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American National Standard

Transducer and Transmitter Installation For Nuclear Safety Applications

ANSI/ISA-S67.01 — Transducer and Transmitter Installation For Nuclear Safety Applications

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Preface

This preface, as well as all annexes and footnotes, is included for informational purposes and is not a part of ANSI/ISA-S67.01.

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

Begun in April 1974, under the directorship of Robert L. Galley and the assistance of H. C. Schmidt, W. M. Deutsch, J. A. Nay, and M. J. Kimbell, this standard was one of the first ISA ventures directed specifically at the nuclear power industry. Shortly thereafter, the ISA Nuclear Power Plant Standards Committee (NPPSC) was formed within the Power Industries Division of ISA to oversee the development of standards for the nuclear power industry and to serve as the SP67 Committee for those standards.

The question of definitions between "transducer" and "transmitter" was raised repeatedly in the early development of this standard. It was generally agreed that industry practice is to use "transmitter" for devices in which the values of the measurand are converted, operated upon, and scaled to a standardized output signal. In contrast, a "transducer" is commonly considered to be a fixed device for a single conversion of measurand value to some signal that is physically inherent to the "transducer" design, and that cannot be scaled or operated upon within the "transducer" itself. Thus, in common usage as seen by this Subcommittee, a "transmitter" will contain at least one "transducer" (and often several) along with amplifiers and other devices. However, the Subcommittee recognizes (with some reservation) that "transducer" can, through generic expansion, be used to designate devices commonly referred to as "transmitters." Because this standard is meant to apply to instruments included in both definitions, the word "transducer" has been selected for consistent use throughout. The user of this standard is respectfully requested to include the instrument person's common usage of "transmitter" or "sensor" as part of the thought process when the single word "transducer" appears.

It is important to note that the installation of transducers, if not done properly, can negate the suitability of a device for its use in nuclear safety-related systems. Since there are many different instrument service conditions and a wide variety of viable system and instrument designs, the user of this standard will find that the design responsibilities, rather than the design itself, are sometimes delineated herein.

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 and SI-acceptable metric units as optional alternatives to English units in all new and revised standards, recommended practices, and technical reports to the greatest extent possible. SI (metric) unit conversions in this standard are given only to the precision intended in selecting the original numerical value. When working in the SI units system, 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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Contents

1 Scope

This Standard covers the installation of transducers for nuclear safety-related applications.

2 Purpose

This Standard establishes requirements and recommendations for the installation of transducers and auxiliary equipment for nuclear applications outside of the main reactor vessel.

3 Definitions and terminology

ISA-S51.1* is the basic reference for terms not defined herein. ISA-S37.1* is the reference for terms not included in S51.1.

3.1 auxiliary equipment: Separate devices, such as field-mounted power supplies, that are appended to the basic transducer and are located in the same general area as the transducer. Equipment located away from the transducer (such as control-board-mounted controllers and rack-mounted power supplies) is not included in the definition as used in this Standard.

3.2 Code: Refers to the ASME Boiler and Pressure Vessel Code, Section III* and other sections required to implement the requirements of Section III.

3.3 Code class: The applicability of the Code, determined through consideration of pressure-boundary integrity.

3.4 in-line: Transducers exposed directly to the process fluid in piping, vessels, equipment, or the main flow paths of fluid systems.

3.5 nuclear safety-related: That which is essential to

a) emergency reactor shutdown;
b) containment isolation;
c) reactor core cooling;
d) containment or reactor heat removal;
e) prevention or mitigation of a significant release of radioactive material to the environment; or
f) maintaining safe shutdown conditions;

*See References and bibliography

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.

3.6 off-line: Transducers that are either connected to the process fluid via sensing lines with one or more isolation valves or are not exposed to the process fluid.

3.7 pressure boundary integrity: The capability to retain process fluid.

3.8 qualified: Demonstrated to be acceptable for the design requirements.

3.9 sensing line: Piping or tubing connecting a transducer to the process.

3.10 allowable stress: The stress values allowed by the applicable piping or structural design standard.

