U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE 1.151, Revision 2

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INSTRUMENT SENSING LINES

A. INTRODUCTION

Purpose

This regulatory guide (RG) describes an approach that is acceptable to the staff of the U.S. Nuclear Regulatory Commission (NRC) to meet regulatory requirements for the design and installation of safety related instrument sensing lines in nuclear power plants.

This RG endorses, as a preferred method, with certain exceptions described in the regulatory positions in Section C of this guide, American National Standards Institute/International Society of Automation (ANSI/ISA) 67.02.01-2014, "Nuclear Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants" (Ref. 1). In addition, this RG finds that the Institute of Electrical and Electronic Engineers (IEEE) Standard (Std.) 622-1987, "IEEE Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Systems," reaffirmed in 1994, is an available method that is acceptable for use as described in the regulatory position in Section C of this guide.

Applicability

This RG applies to applicants and licensees under Title 10 of the Code of Federal Regulations (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities" (10 CFR Part 50), and applicants and licensees under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." This RG also applies to applicants for, and holders of, a standard design approval issued under Subpart E, "Standard Design Approvals," of 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Ref. 3), and applicants for a standard design certification issued under Subpart B, "Standard Design Certifications," of 10 CFR Part 52.

Applicable Regulations

- 10 CFR 50.34, "Contents of applications; technical information" provides requirements for the content of the preliminary safety analysis report to be included in a construction application.

Written suggestions regarding this guide or development of new guides may be submitted through the NRC's public Web site in the NRC Library at https://nrcweb.nrc.gov/reading-rm/doc-collections/reg-guides/, under Document Collections, in Regulatory Guides, at https://nrcweb.nrc.gov/reading-rm/doc-collections/reg-guides/contactus.html.

Electronic copies of this RG, previous versions of RGs, and other recently issued guides are also available through the NRC's public Web site in the NRC Library at https://nrcweb.nrc.gov/reading-rm/doc-collections/reg-guides/, under Document Collections, in Regulatory Guides. This RG is also available through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under ADAMS Accession Number (No.) ML19156A129. The regulatory analysis may be found in ADAMS under Accession No. ML18158A301. The associated draft guide DG-1352 may be found in ADAMS under Accession No. ML18158A303, and the staff responses to the public comments on DG-1352 may be found under ADAMS Accession No. ML19156A128.

- Under the provisions of 10 CFR 50.34, an application for a construction permit must include the principal design criteria for a proposed facility. In addition, under the provisions of 10 CFR 52.47, 52.79, 52.137, and 52.157, an application for a design certification, combined license, design approval, or manufacturing license, respectively, must include the principal design criteria for a proposed facility. The principal design criteria establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components important to safety; that is, structures, systems, and components that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

- The General Design Criteria (GDC) in Appendix A to 10 CFR Part 50 establish minimum requirements for the principal design criteria for water-cooled nuclear power plants similar in design and location to plants for which construction permits have been issued by the Commission. The General Design Criteria are also considered to be generally applicable to other types of nuclear power units and are intended to provide guidance in establishing the principal design criteria for such other units. The following GDC are of importance to the instrument sensing lines of nuclear power plants:

    - GDC 1, "Quality Standards and Records," requires, in part, SSCs important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

    - GDC 2, "Design Bases for Protection Against Natural Phenomena," requires, in part, structures, systems, and components important to safety to be designed to withstand the effects of natural phenomena to perform their safety functions. GDC-2 further requires that the design bases for these structures, systems, and components reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

    - GDC 13, "Instrumentation and Control," requires, in part, instrumentation to 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, "Protection System Reliability and Testability," requires, in part, the protection system to be designed for high functional reliability and inservice testability commensurate with the safety functions to be performed.

    - GDC 22, "Protection System Independence," requires, in part, the protection system to 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.

    - GDC 24, "Separation of Protection and Control Systems," requires, in part, the protection system to be separated from control systems to the extent that failure of any single control system component or channel, or failure or removal from service of any single protection system component or channel which is common to the control and protection systems leaves intact a system satisfying all reliability, redundancy, and independence requirements of the protection system.

- GDC 55, “Reactor Coolant Pressure Boundary Penetrating Containment,” requires, in part, each line that is part of the reactor coolant pressure boundary and that penetrates the primary reactor containment to 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.

