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Nuclear Safety-Related Instrument-Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants

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for Use in Nuclear Power Plants

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Preface

This preface, as well as all footnotes and annexes, is included for information purposes only and is not part of the revised ANSI/ISA-67.02.01-2021. The 1999 revision incorporated ISA-S67.10, *Sample Line Piping and Tubing Standard for Use in Nuclear Power Plants*. Applicability of other standards or codes is as stated in the text. Where references are made to other standards, a particular paragraph reference is indicated for clarity where applicable. The 2021 revision made minor changes to the 2014 revision. Clarifications were made to considerations for gaseous and particulate effluent monitoring in 6.1.1, using ANSI/HPS N13.1 for guidance. The 2014 revision made minor changes to the 1999 revision. The figures were redrafted to clarify sensing lines from governing ASME codes, and sensing line slopes requirements were clarified with respect to liquid and gas service. Two figures were added that are applicable to containment monitoring. The minimum slope recommendation for sensing lines was revised.

This revised document has been prepared as part of the service of ISA, the International Society for Automation, toward a goal of uniformity in the field of instrumentation. To be of real value, this document should not be static but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms and asks that they be addressed to the Secretary, Standards and Practices Board; ISA; 67 T.W. Alexander Drive; P. O. Box 12277; Research Triangle Park, NC 27709; Telephone (919) 549-8411; Fax (919) 549-8288; E-mail: standards@isa.org.

ISA Committee SP67.02 formed in 1974, adopted its draft scope on 19 September 1974, and forwarded it to the ISA Standards and Practices Board for acceptance as part of the minutes of that meeting. On 9 December 1974, this committee received an approved Scope and Project, Charter N677, from the American National Standards Institute (ANSI).

It is the consensus of the committee that this document addresses those portions of the safety-related, instrument-sensing line and sampling tubing (piping) runs that are unique to the nuclear power plant, concentrating therefore on meeting nuclear safety considerations as legislated by 10 CFR 50 (Code of Federal Regulations), Appendix A General Design Criteria for Nuclear Power Plants. The separation of redundant sensing lines as contained in this document is predicated on the assumption that the equipment and instruments to which those sensing lines are connected are adequately separated.

The ISA Standards and Practices Department is aware of the growing need for attention to the metric system of units in general, and the International System of Units (SI) in particular, in the preparation of instrumentation standards, recommended practices, and technical reports. The Department is further aware of the benefits to USA users of ISA standards of incorporating suitable references to the SI (and the metric system) in their business and professional dealings with other countries. Toward this end, this Department will endeavor to introduce SI-acceptable metric units in all new and revised standards, recommended practices, and technical reports to the greatest extent possible. IEEE/ASTM SI 10, *American National Standard for Metric Practice*, and future revisions, will be the reference guide for definitions, symbols, abbreviations, and conversion factors.

Where the failure of instrument-sensing lines from nuclear safety-related processes to instruments that are not nuclear safety-related is demonstrated not to produce either unacceptable leakage of process fluid or unacceptable flooding, jet impingement forces or other failure-related hazards to nuclear safety-related equipment, this document does not apply.

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1 Scope

This standard covers design, protection, and installation of nuclear safety-related instrument-sensing lines and sampling lines for nuclear power plants. The standard covers 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.

2 Purpose

This standard establishes the applicable code requirements and code boundaries for the design and installation of instrument-sensing lines interconnecting nuclear safety-related power plant processes with both nuclear safety-related and nonnuclear safety-related instrumentation. This standard also establishes the applicable requirements and limits for the design and installation of sample lines interconnecting nuclear safety-related power plant processes with sampling instrumentation. This standard addresses the pressure boundary integrity of an instrument-sensing line and sampling line in accordance with the appropriate parts of Section III, *Boiler and Pressure Vessel Code*, American Society of Mechanical Engineers (ASME) or ASME B31.1, as applicable, and the assurance that the safety function of the nuclear safety-related instruments and process sampling is available.

3 Definitions

3.1 accessible isolation valve:

the isolation valve nearest the measured process on an instrument-sensing line, which is available to personnel during normal plant operation. The root valve may or may not perform the function of the accessible isolation valve, depending on its location.

3.2 backflush:

the injection of a fluid from the instrument location toward the process connection to remove line fluid or obstructions.

3.3 flush:

the injection of a fluid into the line at an upstream point to remove line fluid from the downstream line.

