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INSTRUMENT SENSING LINES

A. INTRODUCTION

This guide describes a method that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in complying with the agency's regulations with respect to the design and installation of safety-related instrument sensing lines in nuclear power plants. To meet these objectives, the sensing lines must serve a safety-related function to prevent the release of reactor coolant as a part of the reactor coolant pressure boundary and to provide adequate connections to the reactor coolant system for measuring process variables (e.g., pressure, level, and flow). The term "safety-related" refers to those structures, systems, and components necessary to ensure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in a safe-shutdown condition, or (3) the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures in Title 10, of the *Code of Federal Regulations*, Part 100, "Reactor Site Criteria" (10 CFR Part 100) (Ref. 1).

The regulatory framework that the NRC has established for nuclear power plants consists of a number of regulations and supporting guidelines, include, but are not limited to, General Design Criterion (GDC) 1, "Quality Standards and Records"; GDC 13, "Instrumentation and Control"; GDC 24, "Separation of Protection and Control Systems"; and GDC 55, "Reactor Coolant Pressure Boundary Penetrating Containment," as set forth in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities" (Ref. 2). The provisions of 10 CFR Part 50 require that design criteria be established for structures, systems, and components important to safety to provide reasonable assurance that the facility can be operated without undue risk to public health and safety. GDC 1 requires that structures, systems, and components important to safety be designed and installed to quality standards commensurate with the safety

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The NRC issues regulatory guides to describe and make available to the public methods that the NRC staff considers acceptable for use in implementing specific parts of the agency's regulations, techniques that the staff uses in evaluating specific problems or postulated accidents, and data that the staff needs in reviewing applications for permits and licenses. Regulatory guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions that differ from those set forth in regulatory guides will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public.

Regulatory guides are issued in 10 broad divisions: 1, Power Reactors; 2, Research and Test Reactors; 3, Fuels and Materials Facilities; 4, Environmental and Siting; 5, Materials and Plant Protection; 6, Products; 7, Transportation; 8, Occupational Health; 9, Antitrust and Financial Review; and 10, General.

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importance of the functions to be performed. GDC 13 requires that instrumentation be provided to monitor variables and systems to ensure adequate safety. GDC 24 requires, in part, that the interconnection of the protection and control systems be limited so as to ensure that safety is not significantly impaired. GDC 55 requires, in part, that each line that is part of the reactor coolant pressure boundary and that penetrates the primary reactor containment be provided with containment isolation valves, 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. Regulatory Guide 1.53, "Application of the Single-Failure Criterion to Safety Systems" (Ref. 3), provides guidance on acceptable methods for satisfying the Commission's regulations with respect to the separation and independence of the electrical power, instrumentation, and control portions of nuclear power plant safety systems.

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

Committee SP67.02 of the Instrument Society of America (ISA) prepared American Nuclear Standards Institute (ANSI)/ISA-67.02.01-1999, "Nuclear Safety-Related Instrument-Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants" (Ref. 4), and ISA approved the standard on November 15, 1999. ANSI/ISA-67.02.01-1999 provides design, physical protection, and installation requirements for safety-related instrument sensing lines, and for sampling lines previously covered by ANSI/ISA-S67.10-1994, "Sample-Line Piping and Tubing Standards for Use in Nuclear Power Plants" (Ref. 5). ANSI/ISA-67.02.01-1999 establishes the applicable code requirements and code boundaries for the design and installation of instrument sensing lines interconnecting safety-related piping and vessels with both safety-related and nonsafety-related instrumentation.

The Power Generation Committee of the Institute of Electrical and Electronics Engineers (IEEE) Power Engineering Society developed ANSI/IEEE Standard (Std) 622-1987, "Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Stations" (Ref. 6), and the IEEE Standards Board approved it on December 11, 1986. ANSI approved it on November 23, 1987. The standard provides recommended practices for designing and installing electric heat tracing on systems in nuclear power generating stations to prevent them from freezing in cold weather and to prevent certain concentrations of chemicals, such as boric acid solutions, from crystallizing or solidifying within an instrument piping system. The recommendations include identification of requirements, heater design considerations, power systems design considerations, temperature control considerations, alarm considerations, finished drawings and documents, installation of materials, startup testing, temperature tests, and maintenance of electric pipe heating systems.