4 Safety classification

4.1 Code applicability

The reason that a transducer is classified as safety-related is important in determining which of the criteria in this Standard shall be applicable. In general, transducers are classified as safety-related for one or more of the following reasons:

a) Pressure boundary integrity

b) Mounting

The transducer must be mounted in a manner that prevents it from affecting the performance of other safety-related equipment, such as following a seismic event.

c) Electrical connection

The transducer must be electrically installed in a manner that prevents it from affecting the performance of other safety-related equipment.

d) Function

The transducer's signal is to be utilized in the performance of a safety-related function.

If the reason that a transducer is classified as safety-related is its function, then all of the criteria of this Standard should be considered for applicability. However, if a transducer is safety-related due to one of the other three reasons, only certain criteria within this Standard need to be considered for applicability.

Consider, for example, a transducer whose only safety-related function is its pressure boundary. Those criteria within this Standard relative to ensuring that the transducer maintains the pressure boundary would be applicable to the transducer. Criteria associated with electrical connections, separation, calibration, testing, etc. may not be relevant to such a transducer. Similarly, the user of a transducer whose only safety-related function is its electrical connection would find the criteria of this standard associated with maintaining that electrical connection to be applicable. Criteria associated with process-fluid connections, environmental considerations, accessibility, etc. may not be applicable for such a transducer.

It is the responsibility of the user to determine the reasons that a transducer is classified as safety-related and to apply the criteria of this Standard that will maintain these safety-related functions.

4.1.1 In-line transducers

Installations of transducers in Code piping, vessels, or equipment shall comply with the Code. Transducers for nuclear safety-related applications may be installed in or connected to non-Code piping, vessels, or equipment, as necessary to obtain measurements from non-Code systems. The Code shall not apply to these installations.

4.1.2 Off-line transducers

The Code shall not apply to off-line transducers. Sensing lines for off-line transducers shall be installed in accordance with ISA-S67.02.*

4.1.3 Mounting structures

Mounting structures that support Code equipment shall comply with the Code (subsection NF).

5 Equipment mounting

5.1 Mounting of in-line transducers

5.1.1 Flow-through devices

To facilitate replacement and periodic inspections, flow-through transducers, such as differential pressure meters (orifice plates, flow nozzles, venturi tubes, etc.), electromagnetic flowmeters, mass flowmeters, vortex flowmeters, positive displacement flowmeters, turbine flowmeters, ultrasonic flowmeters, variable area flowmeters, and certain radiation monitors should be flange-mounted to the piping, except in ASME Code Class 1 installations.

The piping shall not impose unacceptable loads on the instrument. Auxiliary supports shall be provided to restrain the instrument where the mass of the instrument puts unacceptable stress on the piping.

5.1.2 Flow-past devices

Flow-past devices (such as protective wells, differential pressure meters [pitot tubes], insertion-type electromagnetic vortex, target, and turbine flowmeters) designed to be inserted into the flow path through the wall of the pipe or vessel, shall be installed and mounted through a piping penetration specifically designed to accommodate the transducer.

Where removal is required for service, one of the following alternatives to permanent welding of the transducer shall be used:

a) A qualified flange connection

b) For insertion shank diameters of 25 mm OD (1 in.) or less, mounting with a flareless fitting (see 8.2.3)

* See References and bibliography.

Mating fittings shall be welded into the pipe boss or fitting. The mating bodies, nuts, and ferrules shall be obtained from the same manufacturer or shall otherwise be qualified to perform their intended function.

c) Designs permitting removal of transducers from pressurized systems

They shall provide positive nonfriction restraint in both the inserted and the withdrawn position.

d) Straight threads with resilient seals, and conical or spherical seat unions

5.2 Mounting of off-line transducers

5.2.1 Mounting structure design

The mounting structure shall not induce stresses greater than the allowable stresses on the transducer or on the sensing lines, signal lines, and electrical cables serving the transducer.