- 10 CFR 50.55a(h) states that protection systems of nuclear power reactors of all types must meet the requirements specified in 10 CFR 50.55a(h), and each combined license for a utilization facility is subject to the conditions in 10 CFR 50.55a(h).

  - 10 CFR 50.55a(h)(2) addresses protection systems, and requires that, for nuclear power plants with construction permits issued after January 1, 1971, but before May 13, 1999, protection systems must meet the requirements in IEEE Std 279–1968, "Proposed IEEE Criteria for Nuclear Power Plant Protection Systems" (Ref. 4), or the requirements in IEEE Std 279–1971, "Criteria for Protection Systems for Nuclear Power Generating Stations" (Ref. 5), or the requirements in IEEE Std 603–1991, "Criteria for Safety Systems for Nuclear Power Generating Stations,” and the correction sheet dated January 30, 1995 (Ref. 6). For nuclear power plants with construction permits issued before January 1, 1971, protection systems must be consistent with their licensing basis or may meet the requirements of IEEE Std. 603–1991 and the correction sheet dated January 30, 1995.

  - 10 CFR 50.55a(h)(3) addresses safety systems, and requires that applications filed on or after May 13, 1999, for construction permits and operating licenses under 10 CFR Part 50, and for design approvals, design certifications, and combined licenses under 10 CFR Part 52, must meet the requirements for safety systems in IEEE Std. 603–1991 and the correction sheet dated January 30, 1995.

Related Guidance

- RG 1.53, “Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems” (Ref. 7), states that IEEE Std. 379-2000, “IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems” (Ref. 8), is an acceptable method to meet the regulations concerning the application of the single-failure criterion to the electrical power, instrumentation, and control portions of nuclear power plant safety systems.

Purpose of Regulatory Guides

The NRC issues RGs to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency’s regulations, to explain techniques that the staff uses in evaluating specific problems or postulated events, and to provide guidance to applicants. RGs are not substitutes for regulations and compliance with them is not required. Methods and solutions that differ from those set forth in RGs 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.

Paperwork Reduction Act

This RG provides guidance for implementing the mandatory information collections in 10 CFR Parts 50 and 52 that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et. seq.). These information collections were approved by the Office of Management and Budget (OMB), under control numbers 3150-0011 and 3150-0151. Send comments regarding this information collection to the

Information Services Branch, (T6-A10M), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by e-mail to Infocollects.Resource@nrc.gov, and to the OMB reviewer at: OMB Office of Information and Regulatory Affairs (3150-0011 and 3150-0151), Attn: Desk Officer for the Nuclear Regulatory Commission, 725 17th Street, NW Washington, DC20503; e- mail: oira_submission@omb.eop.gov.

Public Protection Notification

The NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless the document requesting or requiring the collection displays a currently valid OMB control number.

B. DISCUSSION

Reason for Revision

This revision of RG 1.151 (Revision 2) incorporates new information since the NRC staff last revised the guide in 2010. This information includes (1) endorsement of the latest version of American National Standards Institute (ANSI)/International Society of Automation (ISA) standard ANSI/ISA 67.02.01-2014, "Nuclear Safety-Related Instrument-Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants," (2) identification, but not endorsement, of the International Organization for Standardization (ISO) standard ISO 2186-2007, "Fluid Flow in Closed Conduits—Connections for Pressure Signal Transmissions between Primary and Secondary Elements" (Ref. 9), and (3) a reference to recent operating experience, as described in NRC Information Notice (IN) 2013-12, "Improperly Sloped Instrument Sensing Lines," dated July 3, 2013 (Ref. 10), as it relates to improperly sloped sensing lines. This revision of RG 1.151 (Revision 2) also discusses GDC 2, which was not discussed in Revision 1 but is relevant to this RG because the fluids or gases in sensing lines are required to remain within the temperature ranges necessary to perform their intended functions.

Background

The NRC issued Revision 1 of RG 1.151 in July 2010, which endorsed ANSI/ISA-67.02.01-1999 (Ref. 11) with certain clarifying regulatory positions. ANSI/ISA-67.02.01-1999 provided design, physical protection, and installation requirements for safety-related instrument sensing lines, as well as for sampling lines previously covered by ANSI/ISA-S67.10-1994, "Sample-Line Piping and Tubing Standard for Use in Nuclear Power Plants" (Ref. 12). ANSI/ISA-67.02.01-1999 discussed the pressure boundary requirements for sensing lines up to and including one inch (25.4 mm) outside diameter or three-quarter inch nominal pipe 1.050 inch (26.67 mm) outside diameter. The boundaries of this standard for instrument-sensing lines span from the root valve/piping class change up to but not including the manufacturer-supplied instrument connection. The boundaries of this standard for sampling lines span from the process tap to the upstream side of the sample panel, bulkhead fitting, or analyzer shutoff valve, and include in-line sample probes.

