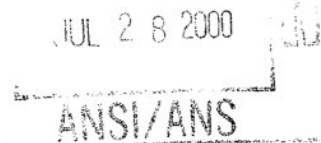


American Nuclear Society

**containment isolation provisions
for fluid systems after a LOCA**

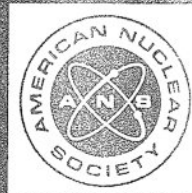


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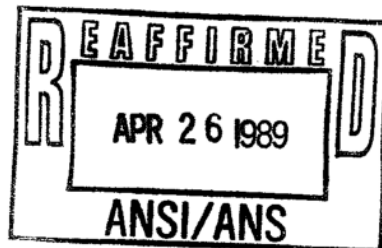
**American National Standard
Containment Isolation Provisions
for Fluid Systems After a LOCA**

Secretariat
American Nuclear Society

Prepared by the
**American Nuclear Society
Standards Committee
Working Group ANS-56.2**

Published by the
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Foreword (This Foreword is not a part of American National Standard Containment Isolation Provisions for Fluid Systems After a LOCA, ANSI/ANS-56.2-1984.)

This revision to N271-1976 has been prepared by Working Group ANS-56.2 of the American Nuclear Society. The working group was asked by the Nuclear Power Plant Standards Committee (NUPPSCO) of the American Nuclear Society to reconvene for the purpose of reviewing N271-1976, in light of the events of March 28, 1979, at Three Mile Island - Unit 2.

The ANS-56.2 Working Group was reconstituted in August 1979. Upon reviewing this standard, the Working Group found that N271-1976 provides proper guidance for the design of the containment isolation provisions of fluid systems which penetrate the primary containment boundary of light water reactors. It was determined, however, that more specific guidance was required for the actuation of these containment isolation provisions. Accordingly, this revision to N271-1976 contains criteria for containment isolation provisions actuation, including diversity of actuation parameters and the concept of phased isolation.

Other modifications made to this standard include an updating of the references, an updating of Appendix A, the addition of criteria for the protection of the isolation provisions against overpressure from thermal expansion, and the inclusion of criteria for the use of relief valves in the forward flow direction as containment isolation valves.

The purpose of this revision to N271-1976 remains the same as that of the original standard, i.e., to specify minimum design requirements for fluid systems which penetrate the primary containment boundary of light water reactors to provide for isolation of the containment. The objective of the standard is to assist designers of containment isolation provisions in providing systems which meet applicable standards, codes, and regulations. Designers of the fluid systems, containment penetrations, electrical systems, etc., which are involved with a containment isolation function must consider the requirements of the isolation function as well as the fluid system requirements. This standard is also intended to assist the plant operating staff with respect to performance testing and maintenance.

As of November 1983, the membership of ANS-56.2 was:

P. A. Totten, Chairman, <i>Gibbs & Hill, Incorporated</i>	E. V. Imbro, <i>U.S. Nuclear Regulatory Commission</i>
R. A. Berry, <i>Stone & Webster Engineering Company</i>	J. O. Schuyler, <i>Pacific Gas & Electric Company</i>
R. A. Bruce, <i>Westinghouse Electric Corporation</i>	R. S. Turk, <i>Combustion Engineering, Inc.</i>

C. Christensen (General Electric Company) and J.C. Evans (Babcock & Wilcox Company) were also members of the working group during part of the revision process.

This standard provides guidance in satisfying several of the General Design Criteria of Title 10 of the Code of Federal Regulations, Part 50, Appendix A and the systems criteria developed by the ANS NUPPSCO.

This standard considers only a single active failure after the loss-of-coolant accident or any other accident requiring actuation of the same containment isolation provisions. Any other failure requirements are not addressed in this standard. Specific guidance on the single failure for LWR fluid systems is contained in American National Standard Single Failure Criteria for LWR Safety-Related Fluid Systems, ANSI/ANS-58.9-1981.

The Working Group still notes that there is no standard which identifies an explicit list of plant conditions requiring protection system function including containment isolation. It was believed inappropriate for the present standard to develop those conditions requiring containment isolation. The working group has recommended to NUPPSO that a separate working group should be formed for the purpose of preparing a standard dealing with containment isolation requirements for accidents other than LOCAs, if NUPPSO believes it is necessary to address the subject of accident isolation.