The structure shall be designed to support the transducer in the physical orientation(s) for which it is qualified. Only qualified mounting hardware shall be used. Preference should be given to use of hardware furnished and qualified as part of the transducer.

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

5.2.2 Fasteners

Bolts, screws, or other fasteners used for mounting shall be chemically and metallurgically compatible with the equipment, the structure, and the environment. Fasteners shall be qualified to withstand all loads including normal loads, structural vibrations, and seismic stresses.

5.2.3 Materials

The materials selected for the mounting structures shall be resistant to or protected against the design environment; for example, aluminum may be prohibited in caustic spray environments.

Protective coatings shall be resistant to both normal and (where applicable) accident environments, and the coatings shall be chemically and metallurgically compatible with the materials to be protected. Paints or paint-type coatings used on mounting structures shall be fire-retardant.

5.2.4 Mounting structure configurations

One of the following configurations shall be used for mounting:

a) Wall bracket

b) Open rack (partial combination with cabinet-type structure)

The addition of flat plate side panels or cross-bracing is permitted to obtain satisfactory stiffness. Bracing to the wall or other structures is permitted.

c) Cabinet (totally enclosed construction)

Unless cabinets are designed specifically to control the transducer environment, they shall be designed to allow natural air circulation. Where a controlled environment is essential to the accuracy or continued function of the enclosed equipment, the auxiliary equipment for controlling the environment shall be designed and installed to the same

requirements as the enclosed equipment. Monitoring of the controlled environment parameters shall be provided.

d) Panels (flat plates attached to open racks, wall brackets, or cabinets, as defined in 5.2.4.(c))

e) Pipe stands or stanchions (a single length or assembly of pipe or structural shapes that is mounted to the floor, wall, or structural steel)

Friction mounting of the bracket (such as that provided by U-bolt clamps around a pipe) may be used when qualified.

5.2.5 Construction and assembly methods

Bolting methods shall meet the requirements of 5.2.2.

Attachments to Code components shall conform to the requirements of the Code.

If welding is specified for non-Code attachment or assembly, the weld shall be shown to have a stressed cross section sufficient to support the maximum design loads. Tack welding shall not be used as a structural weld.

All welds shall be made in accordance with qualified procedures.

Other assembly methods (such as bonding or adhesives) shall be qualified for all structural, environmental, and design-life conditions.

5.2.6 Mounting structure attachment

The mounting structure shall be attached to its supporting structure by bolting or welding in place.

Plates connected to embedded anchors, expansion bolts, cement, or other means of attachment in concrete are acceptable.

5.2.7 Inspection requirements for mountings

Inspection of the final assembly shall be performed and documented to verify that

a) fasteners used are the size, type, and material specified and have been properly tightened;

b) welding is as specified;

c) paint and other protective coatings have been applied as specified to corrodible materials, and that the coating remains intact or has been repaired;

d) transducers and auxiliary equipment items are installed in the orientation appropriate for seismic qualification, and the designated mounting brackets or supports shown on the approved design drawings have been properly installed;

e) piping, tubing, fittings, valves, and electrical connections have been installed and tested in accordance with the drawings or specifications; and

f) nondestructive examination, if specified on the drawings or other documents, has been completed.

5.3 Mechanical protection

Impingement barriers shall be used where required to protect against damage from postulated missiles, fluid jets, and other identified moving objects. The barriers may also serve to separate redundant transducers and auxiliary equipment. The barriers shall be designed consistent with the seismic qualification requirements for the protected devices.

5.4 Auxiliary equipment

Unless otherwise justified, the requirements of subclauses 5.2 and 5.3 shall apply to auxiliary equipment.

6 Location of equipment

6.1 Selecting a location

6.1.1 Transducers shall not be installed in locations with environments that may exceed the qualified capabilities of the transducer, except when it can be shown that a potentially adverse environment will exist only after the transducer's function is no longer required. For instance, transducers with no post-accident requirements may be located in the reactor containment without being qualified for post-accident environments, so long as their failure will not degrade the availability of other equipment that is required to be operable. Selection of locations for transducers should consider the availability of transducers qualified to operate in the various design environments.

