATING THE PRIMARY REACTOR CONTAINMENT

A. INTRODUCTION

This guide defines a basis that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable to implement the intent of General Design Criterion (GDC) 55, "Reactor Coolant Pressure Boundary Penetrating Containment," and GDC 56, "Primary Containment Isolation," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, of the *Code of Federal Regulations*, Part 50, "Domestic Licensing of Production and Utilization Facilities" (10 CFR Part 50) (Ref. 1), with regard to instrument lines. This guide applies to light-water-cooled reactors with a primary containment.

GDC 55 and GDC 56 establish that a plant's principal design criteria require, in part, that each line that penetrates the primary reactor containment and that is part of the reactor coolant pressure boundary or connects directly to the containment atmosphere has at least one locked, closed isolation valve or one automatic isolation valve inside containment, and at least one locked, closed isolation valve or one automatic isolation valve outside containment (a simple check valve may not be used as the automatic isolation valve outside containment) "unless it can be demonstrated that the containment isolation provisions for a specific class of lines, such as instrument lines, are acceptable on some other defined basis."

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Valves provided for each instrument line that penetrates the primary reactor containment and that is part of the reactor coolant pressure boundary or that penetrates the primary reactor containment and connects directly to the containment atmosphere should be chosen with consideration of the importance of the following two safety functions:

1. the function that the associated instrumentation performs, and

2. the need to maintain containment leak-tight integrity.

The likelihood of achieving the first function is enhanced by the presence of fewer valves (e.g., one valve rather than two), whereas the likelihood of achieving the second function is enhanced by having multiple valves in the line.

In the event of a rupture of any component in an instrument line outside of the primary containment, it is important to ensure that the integrity and functional performance of the secondary containment and its associated air treatment systems (e.g., filters and the standby gas treatment system) are maintained. For those instrument lines that are part of the reactor coolant boundary, it is also important to ensure that the rate and the extent of coolant loss from the ruptured component are within the capability of the normal reactor coolant makeup system. Because the likelihood of such a rupture is conservatively assumed to be higher than that of the analyzed accidents, the system is designed to result in calculated radiation doses from such an instrument line failure during normal operation being substantially below the guidelines of 10 CFR Part 100, "Reactor Site Criteria" (Ref. 2), and GDC 19, "Control Room," or of 10 CFR 50.67, "Accident Source Term."

The rate of coolant loss from an instrument line rupture outside containment can be reduced by including flow restrictions, such as orifices, in the instrument line. These flow restrictions should be sized to reduce the potential rate of coolant loss to the extent practical without adversely affecting the capability of the connected instruments to perform their functions. In particular, the response time of connected instruments must remain acceptable, and the potential for obstruction of the flow restrictions must be kept very low. It is also desirable that instrument line flow restrictions be located as close as practical to where the instrument line connects to the reactor coolant system to reduce potential blowdown inside of the primary containment.

If the conditions presented in the two preceding paragraphs are satisfied, a single automatically operated isolation valve (i.e., no dependence on operator actions) or one that an operator can manually operate from a remote location (e.g., in the control room or in another appropriate location) can provide acceptable capability for isolating instrument lines that penetrate the primary reactor containment. A self-actuated excess-flow check valve is acceptable as an automatically operated valve if it has the other features needed for this service. It is desirable that the isolation valve be located outside containment for greater accessibility. Power-operated isolation valves that provide a safety function in both the open and closed position would likely afford greater safety if designed to remain "as is" (usually open) if power is lost. The optimum fail condition, open, closed, or "as is," should be determined and implemented for each power-operated instrument line containment isolation valve. Not having an isolation valve inside containment makes it even more important that there be a high degree of assurance that the instrument line from the containment out to and including the outside valve retains its integrity during normal reactor operation and under accident conditions. This assurance can be provided by taking the following four actions:

1. locating the valve as close to containment as practical,

2. adopting a conservative approach in the design of this section of the line,

3. implementing suitable quality assurance provisions, and

4. performing suitable visual inservice inspections.

Performing periodic visual inspections should not increase the probability of damaging the instrument lines. Plant and system layout should allow for general visual inspection of the lines, either directly or with remote imaging capability, with minimal risk of instrument line damage. Prior to installing a particular valve model, sufficient industry or testing experience with similar valves should be available that demonstrates a high likelihood that the valves to be installed will not close when the instrument line is intact and its safety function is required. In the event of a rupture downstream of the valve, the valve should close automatically or be capable of being readily closed during normal reactor operation and under accident conditions. In addition, the valve should reopen or be capable of being readily reopened under the conditions that prevail when reopening it is appropriate. It should not be necessary to externally backfill an instrument line to reopen a closed isolation valve with an intact downstream line.

