U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH

December 2008
Division 1

DRAFT REGULATORY GUIDE

Contact: K. Nguyen
(301) 251-7453

DRAFT REGULATORY GUIDE DG-1178

(Proposed Revision 1 of Regulatory Guide 1.151, dated July 1983)

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 Commission's regulations with regard 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 provide adequate connection 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, Part 100, "Reactor Site Criteria," of the *Code of Federal Regulations* (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, including but not limited to the general design criteria (GDC) of 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, "Quality Standards and Records," requires that structures, systems, and components

---

This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received final staff review or approval and does not represent an official NRC final staff position.

Public comments are being solicited on this draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rulemaking, Directives, and Editing Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; emailed to nrcrep.resource@nrc.gov; submitted through the NRC's interactive rulemaking Web page at http://www.nrc.gov; faxed to (301) 415-5144; or hand-delivered to Rulemaking, Directives, and Editing Branch, Office of Administration, US NRC, 11555 Rockville Pike, Rockville, Maryland 20852. Between 7:30 a.m. and 4:15 p.m. on Federal workdays. Copies of comments received may be examined at the NRC's Public Document Room, 11555 Rockville Pike, Rockville, MD. Comments will be most helpful if received by February 6, 2009.

Electronic copies of this draft regulatory guide are available through the NRC's interactive rulemaking Web page (see above); the NRC's public Web site under Draft Regulatory Guides in the Regulatory Guides document collection of the NRC's Electronic Reading Room at http://www.nrc.gov/reading-rm/doc-collections/; and the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under Accession No. ML080510453.

important to safety be designed and installed to quality standards commensurate with the importance-to-safety of the functions to be performed. GDC 13, "Instrumentation and Control," requires that instrumentation be provided to monitor variables and systems to assure adequate safety. GDC 24, "Separation of Protection and Control Systems," 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, "Reactor Coolant Pressure Boundary Penetrating Containment," requires, in part, that each line that is part of the reactor coolant pressure boundary and that penetrates the primary reactor containment shall 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 Nuclear Power Plant Protection 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.

The NRC issues regulatory guides 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 accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required.

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

Background

Committee SP67.02 of the Instrument Society of America (ISA) prepared American Nuclear Standards Institute (ANSI)/ISA-S67.02.01-1999, "Nuclear Safety-Related Instrument-Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants" (Ref. 4). On December 9, 1974, this committee received an approved scope and project, Charter N677, from ANSI. ISA approved ANSI/ISA-S67.02.01-1999 on November 15, 1999, following approval by the ISA Standards and Practices Board on July 15, 1999. The standard provides design, physical protection, and installation requirements for instrument sensing lines and sampling lines for nuclear power plant applications. The standard 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 supplementary portions of the regulatory position of Regulatory Guide 1.151, Revision 0, "Instrument Sensing Lines," issued July 1983, have now been included in the updated ANSI/ISA-S67.02.01-1999 and, consequently, are no longer needed.

The Power Generation Committee of the Institute of Electrical and Electronics Engineers (IEEE) Power Engineering Society developed IEEE Std 622-1987, "Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Stations" (Ref. 5), 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 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 sensing lines have affected measured water levels in operating boiling-water reactors (BWRs). Concern over these events has resulted in staff guidance to ensure that plants are operated safely and conservatively. The potential problem is that dissolved gases can evolve in the reference leg for level measurements in the reactor vessels of BWRs as the solubility of the gases decreases during depressurization. Such gases can be trapped in the 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. 6), 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 (CRD) 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. 7), reported on several potential design problems with the retrofit backfill system by which a single failure in the backfill system would lead to a severe transient. The design measures that respond to this potential problem 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 sensing lines:

- GDC 13 (in Appendix A of Part 50) 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, "Protection System Reliability and Testability" (in Appendix A of Part 50), states, "The protection system shall be designed for high functional reliability commensurate with the safety function to be performed."
- GDC 22, "Protection System Independence" (in Appendix A of Part 50), 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, do not result in loss of the protection function."
- 10 CFR 50.55a(h)(2), "Protection systems," requires that protection systems for plants with construction permits issued after January 1, 1971, but before May 13, 1999, meet the requirements stated in either IEEE Std 279, "Criteria for Protection Systems for Nuclear Power Generating Stations," or in IEEE Std 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations" (Ref. 8).

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

- Level-sensing instrumentation may not accurately monitor reactor vessel water level 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.
- Section 5.5, "System Integrity," of IEEE Std 603-1991 states: "The safety system shall be designed to accomplish their safety function under the full range of applicable conditions enumerated in the design basis." While Section 4.20 of IEEE Std 279-1971 (Ref. 9) 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." However, using this approach, the water level instrumentation for the reactor vessel may not be accurate during and following normal depressurization and rapid depressurization.