6.1.2 Transducers shall be located or enclosed as necessary to protect them against physical damage, radiation, freezing, and changes or rates-of-change in ambient conditions in excess of that for which they have been qualified.

6.2 Separation of redundant transducers

6.2.1 Transducers shall be located so that no credible single event can prevent the required nuclear safety-related functions. Piping, tubing, and wiring associated with the transducers shall be placed with similar attention to separation of locations. A minimum of 450 mm (18 in.) separation shall be provided between surfaces of redundant transducers. Where analysis shows that specific postulated events, including but not limited to fires, missiles, and fluid jets, could circumvent the protection afforded by this separation, additional spacing or protective barriers shall be provided. Protective barriers may also be used in lieu of separation where it is impractical to maintain the required spacing. If barriers are used, a minimum of 25 mm (1 in.) of free space shall be provided on each side between transducers and the barrier.

6.2.2 Where redundant transducers must be included on the same structure, service access to the transducers, or to the subassemblies of one transducer, shall be separated from access to components or subassemblies of their redundant counterpart(s). (For instance, with cabinet con-

struction, separate access doors should be provided.)

6.3 Accessibility for periodic test and service

6.3.1 The transducers should be located in an accessible place for ease of periodic testing, servicing, removal, and replacement. Adequate lighting, electrical outlets, water, compressed air, and similar utility services should be provided to support testing and surveillance requirements.

6.3.2 Placement of equipment (with respect to the mounting structures, impingement barriers, and adjacent equipment) shall allow clearance for the removal of covers and normal use of hand tools for mounting, calibration, and servicing. Placement shall allow removal and replacement of a complete device without disturbing equipment not functionally associated with the instrument loop being serviced. (That is, it shall not be necessary to shut down one instrument loop to facilitate replacement or service of a transducer or auxiliary equipment in another instrument loop.)

6.4 Auxiliary equipment

Unless otherwise justified, the requirements of 6.1, 6.2, and 6.3 shall also apply to auxiliary equipment.

7 Environmental considerations

7.1 Seismic considerations

The design of nuclear safety-related transducer installations shall accommodate seismic disturbances such that the transducers are not subjected to seismic shock or vibration in excess of that for which they are qualified. Addition, deletion, or relocation of equipment on mounting structures (beyond the original design considerations) shall require re-verification of the seismic suitability.

7.2 Operating vibration

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 vibratory motion.

7.3 Ambient operating conditions

The design of a nuclear safety-related transducer installation shall accommodate normal and abnormal ambient operating and accident conditions. As a minimum, limits of the following parameters shall be determined and documented:

a) Temperature
b) Pressure
c) Humidity
d) Radiation

7.4 Special operating conditions

7.4.1 Chemical environments

When chemicals are transported in the lines being measured, the wetted materials of the transducer installation shall be compatible with the chemical. When the environment includes a chemical component, the installation shall be qualified for the environment.

7.4.2 Temperature protection

If the installation is exposed to ambient temperatures below the freezing, condensation, or precipitation point of fluids, the transducer, lines, and other parts shall be heated by steam studs, electrical heat tracing, a radiant electric housing, or another suitable means. Conversely, insulation or cooling of instruments may be required in high temperature environments. Such provisions shall be treated as auxiliary equipment. (See 5.2.4 also.)

7.5 Auxiliary equipment

Unless otherwise justified, the requirements of 7.1 to 7.4 also apply to auxiliary equipment.

8 Interface connections

8.1 Process fluid connections

Valves, fittings, attaching bosses, adapters, tubing, and piping used to connect transducers to process piping shall be installed per ISA-S67.02.*

* See References and bibliography.

8.1.1 Performance considerations

8.1.1.1 Temperature measurements

Interface connection methods that do not involve the use of thermowells between the measurand and the transducer (that is, in-line installation) shall be used wherever necessary to achieve the response required by the system design. The designer of the installation should consider sources of error in accordance with ASME Performance Test Code, PTC19.3, "Temperature Measurement,"* as applicable to the measurand and selected transducer.