Recent operating experience at U.S. nuclear power plants has shown that improperly sloped instrument sensing lines are contributing to the degradation of safety-related instrumentation operation. In response, the NRC issued IN 2013-12 to address this operating experience, particularly with regard to instrument sensing line sloping issues caused by improper design or installation, including inadequate sensing line slope. The importance of applying related design and installation criteria and providing adequate oversight is emphasized in IN 2013-12.

In 2014, ISA issued ANSI/ISA-67.02.01-2014. The most important changes in ANSI/ISA-67.02.01-2014 were to identify the minimum slope requirements for instrument sensing lines. These changes addressed the issues identified and discussed in NRC's IN 2013-12. This version of the standard also added new figures to address Regulatory Position C.2 in RG 1.151, Revision 1, with respect to containment isolation requirements for water-filled sensing lines that penetrate the containment boundary. It also added information to address Regulatory Position C.4 in RG 1.151, Revision 1, which clarified the potential impacts of noncondensable gases in sensing lines during or following depressurization, and the potential impacts of flashing reference legs. In addition, the revision corrected the technical information in some of the figures included in the 1999 version. Therefore, this revision (Revision 2) of RG 1.151 removes Regulatory Positions C.2 and C.4 that were in Revision 1.

The NRC staff also reviewed ISO 2186-2007 and found that it contains additional technical information and criteria useful for the design, lay-out and installation of a pressure signal transmission system, including minimum instrument sensing line diameter based on the length of long impulse sensing lines. But, this revision (Revision 2) of RG 1.151 does not endorse ISO 2186-2007.

Separately, ANSI/IEEE Std. 622-1987 (reaffirmed in 1994), "IEEE Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Systems" (Ref. 13), provides recommended practices for designing and installing electric heat tracing on systems in nuclear power generating stations. These electric heat tracing systems are applied to both critical process temperature control and process temperature control, in mechanical piping systems that carry borated water, caustic soda, and other solutions. Electric heat tracing systems are also applied to water piping systems 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. Regulatory Position C.2. in this revision (Revision 2) of RG 1.151 clarifies the previous Regulatory Position C.3 that was in Revision 1 regarding the acceptability and use of ANSI/IEEE Std. 622-1987.

Harmonization with International Standards

The NRC staff reviewed guidance from the International Atomic Energy Agency and did not identify any standards that provided guidance to NRC staff, applicants, or licensees, as it relates to the content of this RG. In addition, the NRC staff reviewed guidance from ISO and found that ISO 2186-2007 includes guidance on pipe diameters for long impulse sensing lines and provides useful information for sensing line designs, as discussed above.

Documents Discussed in Staff Regulatory Guidance

This RG endorses, in part, the use of one or more codes or standards developed by external organizations, and other third-party guidance documents. These codes, standards and third-party guidance documents may contain references to other codes, standards or third-party guidance documents ("secondary references"). If a secondary reference has itself been incorporated by reference into NRC regulations as a requirement, then licensees and applicants must comply with that standard as set forth in the regulation. If the secondary reference has been endorsed in a RG as an acceptable approach for meeting an NRC requirement, then the standard constitutes a method acceptable to the NRC staff for meeting that regulatory requirement as described in the specific RG. If the secondary reference has neither been incorporated by reference into NRC regulations nor endorsed in a RG, then the secondary reference is neither a legally-binding requirement nor a "generic" NRC approved acceptable approach for meeting an NRC requirement. However, licensees and applicants may consider and use the information in the secondary reference, if appropriately justified, consistent with current regulatory practice, and consistent with applicable NRC requirements.

C. STAFF REGULATORY GUIDANCE

1. ANSI/ISA-67.02.01-2014 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 RG endorses ANSI/ISA-67.02.01-2014, with the following exceptions and clarifications:

    a. The endorsement of ANSI/ISA-67.02.01-2014 is limited to instrument sensing lines and does not include Section 6, "Sample-Line Fabrication, Routing, Installation, and Protection."

    b. The term "instrument sensing line" used in this guidance applies to the lines, valves, fittings, manifolds, tubing, and piping used to connect instruments to main piping, other instruments, other apparatus, or to measuring equipment.