Operational events have occurred in which evolved gases in instrument sensing lines have affected measured water levels in operating nuclear power plants. The NRC issued Information Notice 92-54, "Level Instrumentation Inaccuracies Caused by Rapid Depressurization," dated July 24, 1992 (Ref. 7), to alert licensees to potential inaccuracies in water-level indication during and after rapid depressurization events. NRC Information Notice 93-27, "Level Instrumentation Inaccuracies Observed during Normal Plant Depressurization," dated April 8, 1993 (Ref. 8), alerts licensees to potential inaccuracies in reactor vessel level indication during normal reactor depressurization. In addition to potential inaccuracies in reactor vessel level indication during normal and rapid reactor

depressurizations, operational events have occurred in which flashing within reactor water level reference legs affected reactor water level measurements in operating nuclear power plants.

Inaccuracies in level instrumentation could affect the performance of safety functions in pressurized-water reactor (PWR) and boiling-water reactor (BWR) plants. NRC Information Notice 95-20, "Failure in Rosemount Pressure Transmitters Due to Hydrogen Permeation into the Sensor Cell," dated March 22, 1995 (Ref. 9), presents evidence of the presence of dissolved gas in a PWR instrument line. For BWRs, a potential problem is that dissolved gases can evolve in the reference leg for level measurements in the reactor vessels as the solubility of the gases decreases during depressurization. Such gases can be trapped in the instrument sensing line and affect differential pressure measurements, particularly level measurements. Such events have been reported in licensee event reports with significant level measurement errors. Since level instrumentation plays an important role in plant safety and is required for both normal and accident conditions, NRC Bulletin 93-03, "Resolution of Issues Related to Reactor Vessel Water Level Instrumentation in BWRs," dated May 28, 1993 (Ref. 10), recommended that each utility implement corrective actions to ensure that the level instrumentation design is of high functional reliability for long-term operation. In response to the bulletin, the majority of BWR licensees decided to install a reference leg backfill system to supply a continuous flow of water from the control rod drive hydraulic system through the reference legs to preclude migration of dissolved noncondensable gases into the legs. However, NRC Information Notice 93-89, "Potential Problems with BWR Level Instrumentation Backfill Modifications," dated November 26, 1993 (Ref. 11), reported on several potential design problems with the retrofitted backfill system by which a single failure in the backfill system would lead to a severe transient on multiple level sensing channels. Consequently, the design measures that respond to trapped gas in the reference leg should ensure that the features and systems that mitigate or preclude evolved gases do not themselves introduce additional single-failure mechanisms in the protection system. The following regulatory provisions support taking additional measures to address the potential for evolved gases in instrument sensing lines:

- GDC 13 states, "Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety."

- GDC 21 states, "The protection system shall be designed for high functional reliability and inservice testability commensurate with the safety function to be performed."

- GDC 22 states, "The protection system shall be designed to assure that the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels do not result in loss of the protection function."

- 10 CFR 50.55a(h) requires that reactor protection systems satisfy the criteria of IEEE Std 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generation Stations" (including a correction sheet, dated January 30, 1995) (Ref. 12), or of IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations" (Ref. 13). Section 5.5, "System Integrity," of IEEE Std 603-1991 states, "The safety systems shall be designed to accomplish their safety functions under the full range of applicable conditions enumerated in the design basis." Section 4.20 of IEEE Std 279-1971 states, "The protection system shall be designed to provide the operator with accurate, complete, and timely information pertinent to its own status and to generating station safety."

  Additionally, the staff notes the following concerns that support these measures:

- Level-sensing instrumentation may not accurately monitor reactor vessel water levels under normal cooldown or accident conditions.

- Instrumentation may not be reliable during and following normal and rapid depressurization.

- Degassing may cause a loss of the reactor vessel water-level indication function during and following normal depressurization and rapid depressurization.

C. REGULATORY POSITION

ANSI/ISA-67.02.01-1999 provides an approach that the NRC staff considers acceptable for satisfying the agency's regulatory requirements with respect to designing and installing safety-related instrument sensing lines in nuclear power plants. This regulatory guide endorses ANSI/ISA-67.02.01-1999, with the following exceptions and clarifications:

1. The endorsement of ANSI/ISA-67.02.01-1999 is limited to instrument sensing lines and does not include Section 6, "Sample-Line Fabrication, Routing, Installation, and Protection." The original ANSI/ISA-S67.02 covered only sensing lines, while ANSI/ISA-S67.10 addressed sampling lines. ANSI/ISA-67.02.01-1999 combines the two. This regulatory guide addresses only the instrument sensing line guidance. The term "instrument sensing line" used in this guidance applies to valves, fittings, manifolds, tubing, and piping used to connect instruments to main piping, other instruments, apparatus, or measuring equipment.