3.4 grab-sample point:

the point in the sample line where the flow of sample fluid can be directed to a portable container. It may be referred to as "sample point."

3.5 inaccessible area:

an area for which the radiation level precludes personnel entry during power operations and other operational situations. These areas typically are indicated by "zones," which depict accessibility based on various plant evolutions.

3.6 instrument channel:

a collection of instrument loops, including their sensing lines, that may be treated or routed as a group while being separated from instrument loops assigned to other redundant groups.

3.7 instrument shutoff valve:

the valve or valve manifold nearest the instrument.

3.8 loop:

a combination of one or more interconnected instruments arranged to measure and/or control a process variable.

3.9 main-line class:

a term used to specify the pressure and temperature ratings, the material from which it is constructed, and the appropriate code, such as ANSI B31.1.

3.10 nonnuclear safety-related (NNS):

any instrument not included in nuclear safety-related (3.11).

3.11 nuclear safety-related (NSR):

that which is essential to the following:

- a) Provide emergency reactor shutdown
- b) Provide containment isolation
- c) Provide reactor core cooling
- d) Provide for containment or reactor heat removal
- e) Prevent or mitigate a significant release of radioactive material to the environment or is otherwise essential to provide reasonable assurance that a nuclear power plant can be operated without undue risk to the health and safety of the public
- f) Provide for maintaining safe shutdown condition

Where the term "Nuclear Safety-Related" is used in this standard, it refers to meeting the requirements of Title 10, Part 50, *Code of Federal Regulations* (10 CFR 50), Appendix A.

3.12 purge:

the action of increasing the sample flow above normal for the purpose of replacing current sample-line fluid or removing deposited or trapped materials.

3.13 reach rod:

a valve extension mechanism used to provide for manual operation of valves that are inaccessible.

3.14 redundant sensing line(s):

sensing lines for redundant instruments as used in this standard are defined as a sensing line or group of lines that are provided to duplicate the function of another sensing line; e.g., sensing lines that transfer pressure energy for measurement of the same pressure energy for the same process.

3.15 root valve:

the first valve located on the instrument-sensing/sample line after it taps off the main process.

3.16 sample isolation valve:

the valve nearest the instrument, grab-sample point, or in-line component that is available to personnel during normal plant operation to isolate them from the process. The root valve may or may not perform the function of the isolation valve, depending on its location.

3.17 sample lag time:

an interval of time between the initiation of a discrete sample (particle, molecule, or atom) from the sample tap to termination at a specific volumetric flow rate through the sample line.

3.18 sample line:

a piping and/or tubing system that removes fluid from a process either continuously or periodically for the purpose of determining the constituents or the physical properties of the process fluid. The sample line begins at the process tap or nozzle used for sampling and terminates where the flow of sample fluid ends as a discrete and controlled entity.

3.19 sample sink:

an installed device with controlled drainage and/or ventilation at which a grab sample may be obtained.

3.20 sample tap:

the point where the sample line taps into the process line (pipe, duct, container) and the point where sample flow begins. It may also be referred to as "sample connection," "sample nozzle," or "process tap."

3.21 sample vessel:

an integrally valved, portable sample container designed to obtain pressurized samples at process pressure.

3.22 sensing line:

for the purpose of this standard, a pipe or tube or both of relatively static fluid that connects the process being sensed to the sensor (transducer).

4 Pressure boundary and mechanical design requirements

4.1 Summary of requirements for sensing lines

Tables 1 and 2 summarize the minimum pressure boundary and mechanical design requirements for nuclear safety-related instrument-sensing lines utilized in nuclear power plants. Table 1 applies to instrument-sensing lines that do not penetrate the primary reactor containment, and Table 2 applies to instrument-sensing lines that penetrate the primary reactor containment.

Tables 1 and 2 are divided into four columns. Column 1 refers the user to the applicable figure(s) that graphically show the mechanical design requirements specified in columns 2, 3, and 4. The figure referenced in column 1 also indicates the pressure boundary scope of this standard. Column 2 indicates the process system code classification. Column 3 indicates the instrument-sensing line seismic category. Where more than one seismic category is listed, the seismic category change is shown on the figure(s) referenced in column 1. Column 4 indicates the applicable design code for the instrument-sensing line.

4.2 Mechanical design requirements for sensing lines

The design of components, parts, and appurtenances utilized in the instrument-sensing lines under the scope of this standard shall, as a minimum, be in accordance with the design code(s) specified in column 4 of Tables 1 and 2. Figures 1 through 8 illustrate typical applications of these requirements.

4.2.1 Instrument-sensing and sample lines in accordance with ANSI B31.1 power piping

Where ASME B31.1 is required by this standard in Clause 4, the user shall comply with ASME B31.1, paragraph, 122.3 requirements for materials, design, fabrication, examination, and testing.

Where instrument-sensing lines identified as ASME B31.1 are interconnected with process piping systems classified as ASME Section III Class 1, 2, or 3 and are identified as Seismic Category I in Tables 1 and 2, the following additional requirements shall apply:

- a) A material manufacturer's certificate of compliance with the material specification shall be furnished for all pressure boundary items.
- b) All pressure boundary items shall be pressure tested in accordance with the applicable ASME Code.
- c) Design and service limits for lines identified as ASME B31.1 and Seismic Category I by this standard shall be in accordance with ASME B31.1, paragraph 104.8. Movements due to earthquakes and other transient dynamic loading shall be included.
- d) The connection between ASME Section III and ASME B31.1 components shall be in accordance with ASME Section III.

4.2.2 Media isolation devices, bellows or diaphragms, and permanently filled capillaries

This subclause applies principally to capillary instrumentation that is furnished preassembled by the instrument manufacturer, but also may apply to field fabricated assemblies.

4.2.2.1 Bellows or diaphragms

Where bellows or diaphragms are identified as ASME B31.1 by this standard, these devices shall be designed in accordance with ASME B31.1, paragraph 104.7. The requirements of 4.2.1 of this standard shall also apply.

4.2.2.2 Permanently filled capillary tubes

Where permanently filled capillary tubes are identified as ASME B31.1 by this standard, the pressure design and minimum wall thickness shall be established in accordance with ASME B31.1, or the pressure design shall be established by proof tests in accordance with ASME Section I, paragraph A-22.

4.2.2.3 Pressure testing

Each permanently filled capillary tube and media isolation device shall be pressure tested in accordance with the applicable ASME Code.

4.2.2.4 Fill fluid

The fill fluid used shall not shorten the life of or prevent the piping or tubing wetted parts from performing their required functions. Mercury shall not be used as a fill fluid.

Table 1 — Minimum mechanical design requirements for instrument piping and tubing that do not penetrate the primary reactor containment

Illustration	Process Piping ASME Code Class	Instrument-Sensing Line Seismic Category	Applicable Design Code as invoked by this standard in Clause 4
Figure 1 a & b			
Instrument sensing lines for water, gas, or steam services ASME Section III Class 1 and 2 processes	1 and 2	Category I	ASME III, Class 2 and ASME B31.1
Figure 2 a & b			
Instrument sensing lines for water, gas, or steam services ASME Section III Class 3 process	3	Category I	ASME III, Class 3 and ASME B31.1
Figure 3			
Instrument sensing lines for water, gas, or steam service non-safety process connected to nuclear safety-related instrument	N/A	Category I	ASME B31.1

NOTE 1 This table and associated figures do not contain physics of application or containment isolation requirements.

NOTE 2 See referenced figure(s) for seismic category and design-code boundaries.

Table 2 — Minimum mechanical design requirements for instrument piping and tubing that penetrate the primary reactor containment

Illustration	Process Piping ASME Code Class	Instrument-Sensing Line Seismic Category	Applicable Design Code as invoked by this standard in Clause 4
Figure 4			
Containment atmosphere instrument sensing lines, instruments outside containment	N/A	Category I	ASME Section III, Class 2 and ANSI B31.1
Figure 5			
Containment atmosphere instrument sensing lines, capillary-filled instruments outside containment	N/A	Category I	ASME Section III, Class 2 See section 4.2.2
Figure 6			
Containment atmosphere instrument sensing lines, diaphragm with filled instruments outside containment	N/A	Category I	ASME Section III, Class 2 See section 4.2.2
Figure 7 & 8			
Instrument sensing lines with condensing pot inside containment and instruments outside containment	1	Category I	ASME Section III, Class 1 and ASME Section III, Class 2

NOTE 1 This table and associated figures do not contain physics of application or containment isolation requirements.

NOTE 2 See referenced figure(s) for seismic category and design-code boundaries.

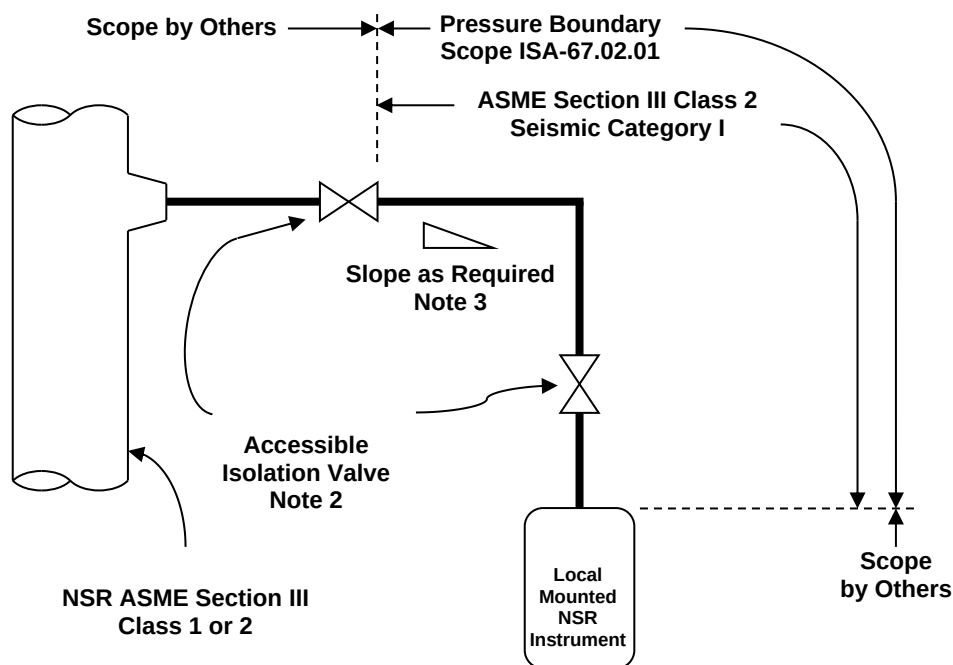


Figure 1a – NSR Instrument Installation

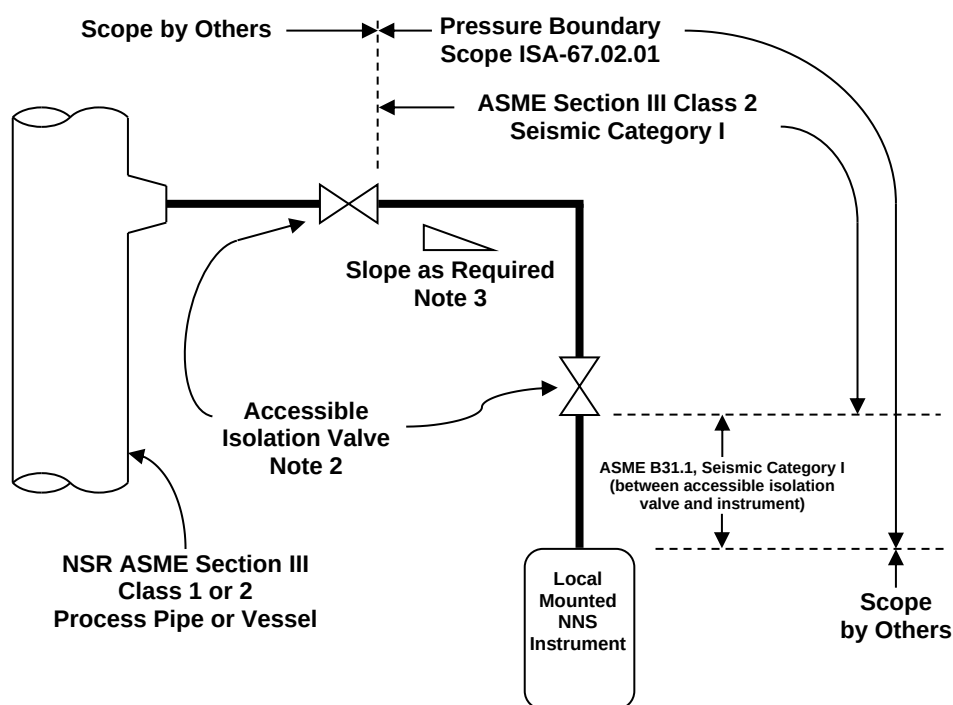


Figure 1b – NNS Instrument Installation

Figures 1a & 1b – Instrument-sensing lines for water, gas, or steam services ASME Section III Class 1 or 2 processes

NOTE See notes for Figures 1 through 8.