It is desirable to have an indication of the valve position status (opened and closed) in the control room because without such an indication, a valve may remain closed, thus impairing instrument functions for an excessive period of time. For remotely operable valves, the operator needs sufficient information about the status of the valve and the condition of the line so that he or she can take proper, timely actions.

Lines connected to instruments that are part of the protection or safety systems are extensions of those systems and should support those systems achieving their requirements for redundancy, independence, and testability to ensure the systems safety functions are accomplished.

Lines connected only to instruments that are not part of the protection or safety systems do not need to meet the requirements of the protection or safety systems. For these lines, the assurance that isolation can be effected when required may be of greater importance to safety than the capability of the connected instrument function; therefore, more extensive valving may be preferable.

C. REGULATORY POSITION

1. Instrument lines penetrating the primary containment that are connected to instruments that are part of the protection or safety systems are extensions of those systems and should support those systems achieving their requirements for redundancy, independence, and testability to ensure the systems safety functions are accomplished.

2. Instrument lines penetrating the primary containment that are part of the reactor coolant boundary should be sized or orificed in such a manner as to ensure that the following occurs in the event of any breach of the line outside of the primary containment during normal reactor operation:

    a. The leakage is reduced to the maximum extent practical consistent with other safety requirements.

    b. The rate and extent of coolant loss are within the capability of the normal reactor coolant makeup system.

c. The integrity and functional performance of the secondary containment air treatment systems will be maintained.

d. The potential radiation doses will be substantially below the guidelines of 10 CFR Part 100 and GDC 19 or of 10 CFR 50.67.

3. Instrument lines penetrating the primary containment should be provided with an automatically operated isolation valve or one that an operator can manually operate from a remote location (e.g., in the control room or in another appropriate location). The valve should be located in the line outside containment as close to containment as practical. Excess-flow check valves may provide acceptable automatic operation in this application. There should be a high degree of assurance that these valves will perform as follows:

   a. They will not close accidentally during normal reactor operation.

   b. They will close or can be readily closed if the integrity of the instrument line outside containment is lost during normal reactor operation or under accident conditions.

   c. They will reopen or can be readily reopened under the conditions that would prevail when reopening them is appropriate.

   Power-operated valves should remain “as is” upon loss of power. The status (opened and closed) of all such isolation valves should be indicated in the control room. If a remotely operated valve is provided, sufficient information should be available in the control room or other appropriate location to ensure that the operator can take timely and proper actions.

4. Instrument lines penetrating the primary containment that are connected to instruments that provide input signals to the protection or safety systems and are closed systems both inside and outside of containment (e.g., for containment pressure instrumentation) are acceptable without containment isolation valves if they meet the conditions specified in Section 3.6.2 of American National Standards Institute (ANSI) N271-1976, “Containment Isolation Provisions for Fluid Systems” (Ref. 3).

5. Instrument lines penetrating primary containment should be designed conservatively from containment out to and including the isolation valve and should be of a quality at least equivalent to that of containment. These portions of the lines should be located and protected so as to minimize the likelihood of their being accidentally damaged. They should be protected or separated to prevent the failure of one line from contributing to the failure of any other line. Provisions should be included to permit periodic visual inspection during plant operation, particularly of those portions of the lines outside containment out to and including the isolation valve.

6. Instrument lines penetrating the primary containment should not be so restricted by components in the lines, such as valves and orifices, that the response time of the connected instrumentation could be increased unacceptably.

7. Instrument lines penetrating the primary containment that are not associated with protection or safety system instrumentation should meet the provisions of the following:

   a. positions 2, 3, 5, and 6 above, or

   b. Regulatory Guide 1.141, "Containment Isolation Provisions for Fluid Systems" (Ref. 4).

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

In some cases, applicants or licensees may propose or use a previously established acceptable alternative method for complying with specified portions of the NRC's regulations. Otherwise, the methods described in this guide will be used in evaluating compliance with the applicable regulations for license applications, license amendment applications, and amendment requests.

REFERENCES[1]

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission, Washington, DC.

2. 10 CFR Part 100, "Reactor Site Criteria," U.S. Nuclear Regulatory Commission, Washington, DC.

3. ANSI N271-1976, "Containment Isolation Provisions for Fluid Systems," American Nuclear Society, La Grange Park, IL, June 1976.[2]

4. Regulatory Guide 1.141, "Containment Isolation Provisions for Fluid Systems," U.S. Nuclear Regulatory Commission, Washington, DC.

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1 Publicly available NRC published documents such as Regulations, Regulatory Guides, NUREGs, and Generic Letters listed herein are available electronically through the Electronic Reading room on the NRC's public Web site at: http://www.nrc.gov/reading-rm/doc-collections/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail PDR.Resource@nrc.gov.

2 Copies of the non-NRC documents included in these references may be obtained directly from the publishing organization.