2. ANSI/ISA-67.02.01-1999 does not address containment isolation requirements for water-filled sensing lines that penetrate the containment boundary. The requirements of GDC 55 regarding penetrations of the containment by lines forming the reactor coolant pressure boundary must be observed. For each sensing line that penetrates primary reactor containment, root valve and accessible isolation valves should be provided, unless it can be demonstrated that the containment isolation provisions for sensing lines are acceptable on some other defined basis in accordance with GDC 55. The root valve and accessible isolation valve may be the same valve, if the arrangement meets all other requirements for isolation and accessibility.

3. IEEE Std 622-1987 provide a basis acceptable to the NRC staff for designing and installing electric heat tracing systems in nuclear power generating stations.

4. In addition to guidance provided by ANSI/ISA-67.02.01-1999, provisions should be made to (a) determine the potential impacts of noncondensable gases in sensing lines during or following depressurization and the potential impacts of flashing in reference leg and (b) mitigate such potential impacts, as long as the associated measurements are required for monitoring the plant or for operating the safety system. This position is based on GDC 13, GDC 21, GDC 22, and 10 CFR 50.55a(h).

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 an alternative 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, design certifications, and amendment requests.

GLOSSARY

backfill—In the context of instrument sensing lines, backfill refers to a specific measure to supply a flow of reactor coolant into sensing lines to prevent the collection of trapped gas. In resolving the occurrence of false level readings, this modification came to be known as the "backfill modification." (See Ref. 9.)

evolved gas—Gas released from reactor coolant caused by a chemical reaction or a change in the solubility of the coolant.

instrument sensing line—A group of valves, fittings, manifolds, tubing, and piping used to connect instruments to main piping, other instruments, apparatus, or measuring equipment.

trapped gas—Gas confined to a region of piping by buoyancy force. Trapped gas in a sensing line gives a false reading of the pressure in the sensing line.

REFERENCES[1]

1. 10 CFR Part 100, "Reactor Site Criteria," U.S. Nuclear Regulatory Commission, Washington, DC.

2. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission, Washington, DC.

3. Regulatory Guide 1.53, "Application of the Single-Failure Criterion to Safety Systems," U.S. Nuclear Regulatory Commission, Washington, DC.

4. ANSI/ISA-67.02.01-1999, "Nuclear Safety-Related Instrument-Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants," American National Standards Institute/Instrument Society of America, Research Triangle Park, NC, 1999.[2]

5. ANSI/ISA-S67.10-1994, "Sample Line Piping and Tubing Standards for Use in Nuclear Power Plants," American National Standards Institute/Instrument Society of America, Research Triangle Park, NC, 1994.

6. ANSI/IEEE Std 622-1987, "Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 1987.

7. NRC Information Notice No. 92-54, "Level Instrumentation Inaccuracies Caused by Rapid Depressurization," U.S. Nuclear Regulatory Commission, Washington, DC, July 24, 1992.

8. NRC Information Notice No. 93-27, "Level Instrumentation Inaccuracies Observed During Normal Plant Depressurization," U.S. Nuclear Regulatory Commission, Washington, DC, April 8, 1993.

9. NRC Information Notice No. 95-20, "Failures in Rosemount Pressure Transmitters Due to Hydrogen Permeation into the Sensor Cell," U.S. Nuclear Regulatory Commission, Washington, DC, March 22, 1995.

10. Bulletin 93-03, "Resolution of Issues Related to Reactor Vessel Water Level Instrumentation in BWRs," U.S. Nuclear Regulatory Commission, Washington, DC, May 28, 1993.

11. Information Notice 93-89, "Potential Problems with BWR Level Instrumentation Backfill Modifications," U.S. Nuclear Regulatory Commission, Washington, DC, November 26, 1993.

12. IEEE Std 603-1991, "Standard Criteria for Safety Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 1991 (and the correction sheet, dated January 30, 1995).[3]

[1] Publicly available NRC published documents are available electronically through the Electronic Reading room on the NRC's public Web site at: http://www.nrc.gov/reading-rm/doc-collections/. The documents can also be viewed on-line or printed for a fee in 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 American National Standards (ANS) may be purchased from the American National Standards Institute (ANSI), 1819 L Street, NW., 6th floor, Washington, DC 20036 [phone: (202) 293-8020)]. Purchase information is available through the ASCE Web site at http://webstore.ansi.org/ansidocstore/.

13. IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 1971.

[3] Copies of Institute of Electrical and Electronics Engineers (IEEE) standards may be purchased from the IEEE Standards Association, 445 Hoes Lane, Piscataway, NJ 08855-1331; telephone (800) 678 4333. Purchase information is available through the IEEE Standards Association Web site at http://www.ieee.org.