8.1.1.2 Pressure and differential pressure measurements

Designers of the installation should consider the performance guides and sources of error given in ASME Performance Test Code, PTC19.2, "Pressure Measurement,"* as applicable to the measurand and method of measurement.

8.1.1.3 Flow measurements

Designers of the installation should consider the general requirements, recommendations, conditions for proper installation and operation, errors, and other characteristics of the primary element or flowmeter, given in the ASME publication on "Fluid Meters"* and ASME-MFC standards.*

8.1.1.4 Dynamic response

The effect of valves, fittings, tubing, and the volumetric displacement of the transducer shall be included in determining the response of the installation.

8.2 Types of instrument connections

Each type of connection selected shall be qualified to the design conditions at the connection. Materials employed for valves, fittings, adapters, tubing, piping, thread lubricants, and seals shall be selected to meet the particular conditions of service required by the design, including material compatibility for welding, compatibility with the fluid chemistry, and material hardness requirements of mechanical joint fittings.

8.2.1 Flanges

Proprietary flange designs (usually two-bolt manifold adapters) are permitted as disassembly joints for the sensing lines at the transducer, when qualified for use with the transducer. Other flanges shall comply with ANSI B16.5.* Due to their bulk, installation of other flanges in the immediate area of off-line transducers is not recommended.

8.2.2 Screwed connections

Tapered pipe threads shall not be used as take-down joints when repeated disassembly and reassembly are planned. Straight thread fittings with metal-to-metal or resilient seals are permitted.

8.2.3 Flareless connections

Disassembly joints, in tubing with diameters of 25 mm OD (1 in.) or less, may be made using flareless couplings. The joints shall be made in accordance with the manufacturer's specification and shall be visually inspectable.

*See References and bibliography

8.2.4 Filled systems

These systems include all filled capillary systems, such as chemical-seal diaphragms with capillary tubing, pressure-sensitive bellows with capillary tubing, temperature bulbs with capillary tubing, and so forth. Whether factory-filled or field-filled, the capillary tubing is an extension of the transducer but shall be routed, separated, supported, and protected per ISA-S67.02. Armor provided as part of the capillary tubing is for protection during normal installation and use; it alone shall not be considered to meet separation or protective barrier requirements.

Shut-off and calibration valves in a sealed capillary line may seriously compromise the functional capability of the transducer and shall not be provided. Valves provided for capillary field-filling operations shall not be capable of interrupting the pressure-sensing path and shall have the capability of being totally sealed against external leakage by welding after the capillary lines are filled. Where an all-welded capillary tubing (that is, no mechanical joints or seals) is provided and qualified, a double leakage barrier for the process fluid or containment atmosphere inherently exists in the design. Therefore, reactor containment penetrations, if any, shall not require additional valving in the capillary.

For piping design purposes, the connection interface shall be defined as the remote bellows, diaphragm, or bulb. The remote bellows, diaphragm, or bulb shall be part of the transducer; the housing for the remote bellows, diaphragm, or bulb and its connections to the process shall be part of the piping and shall meet applicable codes and other design criteria.

8.3 Electrical connection

8.3.1 Connection boxes

Materials at connection boxes shall be compatible with the expected environment. Where electrical connections must be protected from the environment, such as would be experienced in post-accident service, the connection box design shall be qualified for the design conditions. Tapered pipe thread connections for use with conduit or cable adapters are permitted. Connection boxes furnished as part of qualified transducers shall be installed in the same configurations for which they were qualified.

8.3.2 Electrical terminations and connections

8.3.2.1 When screw terminals on terminal boards or strips are used, they shall be qualified and shall have ratings of at least twice the instrument signal voltage (or power supply voltage as applicable).

8.3.2.2 When splices are used, provide a single insulated splice for each wire. The complete splicing system shall be qualified for the design conditions.