C. REGULATORY POSITION

The requirements of ANSI/ISA-S67.02.01-1999 provide a basis acceptable to the NRC staff for designing and installing safety-related instrument sensing lines in nuclear power plants subject to the following:

1. The endorsement of ANSI/ISA-S67.02.01-1999 is limited to instrument sensing lines and does not include Section 6, "Sample-Line Fabrication, Routing, Installation, and Protection." The original ANSI/ISA-S67.01 covered only sensing lines, while ANSI/ISA-S67.10 addressed sampling lines. The revised standard combines the two. This regulatory guide addresses only the sensing line guidance.

2. Root valve and accessible isolation valves shall be provided, unless it can be demonstrated that the containment isolation provisions for sensing lines are acceptable on some other defined basis. The root valve and accessible isolation valve may be the same valve if the arrangement meets all other requirements for isolation and accessibility. Figures 1 through 6 of ANSI/ISA-S67.02.01-1999 show sketches depicting root valve and accessible isolation valve locations. Although not specifically addressed in the standard's Section 4.2, "Mechanical Design Requirements for Sensing," these drawings and guidance are applicable to sensing lines. The provision for root valves and access is derived from GDC 55.

3. The requirements of 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. Provisions shall be made to mitigate the potential effects of trapped, evolved gases in sensing lines during or following depressurization events 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 draft regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. The NRC will consider all public comments received in development of the final guidance document. In some cases, applicants or licensees may use proposed or previously established acceptable alternative methods 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.

REGULATORY ANALYSIS

1. Statement of the Problem

The current revision of Regulatory Guide 1.151 (Revision 0), issued July 1983, is based on ANSI/ISA-S67.02, issued in 1973. A number of reactor events occurring between 1973 and 1983 led to supplementary guidance in Revision 0 of the regulatory guide for concerns not addressed in the ISA standard. The current revision of the standard, ANSI/ISA-S67.02.01-1999, includes all the supplementary guidance, thus obviating the need for most of the current supplementary guidance in the regulatory position.

The revised standard, ANSI/ISA-S67.02.01-1999, also includes guidance regarding sampling lines that was previously included in a separate standard. Regulatory Guide 1.151 only applies to sensing lines, so this change must be addressed.

Additional events have occurred since 1983 that warrant supplementary guidance in the regulatory position that the current ANSI/ISA standard does not include. One is the issuance of NRC Bulletin 93-03 regarding evolved gas in liquid reference legs following depressurization events.

IEEE Std 622-1987 was issued, and is applicable to sensing lines.

2. Objective

The objective of this regulatory action is to review the new ISA standard, reactor operating history, and regulatory basis to determine if any changes should be made to Regulatory Guide 1.151, Revision 0.

3. Alternative Approaches

The NRC staff considered the following alternative approaches:

- Do not revise Regulatory Guide 1.151.
- Update Regulatory Guide 1.151.

3.1 Alternative 1: Do Not Revise Regulatory Guide 1.151

Under this alternative, the NRC would not revise this guidance, and the original version of this regulatory guide would continue to be used. This alternative is considered the baseline or "no action" alternative and, as such, involves no value/impact considerations. If chosen, this alternative would result in referencing an industry standard that is no longer supported and made available by ISA.

3.2 Alternative 2: Update Regulatory Guide 1.151

Under this alternative, the NRC would update Regulatory Guide 1.151, taking into consideration the content of the revised standard ANSI/ISA-S67.02.01-1999 and the events in operating reactors and

additional standards that are applicable to sensing lines. The four position statements in the draft of the revised standard may be considered individually for inclusion in the approved version without affecting inclusion of the others.

One benefit of this action is that it would enhance reactor safety by addressing the most current ANSI/ISA and IEEE standards on safety systems endorsed by the NRC.

A further review of regulatory guidance that references sensing lines or Regulatory Guide 1.151 finds that there are direct references to material in the regulatory positions of the current regulatory guide. The revised regulatory guide now notes that this material is included in ANSI/ISA-S67.02.01-1999. The staff would also have to update these references in the standard review plan and elsewhere.

The costs to the NRC would be the one-time cost of issuing the revised regulatory guide (which is expected to be relatively small), and applicants would incur little or no cost. The staff would also need to revise the other regulatory documents that reference materials in the previous version of the regulatory guide or the previous referenced standard.

4. Conclusion

Based on this regulatory analysis, the staff recommends that the NRC revise Regulatory Guide 1.151. The staff concludes that the proposed action will enhance reactor safety by referencing the latest ANSI/ISA and IEEE standards on safety systems endorsed by the NRC. It could also lead to cost savings for the industry, especially with regard to applications for standard plant design certifications and combined licenses.

REFERENCES

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 Nuclear Power Plant Protection Systems," U.S. Nuclear Regulatory Commission, Washington, DC.

4. ANSI/ISA-S67.02.01-1999, "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.

5. 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.

6. 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.

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

8. 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).

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

10. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC.