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Sample-Line Piping and Tubing Standard for Use in Nuclear Power Plants

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

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Preface

This preface and the appendix referring to other standards and codes are included for informational purposes only and are not part of ISA-S67.10. Applicability of referenced standards and codes is as stated in the text of this standard. Where reference is made to a standard or code, a particular paragraph is indicated for clarity, as applicable.

This standard has been prepared as part of the service of ISA 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 Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709, Telephone (919) 549-8411, e-mail: standards@isa.org.

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 as optional alternatives to English units in all new and revised standards to the greatest extent possible. *The Metric Practice Guide,* which has been published by the Institute of Electrical and Electronics Engineers as ANSI/IEEE Std. 268-1992, and future revisions will be the reference guide for definitions, symbols, abbreviations, and conversion factors. SI (metric) conversions in this standard are given only to the precision intended in selecting the original numerical value. When working in the SI units, the given SI value should be used; when working in customary U.S. units, the given U.S. value should be used.

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ISA Committee SP67.10 was formed in October 1978, after approval of its purpose and scope by the ISA Standards and Practices Board. Approval of the project charter was granted by the American National Standards Institute (ANSI) on March 18, 1981.

The intent of this standard is to provide criteria for the design and installation of lines through which liquid or gaseous samples flow. This standard has been developed to complement ISA - S67.01 and S67.02, which address instrument installation and sensing lines, respectively. S67.10 is now the responsibility of the S67.02 Subcommittee. Only editorial changes were made in this revision. The next revision of this standard will be incorporated into S67.02.

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1 Scope

This standard covers design, protection, and installation of sample lines for light-water-cooled nuclear power plants and the pressure boundary requirements for piping and tubing. The boundaries of this standard 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 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 maintenance of the pressure boundary integrity of a sample line (in accordance with the appropriate parts of the American Society of Mechanical Engineers [ASME], *Boiler and Pressure Vessel Code*, Section III or American National Standards Institute [ANSI] B31.1* as applicable and provides assurance that the protection function of nuclear safety-related sample instruments is available.

3 Definitions and terminology

3.1 backflush: The injection of a fluid in a reverse flow manner to remove sample-line fluid or obstructions.

3.2 channel: A collection of instrument loops, including their sample lines, which may be treated or routed as a group while being separated from instrument loops assigned to other redundant channels. (See ANSI/ISA-S67.02-80.)

3.3 flush: The injection of a fluid into the sample line at an upstream point to remove sample 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 instrument: For the purpose of this standard, the device that performs some analysis of the sample fluid and for which a sample line is required and connected. Also referred to as "analyzer" or "monitor."

*The titles of standards referenced within are listed in Appendix A.

3.6 instrument shutoff valve: The valve or valve manifold of the sample line located nearest the instrument. Also referred to as "component isolation valve."

3.7 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 the instrument from the process. The root valve may or may not perform the function of the isolation valve, depending on its location.

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

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 Nuclear Safety-Related (NSR): Activation or control of systems or components that are essential to emergency reactor shutdown, containment isolation, reactor core-cooling, and containment and reactor heat removal, or are otherwise essential in preventing or mitigating a significant release of radioactive material to the environment, or are otherwise used to provide reasonable assurance that a nuclear power plant can be operated without undue risk to the health and safety of the public.

3.11 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.

3.12 reach rod: A valve extension mechanism used to provide for manual operation of valves which are inaccessible.

3.13 root valve: The first valve located in a sample line after it taps off the process. It is typically located in close proximity to the sample tap. (See ANSI/ISA-S67.02.80.)

3.14 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.

3.15 sample sink: An installed device with controlled drainage and/or ventilation at which a grab sample may be obtained.

3.16 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."

3.17 sample vessel: An integrally valved, portable sample container designed to obtain pressurized samples at process pressure.

3.18 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.

4 Pressure boundary and mechanical design requirements

4.1 General

4.1.1 All sample pressure boundary connections, tubing, piping, fittings, valves, and in-line sampling devices and equipment shall be in accordance with the requirements of ASME Section III, the requirements of ANSI B31.1, and as described in this standard. Additional installation requirements are made by ASME Performance Test Codes PTC 19.2 and 19.11 and ASTM Standard D1192 for water and steam sampling. Additional installation requirements are made by ANSI N13.1 for airborne radioactive materials sampling.

4.1.2 Sample-line classifications are derived from the process (source) pipe class. ASME Section III classes or other standards defined for the process pipe are matched in the sample line up through and including the root valve or other device(s) that permit a change of the code classification. ISA-S67.02 provides guidance in the determination of code classification.

4.1.3 Sample lines shall meet, as a minimum, ANSI B31.1 requirements from the root valve until sample-line termination up through the last in-line grab-sample isolation and/or throttling valve.

4.1.4 All lines classified as "ASME Section III" shall be designed and classified as "Seismic Category 1." Seismic Category 1 may apply to other classifications (see ANSI B31.1). It is the responsibility of the plant owner to establish the Seismic Category 1 applicability on a case-by-case basis.

4.1.5 Attachments to ASME Code equipment shall conform to the requirements of the ASME Code. For non-Code attachment or assembly, the weld shall be shown to have a stressed cross section sufficient to support the maximum design loads without exceeding allowable stresses.

4.2 Mechanical design

The design of components, parts, and appurtenances utilized in the instrument sample lines under the scope of this standard shall be, as a minimum, in accordance with the stipulated design codes specified in this section.

4.2.1 Sample lines in accordance with ASME Section III

Where ASME *Boiler and Pressure Vessel Code* Section III requirements are identified as applicable by the standard, they shall apply to design, materials, fabrication, examination, testing, marking, stamping, and documentation of the sample line and all components included in the sample line.

Design and service limits for instrument sampling lines identified as ASME Class 1, 2, or 3 and Seismic Category 1, by this standard, shall be in compliance with ASME Section III. Moments due to earthquakes and other transient dynamic and static loadings shall be included.

ASME Class 1: Where instrument sampling lines are identified as ASME Class 1 by this standard, the applicable requirements of ASME Section III, Subsections NCA and NB, shall apply.

ASME Class 2: Where instrument sampling lines are identified as ASME Class 2 by this standard, the applicable requirements of ASME Section III, Subsections NCA and NC, shall apply.

ASME Class 3: Where instrument sampling lines are identified as ASME Class 3 by this standard, the applicable requirements of ASME Section III, Subsections NCA and ND, shall apply.

4.2.2 Sample lines in accordance with ANSI B31.1

Where ANSI B31.1 *Power Piping Code* requirements are identified as applicable by this standard, they shall comply with ANSI B31.1, with respect to materials, design, fabrication, examination, and testing.

The Quality Assurance Program requirements that are implemented should provide control over activities affecting quality to the extent consistent with the importance to safety of the sample lines.

Where instrument sample lines identified as ANSI B31.1 are interconnected to process piping systems classified as ASME Class 1, 2, or 3 and are identified as Seismic Category 1, the following additional requirements shall apply:

1) A material manufacturer's certificate of compliance with the material specification shall be furnished for all pressure boundary items.

2) All pressure boundary items shall be pressure-tested in accordance with ANSI B31.1.

3) Design and service limits for instrument sample lines identified as ANSI B31.1 and Seismic Category I by this standard shall be in accordance with ANSI B31.1.

4) The connection between ASME Section III and ANSI B31.1 components shall be in accordance with ANSI B31.1.

4.2.3 Temperature and pressure design

A sampling line and all its associated wetted parts shall be suitable for use at the design temperature and the design pressure of the process system from which the sample is drawn, except as follows:

1) If a reliable means of cooling is provided, the sample system downstream of the cooler may be designed to the lowest reduced temperature.

2) If a reliable means of pressure reduction is provided, the sampling system downstream of the pressure-reduction means may be designed to the lowest reduced pressure.

A "reliable means" denotes a method that satisfies the single-failure criterion. For temperature, a passive cooling device, such as a length of pipe of suitable design transferring heat to the atmosphere, may serve. For pressure, a fixed-restriction orifice, though passive, if used alone is not acceptable. For temperature reduction and pressure reduction, active devices may be used provided that safeguard instrumentation is provided to protect the sample system in the event of failure of the active device.

4.2.4 Sample cooler design

Sample coolers, heat exchangers, and associated pressure boundary equipment for sampling shall conform to the following applicable requirements:

1) American Society of Mechanical Engineers (ASME), Section VIII of the *Boiler and Pressure Vessel Code*;

2) American Society for Testing and Materials (ASTM), D1192; and

3) Tubular Exchanger Manufacturers Association (TEMA), Standards.

4.2.5 Sample-line diameter sizing

Line size should be based on process requirements such as pressure and temperature, flow and fluid state, and installation requirements such as mechanical support strength and routing. To assist in the design of diameter sizing, the following should be considered and documented.

4.2.5.1 Small [less than or equal to 3/4-inch (19 mm) nominal pipe size] sample lines provide advantages where space is limited and routing is complex. Due to the low mass, small sample lines provide an advantage where rapid cooling or heating of the line is required, and their low internal volume minimizes radioactive shielding. Small sample lines may also reduce class requirements in ASME Section III applications.

4.2.5.2 Large [greater than 3/4-inch (19 mm) nominal pipe size] sample lines provide high mechanical strength and large flow capabilities for viscous or particulate containing fluid. The increased mass provides an advantage where slow cooling or heating of the line is required.

4.2.6 Restriction orifices

Restriction orifices may be installed in sample lines as a passive flow-limiting device. Such devices should not be installed in applications where constituents of the sample flow may collect and release from the restriction. Restriction orifices may be used to change the Code classification of the sample line by limiting maximum sample flow should the sample line break. (For the use of a restriction orifice as a class break device, see ANSI/ISA-S67.02.)

The application of orifices for the purpose of downgrading the classification of a system shall be in concert with the other design considerations necessary to allow this action.

It is recommended that wherever practical the restriction orifice be installed as close as possible to the process piping. Restriction orifices shall not be used where fluid may plug the orifice bore and should not be utilized where accumulation of radioactive particles is possible.

5 Fabrication, routing, installation, and protection

5.1 General

5.1.1 Sample lines and components shall be fabricated, routed, installed, and protected in the most efficient manner possible in accordance with this standard and related documents. (See Appendix A.)

5.1.2 Sample lines shall be as short as practical, consistent with design requirements and personnel safety. Sample lines shall have no unnecessary in-line components and shall have as few taps and dead legs as practical, consistent with required function.

5.1.3 Lag times should be as short as practical, as determined by the requirements of the sample. The desired sample time can be obtained by adjusting the flow rate and by proper choice of the sample line I.D.

5.1.4 Sample lines shall be protected against mechanical loads; otherwise, additional wall thickness or support may be required for mechanical strength.

5.1.5 Any permanent taps, piping, and tubing provided for testing or calibration shall comply with this standard.

5.1.6 Where samples are being taken to measure particulates or other impurities that are expected to stratify, a multi-port-type sampling tap extending across the pipe diameter should be provided. Further, sample-flow rates should be adjusted so that fluid velocity through the sample nozzles is the same as that which exists in the process lines (isokinetic sample rate).

The isokinetic sample rate normally should be adjusted for the flow rate expected at 100 percent load.

Where isokinetic sampling is required, it is important that there be sufficient upstream straight run ahead of the sample tap to assure a stable, predictable flow profile across the line. Straight-run requirements vary with the upstream configuration.

5.1.7 When sampling water, samples should be taken at a point where the fluid is turbulent. If one of the constituents to be measured is considerably heavier than water, or if there is two-phase flow, the points where centrifugal action may cause concentration of any constituents shall be avoided. (Water samples do not present much of a problem where the flow rate assures turbulent flow.) A Reynolds number of 4000 or greater is usually considered sufficient to assure turbulent flow, although there is some variation depending on pipe size and wall roughness. Even with turbulent flow, the sample should be taken at a distance from the pipe wall (to avoid sampling a stagnant wall film).

5.1.8 In non-radioactive sample lines, the sample-line length should be kept to a minimum for applications where dissolved solids or suspended particulates are the constituent of interest in the sample. Local grab-sample points shall be as close to the process-sampling connection as practical.

5.2 Selection of piping versus tubing

Tubing is generally preferred over piping because of lower initial cost and greater ease of handling. However, piping should be used in the following cases:

1) Where rigidity is required, as for line-mounted instruments that generally do not have other means of supports; and

2) Where required as follows:

   a) To permit welding austenitic steel to ferritic steel, utilizing a dissimilar weld process or dissimilar metal transition joint; and

   b) To avoid overstressing tubing under the design conditions of pressure and temperature, where tubing of greater wall thickness does not meet design requirements and/or exceeds tubing fitting manufacturer recommendations.

Wherever practical, stainless steel tubing should be used for sample lines. Except where rigidity is required, tubing of main-line material and of suitable strength may be substituted for main-line class piping.

5.3 Assembly

Sample lines shall be assembled using approved methods as required by codes, standards, and manufacturers' recommendations. Moisture, dirt, and other foreign material shall be cleaned from the sample-line interior.

5.3.1 Welding

Welding procedures and welding performance qualifications shall be in accordance with the latest edition and addenda of ASME Section IX at the time of qualification. Filler materials used for qualification and/or installations shall meet the requirements of ASME Sections IX and XI, Part C, as applicable.

5.3.2 Assembly of fittings

Flareless fittings, flexible metal-hose fittings, threaded fittings, and other joining devices shall be assembled and installed as recommended by the manufacturer. (See Section 5.6.)

5.3.3 Other assembly methods shall be qualified by testing for all structural and environmental design conditions, including vibration and mechanical cycling.

5.4 Sample taps

Sample taps shall be installed to provide a representative sample flow. Sample nozzles shall be used when a surface tap does not provide representative flow.

5.4.1 Sample taps shall be installed far enough downstream of injection points to the process so that the additional material will be well mixed in the process fluid.

5.4.2 Liquid sample connections should be made on the side of horizontal pipe runs. Steam and gas sample connections should be made on vertical pipe or duct runs wherever practical. Steam and gas sample connections to horizontal pipe or duct runs should be made on the top of the pipe or duct run.

5.4.3 An individual sampling tap shall not be required for a sampling line if there is a continuous source of system blowdown and if the location and design of the blowdown tap meets requirements for a sampling tap. In this case, the sample line may tap into the blowdown line, or the blowdown line may be used as a continuous-flow sampling line if the sampling function does not interfere with the blowdown function, and if the blowdown cannot damage the sensing element or interfere with the element's function.

5.4.4 A sample line shall have its own dedicated sample tap from the main process connection.

5.4.5 Small-diameter sample taps into larger lines or equipment should be located away from areas where inspection or maintenance is necessary. Minimizing the number and locating such penetrations away from maintenance or inspection work areas can reduce radiation exposure.

5.5 Routing

5.5.1 General routing considerations

All sample lines including instrumentation, valving, other in-line devices, trays, and supports shall be installed with good engineering practices in order to avoid contact interferences caused by relative motion between the sample line and other adjacent equipment or devices. Sources of relative motion that shall be considered are thermal expansion, seismic motions, vibrations, and design-basis accidents or events. The Code classification of the sample line will determine the requirements for relative motion that shall be considered.

5.5.1.1 Bends rather than fittings should be used to change the direction of a run of piping or tubing. The minimum bending radius for cold-bending of tubing using a bending tool shall be established by the designer. Larger-radius bends should be considered for slurry samples to lessen the possibility of blockage and for radioactive air samples to lessen the possibility of particle plateout.

5.5.1.2 In the absence of further engineering analysis, sample lines including instrumentation, valving, other in-line devices, trays, and supports shall be installed with the following minimum contact surface separations:

1) Three-inch (75 mm) separation for adjacent large piping [2 1/2 inches (65 mm) and larger], including insulation, appurtenances, and hardware attachments;

2) Two-inch (50 mm) separation for adjacent small piping [2 inches (50 mm) and smaller], including insulation, appurtenances, and hardware attachments; and

3) Two-inch (50 mm) separation for other adjacent equipment and devices, such as cable trays, cable tray supports, mechanical equipment, electrical equipment, ventilation ductwork, and duct supports.

5.5.1.3 Sample lines shall be routed to avoid environmental extremes wherever practical. Sample lines routed through outside or low-temperature areas shall be heat-traced as necessary to prevent freezing, condensing, or solidification with loss of sample flow. Sample lines shall be routed away from significant sources of heat if the source of heat will have a detrimental effect on the sample, or if the rating of the sample line may be exceeded by additional heating.

5.5.1.4 Gas-sampling lines should have a continuous downward slope toward the source to promote their being kept free of liquid. The slope is preferred to be 1 inch, or more, per foot (80 mm or more per meter) of run. Where the preferred minimum slope cannot be obtained, the sample lines shall be installed to the maximum slope available and in no case shall be less than 1/4 inch per foot (20 mm per meter). Liquid-sampling lines need not be sloped; however, standard process piping installation standards shall be used. High-point vent and drains shall be used as necessary to provide system drainage.

5.5.1.5 Process or sampling fluids shall not be piped to an emergency shutdown panel, technical support center, or a control room.

5.5.1.6 Sampling lines should be run along walls, columns, or ceilings, avoiding open or exposed areas to decrease the likelihood of damage to the sample lines by pipe whip, missiles, jet forces, or falling objects.

5.5.1.7 Sample lines should be routed in such a manner that they do not obstruct normal personnel passage within the plant. Additionally, if the sample line is for atmospheric samples, the open end of the line should be directed downward to prevent the entry of foreign matter.

5.5.1.8 Valves, orifices, and instrument taps shall not be located on any piping inside an inaccessible area. Where this cannot be achieved, follow the guidelines of 5.8.6.

5.5.1.9 Portions of the pipe run that require relatively frequent inspection or maintenance should be grouped and arranged to be readily accessible. The intent is to provide optimum access, thereby minimizing the time required for performance of activities in radiation exposure areas.

5.5.1.10 Orientation of process taps for liquid service is preferred on the horizontal side of the process pipe; for gas service, the vertical top side of the process pipe is preferred. Orientation of process taps for liquid or gas shall never be located on the vertical bottom side of the process pipe.

5.5.2 Routing for lines containing radioactive fluids

5.5.2.1 Shielding for sample lines containing radioactive fluids should be used when practicable.

5.5.2.2 Lines containing radioactive fluids shall not be routed through areas requiring low background radiation levels, such as laboratory counting rooms, without being properly shielded.

5.5.2.3 Before routing a line containing radioactive fluids through a low-radiation zone, determine that the line can be properly shielded along its entire length.

5.5.2.4 Lines should be routed taking into consideration the necessity for portable or temporary shielding.

5.5.2.5 Lines containing radioactive fluids should be routed away from components that require frequent maintenance. Additionally, lines containing radioactive fluids shall be away from doorways, accessways, labyrinths, stairways, or ladders.

5.5.2.6 Lines containing radioactive fluids shall not be routed with dead legs or low points that cannot be readily drained or flushed. Draining and flushing connections should be placed at appropriate places accessible from outside the pipeway for all radioactive lines in the pipeway.

5.5.2.7 For tubing and piping penetrating shield walls, care shall be taken to minimize personnel exposure to radiation "streaming" from radioactive sources to the surrounding areas through instrument sampling-line penetrations in the shield walls and the sample line itself. One of the following methods should be used:

1a) All instrument sampling-line penetrations shall be located at a minimum height of 7 feet (2.5 m) above floor level;

1b) The tubing penetrations shall be pitched toward an inner corner of the operating compartment, avoiding a direct radiation-streaming path;

2) The tubing penetration shall be arranged as a labyrinth pattern; or

3) If the method above is not practical, the sampling lines penetrating the shield wall shall be surrounded by a pipe sleeve, and the open space between the sampling line and sleeve shall be filled with a radiation-absorbing material determined by the type of radiation expected. The sampling line shall make a right angle bend after it leaves the sleeve, and a radiation shield shall be placed in front of the line where it exits.

5.5.3 Safety-related sample-line routing

5.5.3.1 Redundant instrumentation sample lines shall be routed and protected so that any credible effect (consequence) of a design-basis event that is to be mitigated through those sample lines shall not render redundant sample lines inoperable, unless it can be demonstrated and documented that the protective function is still accomplished. This level of protection shall assure that, after the event, a single failure shall not prevent mitigation of that event. Credible effects of a design basis event that do not depend on a given group of redundant instrument sample lines for mitigation or accident prevention may render inoperable any or all of that group of sample lines without violating this criterion, provided that the overall protective function is accomplished. All nuclear safety-related instrument sample lines should be protected from damage during normal operating occurrences.

5.5.3.2 The minimum separation between redundant instrument sample lines and taps shall be at least 18 inches (500 mm) in air, in nonmissile, nonhigh-energy jet stream, nonpipe whip, or nonhostile areas. As an alternative, a suitable steel or concrete barrier shall be used. When a suitable barrier is used, it shall extend at least 1 inch (25 mm) beyond the line of sight between redundant sample lines and shall be designed and mounted to Seismic Category 1 requirements. In hostile areas subject to high-energy jet stream, missiles, and pipe whip, the separation shall be provided by space in air, steel or concrete barriers, or both, and documented with analysis or calculations as necessary to prove that the separation protects the redundant sample lines from failure due to a common cause. All barriers shall be designed and mounted to Seismic Category 1 requirements.

5.5.3.3 Where redundant instrument sample lines penetrate a wall or floor, the required separation or barriers shall be maintained.

5.5.3.4 Safety-related redundant sample lines shall not share the same containment penetration. Wherever practical, redundant sample lines shall be routed to separate penetrations, pipe enclosures, or other passageways. Where practical, sample lines should be routed on opposite sides of installed piping or equipment and on opposite walls of piping enclosures or other passageways. Existing unrelated equipment may be used to provide adequate separation.

5.5.4 Post-accident sample-line routing

Post-accident sampling lines shall be routed, installed, and shielded such that under accident conditions the personnel radiation exposure for a grab-sample collection will be minimized. This exposure limitation includes entry, collection, flush, purge, and exit times as well as any time required to manipulate shielded sample containers and other equipment.

5.6 Fittings and connections

5.6.1 In the absence of any existing standards, the designer shall determine that the type of fitting selected is qualified for the design conditions (including vibration, temperature, pressure, thermal shock, material compatibility, and applicable environmental conditions), or shall demonstrate by test that the fitting is capable of performing its intended function.

5.6.2 Welded fittings

5.6.2.1 Piping and tubing

Welded fittings should be used in the following cases listed. Butt-welded fittings should be considered for large [over 1-inch (25 mm)] radioactive sample lines where socket-weld fittings would create radioactive particle traps.

1) If severe erosion, crevice corrosion, shock, or vibration is expected to occur;

2) Radioactive systems;

3) Hazardous fluid systems; and

4) Post-accident sampling systems.

Instruments and in-line components that require frequent removal for maintenance should not have welded fittings.

Welding procedures and materials shall meet the requirements of this standard. (See 5.3.1.)

5.6.2.2 Tubing

For tubing, flareless fittings may be used except in the cases listed below, which require the use of welded fittings:

1) Where a sample line must be protected against inadvertent disassembling; and

2) For those portions of sample lines that are inaccessible or may be hidden from inspection.

The mating parts of the original flareless-tube fittings shall be designed and manufactured by the same company. Replacement parts from different manufacturers may be used, provided both of the manufacturers' guidelines for the use of their fittings is met concerning design service conditions, or provided the complete fitting shall be replaced when service is needed. The connection between the root valve and the sample tap shall be welded.

In the interest of leak integrity, care should be exercised to protect mating seal surfaces before and after original makeup. In particular, care should be exercised during maintenance; body and nut, ferrule, and tube assembly should be protected from dirt and physical damage.

5.6.3 Threaded pipe fittings

5.6.3.1 Threaded pipe fittings are not recommended for general use in nuclear power plant sampling systems. Threaded pipe fittings may be used as necessary with instruments or components that have threaded connections as supplied or when a welded attachment cannot be made.

5.6.3.2 Threaded fittings should be seal-welded. (Exception is made for instruments with integral electronics or other heat-sensitive components.)

5.6.3.3 National Pipe Thread (NPT) connectors may be used; however, the assembly shall comply with the requirements of ANSI B2.1 and B31.1.

5.6.3.4 Tapered pipe threads shall conform to ANSI B2.1. However, tapered pipe threads shall not be used as takedown joints when repeated disassembly and reassembly are planned. Straight thread fittings with metal-to-metal or resilient seals are permitted.

5.6.3.5 Appropriate thread lubricants or compounds should be used in the assembly. For threaded connections of stainless steel to stainless steel, lubrication is required to prevent seizing and galling and to promote sealing. The lubricants shall meet ASME NQA-1 for chloride and halogen content.

5.6.4 Flanges

5.6.4.1 Flanges may be used for in-line components that must be periodically removed. Flanges must be design-rated for the components as well as for the sample line at the point of insertion.

5.6.4.2 Flanges shall comply with ANSI B16.5 unless they are of proprietary design and are provided as an integral part of an instrument.

5.6.4.3 Flange gaskets shall be rated for sample-line pressure and temperature and should not be of the spiral wound design.

5.6.4.4 Flanges shall be installed so that they can be inspected visually and are readily accessible for maintenance.

5.6.5 Flexible metal hose

5.6.5.1 Shielded flexible metal hose may be used in sampling lines to accommodate thermal, seismic, and vibrational motions if its ratings equal or exceed the design requirements, including service life for the sampling line. It shall be installed in accordance with the manufacturer's instructions. Flexible metal hose shall be used within the limits of the manufacturer's ratings. The internal wetted surface shall be compatible with the sample fluid. Flexible metal hose should not be used with highly corrosive, highly radioactive fluids. Any barriers or screens used for protective purposes shall allow for the design motions of the flexible metal hose without contact. The manufacturer's fittings and adapters shall be used at each end to connect to the sample line or component.

5.6.5.2 For sample connections to high-pressure [>900 psi (6200 Kpa)], high-temperature [>260°C (500°F)], radioactive, or otherwise hazardous fluids, flexible tubing or hose shall not be used between the process tap and the root valve. Nonshielded flexible hose or tubing may be used at a sample sink for low-pressure, low-temperature, and nonhazardous applications.

5.7 In-line components

In-line components include all devices through which the sample flows from process connection to sample-line termination. It includes all pressure boundary components except as otherwise covered by this standard. Examples are coolers, degassers, filters, in-line instrument probes, strainers, expansion coils, delay coils, etc.

5.7.1 Expansion coils

Expansion coils that allow for thermal, seismic, or vibrational motion may be used if the expansion coil equals or exceeds the design requirements for the sampling line.

NOTE: Expansion coils increase sample-line volume and lag time.

5.7.2 Sample coolers

Sample coolers should be installed such that the sample flow enters the tube from the top and exits the bottom, and the cooling fluid enters the shell from the bottom, and exits the top.

5.7.3 Sample pumps

Sample pumps should be properly sized to provide the required flow. Sample pumps shall have a pressure-relief capability from discharge to suction, or discharge to a suitable container.

5.7.4 Strainers and filters

5.7.4.1 Strainers or filters should not be used in sample lines unless:

1) The strainer or filter is necessary for the protection of an in-line instrument; or

2) The strainer or filter is necessary for sample preparation or conditioning.

5.7.4.2 If a filter or strainer is installed in a sample line for a startup service, then there shall be a direct or straight bypass line, and the filter or strainer shall be tapped off the main sampling line. Two isolation valves shall be provided to isolate the filter. These isolation valves shall be installed as close as practical to the sample line to reduce the volume of dead leg.

5.7.5 Moisture traps

Use of moisture traps should be limited to those applications where they do not have an adverse effect on the sample.

5.8 Valves

5.8.1 Sampling systems shall have as few valves installed as practical, consistent with code, design, and functional requirements.

5.8.2 Valves shall be installed with the stem oriented in the most accessible direction, consistent with other requirements.

5.8.3 Where practical, valves shall be located in low-radiation zones or in locations where radiation exposure to personnel will be minimal.

5.8.4 If a reach rod must be used, it shall be less than 10 feet (3 m) long and should have no more than one gear box.

5.8.5 The pressure-temperature ratings (class) shall be as required by the main-line class until such point that the sample line is reduced to a lower class.

5.8.6 Root valves

Root valves shall be installed as close as practical to the process connection. The root-valve stem and handle shall be clear of any main-line insulation. The root valve shall be made accessible. If a root valve close to the process connection is not accessible during normal operations due to location or radiation exposure rate, then the root-valve function shall be made accessible by one of the following procedures:

1) Relocate the process connection to an accessible location;

2) Install a reach rod; or

3) Install a second root valve at the point that the sample line becomes accessible.

5.8.7 Component isolation valves

5.8.7.1 Valving shall be installed to allow for the isolation of in-line components or instrumentation as necessary for operation, maintenance, or calibration.

5.8.7.2 When the sample line terminates at an instrument or equipment (dead-end service), an upstream component isolation valve shall be installed.

5.8.7.3 In multicomponent sample lines that require continuous flow, individual component isolation and bypass valves may be installed.

5.8.7.4 Component isolation valves should be installed so that they are accessible from the component location.

5.8.8 Local grab-sample valves

Local grab-sample valves shall be accessible from floor or platform and should be of convenient height. Sample-station collection nozzles shall be directed so that their discharge cannot inadvertently be directed at the operator.

5.8.9 Sample-line grab-sample valves

In welded systems, the last grab-sample valve may be installed with flareless connections if the sample line at that point does not require welded connections. This would allow for greater ease of replacement. Sample-station collection nozzles shall be oriented so that their discharge cannot inadvertently be directed at the operator.

5.9 Sample-line termination

5.9.1 Grab-sample termination

Grab-sample lines shall terminate as close as practical to a drain, drain funnel, sink, or collection sump suitable for their disposal. Adequate spacing shall be provided for the collection of samples.

5.9.2 Sample sinks, panels, and stations

Arrangements should be provided for obtaining samples at central locations where sampling hoods are used to control the release and dispersal of airborne or gaseous radioactivity. Arrangements should be provided for radioactive drain capability and recirculation of the samples. The use of central locations reduces the time required to obtain radioactive samples and to transport the samples to the laboratory. Sample stations should be located such that representative samples can be obtained. In the event that a sampling station is used infrequently, its location in terms of accessibility and radiation dose takes on less significance.

Generally, sampling stations should not be located in areas greater than 2.5 mrem/h (0.025 mSv). Criteria governing the *location of* sample stations are as follows:

1) Sample stations should be located to allow for collection of a representative sample for analysis;

2) The location assigned for sample stations should be within a readily accessible area;

3) Where practical, sample stations should be located in low-radiation zones where radiation exposure to personnel will be minimal; and

4) Where possible, the sample stations should be close to the chemical laboratories.

5.9.3 Sampling return to process

If sampling lines are routed back to process or to where the discharge cannot be observed (including any flushing or calibration fluids used), they shall have flow monitoring in order to determine proper sampling.

5.9.3.1 Sample lines and components shall meet the main-line class requirements of the termination-process pipe, duct, tank, or containment.

5.9.3.2 Sample-flow conditioning shall not degrade the process.

5.10 Supports and mounting structures

5.10.1 General requirements

5.10.1.1 Mounting structures and their attachments shall have a seismic capability not less than that required by any of the supported transducers or auxiliary equipment.

5.10.1.2 Supports, brackets, clips, or hangers shall not be fastened to the sample line or components for the purpose of supporting cable trays or any other equipment.

5.10.1.3 The sample line shall not be supported by the instrument. Auxiliary supports shall be provided to restrain the instrument where the mass of the instrument puts unacceptable stress on the piping.

5.10.1.4 Hanger and support design shall include provisions for seismic, jet impingement, pipe whip, missiles, and thermal expansion of the process tap and instrument sampling line to which the hangers or supports may be subjected during normal operation, seismic, or other credible event.

5.10.1.5 Sample lines shall be supported with anchors and guides. An anchor serves to clamp the line in place, while a guide will allow axial motion of the line. No more than one anchor point will be used in any straight run of line, and sufficient offset shall be provided on both sides of the anchor point to allow for the designed thermal and seismic motions. If a vertical straight run of sample line has dead weight approaching or exceeding the compressive strength of the line, then:

1) The line shall be bent or curved to allow for another anchor point with sufficient offset for design motions; or

2) An expansion loop shall be installed to allow for another anchor point with sufficient offset for design motions.

Such vertical runs should be avoided where practical.

5.10.2 Component supports

5.10.2.1 Sample-line valves should not be supported by the sample-line tubing in an open run of tubing. Sample-isolation valves may be supported by tubing if the tubing is supported within 3 inches (75 mm) from the valve (as by a bulkhead union in a sampling panel) and if the appropriate code permits.

5.10.2.2 Sample-line root valves may be supported by the process pipe or duct as allowed by the appropriate code.

5.10.2.3 In-line isolation and the throttling valves may be supported by sample-line pipe as allowed by the appropriate code.

5.10.2.4 Valves on flexible metal hose shall be independently supported.

5.10.2.5 The weight of insulation, heat tracing, etc., shall be considered.

5.10.3 Operating vibration

> **CAUTION:** Shock mounts are typically low-pass mechanical filters and will often amplify vibrations. Special care in design is essential to avoid this problem.

Exposure to vibrational excitation due to pumps, turbines, or other sources should be avoided. Where high vibration is unavoidable, the equipment should be mounted on an adjoining nonvibrating surface; or, if no other reasonable alternative exists, the equipment should be isolated by shock mounting for the expected vibration frequency.

5.11 Sample-line taps

A tap made on a sample line and the lines and components connected to the tap shall meet the code and design requirements of the sample line until reduced by in-line components (class break). The main-line class of the sample line shall be maintained through an ancillary tap made on the sample line.

5.12 Flush and backflush

5.12.1 Flushing lines shall have at least two means of isolation from the sample line to prevent sample flow through the purge or flushing line. The requirements of the sample line shall apply through the first form of isolation. The first flush valve shall be capable of throttling. It shall be readily accessible from any grab-sample point in high temperature, high-pressure, or hazardous-fluid applications.

5.12.2 Where a comparison of design pressures between the sampling line and the flushing line indicates that contamination of the flushing fluid source is probable and if such contamination is not tolerable, then the second form of isolation should be a check valve.

5.12.3 Where practical, flush and backflush lines should be installed such that the flushing flow is upward in liquid systems and is downward in gas or vapor systems, for the purpose of flushing out unwanted liquid or gas.

5.12.4 Sample lines that have a flushing requirement to control radiation exposure shall have an isolation valve as close as possible to the last place of adequate shielding, and the flushing connection shall be made as near to this isolation valve as possible. Where practical, a manufactured manifold should be used.

5.12.5 Flush connections that could act as a trap or settling point for radioactive solids should be located on the top of the pipe or tube.

5.12.6 Backflush capability shall be installed for post-accident sampling lines to remove sample-line blockages.

5.13 Common sample lines

Sample lines used to sample two or more nonidentical processes shall have valving to ensure selection of the desired sample source and positive isolation of the remaining sources. Where practical, this valving shall be accessible from the sampling-instrument or the grab-sample point. Positive indication of the sample source shall be provided at the grab-sample point and in the area of the sampling instrument. Any alarms or indications derived from the sampling instrument shall clearly indicate the sample source.

5.14 Bypass lines

5.14.1 Sampling instruments shall always be installed in the main sampling line (main-flow path). They shall never be installed in the bypass line.

Radiation-monitoring sample lines that are designed for continuous sampling, but which require periodic stopping of sample flow for calibration, checking, or maintenance, shall have bypass capability, with the bypass flow routed to a safe sample termination point.

5.15 Personnel protection

5.15.1 Hot-sample lines in liquid or gas service shall not be insulated except where sample cooling is undesired. Screens or covered trays shall be provided for personnel protection in normally accessible areas.

5.15.2 High-pressure components shall be installed behind a sample sink or panel for personnel safety in the event of component rupture.

5.15.3 Remotely operated or automatic sampling stations should be used in applications where accumulated personnel dose can be significantly reduced by avoiding exposing personnel to the fluid being sampled.

Appendix A — Interface standards and documents

This appendix is included for information only and is not a part of the standard.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

B2.1-1968	Pipe Threads (Except Dryseal) Specifications, Dimensions, and Gaging for Taper and Straight Pipe Threads, Including Certain Special Applications
B16.5-1981	Pipe Flanges and Flanged Fittings
B31.1-1983	Power Piping, with 1984 Addenda for Parts A, B, and C
N13.1-1969	Guide to Sampling Air Borne Radioactive Materials in Nuclear Facilities

Available from: **ANSI**
11 West 42nd Street
New York, NY 10036 Tel: (212) 642-4900

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

Section III	*Boiler and Pressure Vessel Code*, Nuclear Power Plant Components
Section VIII	*Boiler and Pressure Vessel Code*, Nuclear Power Plant Components
Section IX	*Boiler and Pressure Vessel Code*, Nuclear Power Plant Components
PTC 19.11-1970 (R 1984)	Performance Test Codes, Part 11, Water and Steam in the Power Cycle (Purity and Quality, Leak Detection and Measurement) Instruments and Apparatus
PTC 23-1958	Performance Test Codes, Atmospheric Water-Cooling Equipment
NQA-1-1983	Quality Assurance Program Requirements for Nuclear Facilities

Available from: **ASME**
345 East 47th Street
New York, NY 10017 Tel: (212) 705-7722

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D1192-1970 (R1977)	Specification for Equipment for Sampling Water and Steam

Available from: **ASTM**
1916 Race Street
Philadelphia, PA 19103-1187 Tel: (215) 299-5585

ISA

ANSI/ISA-S67.01-1987	Transducer and Transmitter Installation for Nuclear Safety Applications
ANSI/ISA-S67.02-1983	Nuclear-Safety-Related Instrument Sensing Line Piping and Tubing Standards for Use in Nuclear Power Plants

Available from: **ISA**
PO Box 12277
67 Alexander Drive
Research Triangle Park, NC 27709 Tel: (919) 990-9200

TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION (TEMA)

	Standards of Tubular Exchanger Manufacturers Association (includes 1982 Addenda)
Section 4E-78	Installation, Operation and Maintenance
Section 12RGP-78	Recommended Good Practice

Available from: **TEMA**
25 North Broadway
Tarrytown, NY 10591 Tel: (914) 332-0040

UNITED STATES CODE OF FEDERAL REGULATIONS

Title 10, Part 50-1974 (R1986)	Domestic Licensing of Production and Utilization Facilities

Available from: **Superintendent of Documents**
U.S. Government Printing Office
Washington, DC 20402

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