8.3.3 Quick connectors

Where quick connectors are used, the connector and cable system design shall consider size (conductor size and overall cable size), cable retention, strain relief, and requirements for cable flexibility, pull space, and other applicable factors. Solid wire shall not be used with the removable half of quick connectors. Connectors shall be mechanically retained in the connected configuration by screw threads with a minimum of 1¼ turns or mechanical detent. Both halves of each connector shall be furnished by the same manufacturer or shall otherwise be qualified to mate properly and to provide an adequate electrical connection. The connector and cable combination shall be qualified for the design conditions.

8.3.4 Electrical cable and wire

Cables and wire furnished with racks, or special interconnecting cables furnished for connection between transducers and auxiliary equipment, shall be flame-retardant and qualified for the design conditions.

8.3.5 Shielding

Shielding shall be insulated against grounding, except at the points specified by the design documents. Shielding continuity shall be carried ungrounded through all other connection boxes, penetrations, and connectors. Braided or spiral exterior armor provided for mechanical protection should not be considered shielding.

9 Service, calibration, and test facilities

9.1 Calibration test connectors (input)

Test connections shall be provided in each sensing line for the calibration and test of equipment in place. Test connections shall be capable of being isolated from the process pressure. Test connections shall be located to permit access, testing, and accurate calibration. Connections provided at or near the transducer for the use of portable test and calibration equipment shall be provided with a plugged or capped connection designed for repeated assembly and disassembly.

9.2 Vents and drains

Capability for venting, draining, and flushing the transducer installation shall be provided where required. In addition, methods for capture and disposal of the drained, vented, or flushed process fluid from radioactive systems shall be included as part of this capability.

9.3 Signal test connections (output)

Test connections provided for test and calibration of transducers and auxiliary equipment shall not adversely affect the transducer during those periods when it is required to function. Test connections shall not interfere with the normal operation of any transducer not being tested.

9.4 Communications

Communication methods, for purposes of transducer calibration and service, should be coordinated with (and may be a part of) the overall plant communication network and systems. Due to the possibility of electromagnetic interference, portable radio transceivers shall not be the only method available for transducer calibration and service.

9.5 Labeling

Permanent labels shall be provided to facilitate identification of the installation, for warning purposes, and as guides to service and calibration. As a minimum, each transducer location shall be labeled with the transducer tag number. Where redundant groups or sets of transducers are identified by color coding, transducer and auxiliary equipment mounting labels shall be similarly color coded. Labels for non-nuclear safety transducer and warning labels or service and calibration guide labels that are not unique to a redundant group or protection set shall be of a different color.

Removable service panels or other features that may compromise the internal environment shall bear clear and permanent warning labels that explain the effects of their improper use. An example follows:

> **CAUTION — CABINET CONTAINS TEMPERATURE-SENSITIVE INSTRUMENTS. THIS COVER MUST BE IN PLACE TO MAINTAIN SYSTEM ACCURACY.**

10 Quality assurance

The installation of nuclear safety-related transducers in nuclear facilities shall be in accordance with the requirements of the owner's quality assurance program.

Annex A — References and bibliography

A.1 References

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

B16.5 Pipe Flanges and Flanged Fittings, 1988

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

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345 East 47th Street
New York, NY 10017 Tel. (212) 705-7722

ISA

ISA-S37.1 Electrical Transducer Nomenclature and Terminology, 1975 (R1982)

ISA-S51.1 Process Instrumentation Terminology, 1979

ISA-S67.02 Nuclear Safety-Related Instrument Sensing Line Piping and Tubing Standards For Use In Nuclear Power Plants, 1983

Available from: **ISA**
67 Alexander Drive
P.O. Box 12277
Research Triangle Park, NC 27709 Tel. (919) 549-8411

A.2 Bibliography

The following documents may provide additional information, guidance, or requirements for various aspects of the installation of transducers:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

N45.2 Quality Assurance Program Requirements for Nuclear Facilities, 1987

B-31.1 Power Piping, 1992

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

AMERICAN NUCLEAR SOCIETY (ANS)

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