2. Instrument sensing lines should be designed and maintained to ensure that the fluids or gases in the lines remain within the temperature ranges necessary to perform their intended functions. Should heat tracing be used, the staff considers ANSI/IEEE Std. 622-1987 to be acceptable for the design and installation of these systems.

D. IMPLEMENTATION

The NRC staff may use this regulatory guide as a reference in its regulatory processes, such as licensing, inspection, or enforcement. However, the NRC staff does not intend to use the guidance in this regulatory guide to support NRC staff actions in a manner that would constitute backfitting as that term is defined in 10 CFR 50.109, "Backfitting," and as described in NRC Management Directive 8.4, "Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests," (Ref. 14), nor does the NRC staff intend to use the guidance to affect the issue finality of an approval under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." The staff also does not intend to use the guidance to support NRC staff actions in a manner that constitutes forward fitting as that term is defined and described in Management Directive 8.4. If a licensee believes that the NRC is using this regulatory guide in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfitting or forward fitting appeal with the NRC in accordance with the process in Management Directive 8.4.

REFERENCES[1]

1. American National Standards Institute/Instrument Society of America (ANSI/ISA) 67.02.01-2014, "Nuclear Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants," Washington, DC.[2]

2. Code of Federal Regulations (CFR), "Domestic Licensing of Production and Utilization Facilities," Part 50, Chapter 1, Title 10, "Energy."

3. CFR, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Part 52, Chapter 1, Title 10, "Energy."

4. Institute of Electrical and Electronic Engineers (IEEE) Std 279–1968, "Proposed IEEE Criteria for Nuclear Power Plant Protection Systems," Piscataway, NJ, 1968.

5. IEEE Std. 279-1971, "IEEE Standard: Criteria for Protection Systems for Nuclear Power Generating Stations," Piscataway, NJ, 1971.

6. IEEE Std. 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," Piscataway, NJ, 1991, and the correction sheet dated January 30, 1995.

7. U.S. Nuclear Regulatory Commission (NRC), Regulatory Guide (RG) 1.53, "Application of the Single-Failure Criterion to Safety Systems," Washington, DC.

8. IEEE Std. 379-2000, "IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems," Piscataway, NJ, 2000.

9. International Organization for Standardization (ISO) 2186:2007, "Fluid Flow in Closed Conduits—Connections for Pressure Signal Transmissions between Primary and Secondary Elements," Geneva, Switzerland, 2007.[3]

10. NRC, Information Notice (IN) 2013-12, "Improperly Sloped Instrument Sensing Lines," Washington, DC.

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[1] Publicly available NRC published documents are available electronically through the NRC Library on the NRC's public Web site at http://www.nrc.gov/reading-rm/doc-collections/ and through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. The documents can also be viewed online or printed for a fee in the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD. For problems with ADAMS, contact the PDR staff at 301-415-4737 or (800) 397-4209; fax (301) 415-3548; or e-mail pdr.resource@nrc.gov.

[2] Copies of American National Standards Institute (ANSI) standards may be purchased from ANSI, 1819 L Street, NW, Washington, DC 20036, on the ANSI Web site at http://websotre.ansi.org/, via telephone (202) 293-8202, fax (202) 293 293-9287, or e-mail storemamager@ansi.org.

[3] Copies of International Organization for Standardization (ISO) documents may be obtained by writing to the International Organization for Standardization, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Telephone: +41 22 749 01 11, Fax: +41 22 749 09 47, by E-mail at sales@iso.org, or on-line at the ISO Store Web site: http://www.iso.org/iso/store.htm.

11. ANSI/ISA-67.02.01-1999, "Nuclear Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants," Washington, DC, 1999.

12. ANSI/ISA-S67.10-1994, "Sample-Line Piping and Tubing Standard for Use in Nuclear Power Plants," Washington, DC, 1994.

13. IEEE Standard (Std.) 622-1987, "IEEE Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Systems," Piscataway, NJ, reaffirmed in 1994.[4]

14. NRC, Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection," Washington, DC.

[4] Copies of Institute of Electrical and Electronics Engineers (IEEE) documents may be purchased from the IEEE Services Center, 455 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855 or IEEE's Web site at http://www.ieee.org.publications_standards/index.