The appendices are provided to illustrate methods of application of the standard, but are not mandatory or part of the standard. The footnotes are provided for guidance, but are not mandatory or part of the standard.

*The American Nuclear Society's Nuclear Power Plant Standards Committee (NUPP-SCO) had the following membership at the time of its approval of this standard in May 1980.

J. F. Mallay, Chairman
M. D. Weber, Secretary

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*This roster indicates NUPPSCO members' affiliations at the time of consensus committee ballot.

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Containment Isolation Provisions for Fluid Systems After a LOCA

1. Purpose and Scope.

1.1 Scope. This standard specifies minimum design, actuation, testing, and maintenance requirements for the containment isolation of fluid systems after a LOCA. These fluid systems penetrate the primary containment of light water reactors and include piping systems (including instrumentation and control) for all fluids entering or leaving the containment. Electrical systems are not included. The provisions for containment isolation impose additional requirements which are not required for the fluid system function. This standard does not consider any isolation requirements that may exist for controlled leakage areas either enclosing the primary containment or contiguous to the primary containment. Also, this standard does not address containment isolation requirements for events other than LOCAs.

This standard presents requirements and conditions that are needed for the isolation of the containment and covers requirements for isolation barriers, their actuation, their operators, and connecting piping between isolation barriers. The standard does not cover penetration assemblies, protection systems, power supplies, and equipment qualification.

The design requirements in this standard consider: the system isolation and actuation function, isolation function testing, leakage rate monitoring and testing, and maintenance. This standard gives general requirements or refers to other standards, codes, and regulations for the following requirements: fire protection; protection against natural phenomena such as earthquake, tornado, or flood; environmental conditions such as normal operation, maintenance, testing, and postulated accidents (including the dynamic effects from missiles, pipe whip, and discharging fluids); and separation criteria.

1.2 Purpose. Containment isolation is the closure of isolation provisions in lines penetrating the containment in the event of the loss-of-coolant accident within the containment or any other

accident which calls for actuation of the same containment isolation provisions. Containment isolation provisions are, therefore, provided for these accidents. If such accidents occurred, fluid systems penetrating the containment would be isolated except those which are engineered safety feature systems, or systems which are not required to function following a loss-of-coolant accident but, if available, can be used to accomplish a function similar to an engineered safety feature system (examples of such systems are BWR feed-water systems and PWR fluid systems required for reactor coolant pump operation).

Other accidents may require isolation of a specific fluid system or group of systems. The isolation provisions for such accidents are defined as accident isolation, and in many instances the provisions of this standard apply.

The objective of containment isolation shall be to allow the normal or emergency passage of the following through the containment boundary while preserving the integrity of the containment boundary:

- (1) Engineered safety feature system fluids, or
- (2) Fluids of systems which are not required to function following a loss-of-coolant accident but, if available, can be used to accomplish a function similar to an engineered safety feature system.

Other fluid systems shall be isolated immediately after a postulated loss-of-coolant accident.

2. Definitions and Terminology

accident. For the purposes of this standard, a single event, excluding a loss-of-coolant accident within the containment, that has been hypothesized for analyses purposes or postulated from unlikely but conceivable situations and that causes or threatens to cause a violation of one or more fission product barriers.

accident isolation. Establishment of isolation barrier(s) in a specific fluid system or group of

fluid systems penetrating the containment to arrest or mitigate the potential consequences of an accident.

accident isolation signal. A signal which automatically initiates the accident isolation function.

active component. An active component is one in which mechanical motion must occur to perform the component's intended safety function.

active failure. A malfunction, excluding passive failures, of a component which relies on mechanical movement to complete its intended function upon demand. Examples of active failures include the failure of a valve or a check valve to move to its correct position, or the failure of a pump, fan, or diesel generator to start. Spurious action of a power-operated safety component originating within its actuation system shall be regarded as an active failure unless specific design features or operating restrictions preclude such spurious action. An example is the unintended energization of a power-operated valve to open or close.

actuating (motive) power. Electric, pneumatic, or hydraulic supply required to operate the isolation valve.

administrative controls. Rules, orders, instructions, procedures, policies, practices, or designations of authority and responsibility.

automatic isolation valve. A valve whose closure is initiated by automatic means without any action by a plant operator upon receipt of an isolation signal from a protection system; or a simple or positive acting check valve.

closed system. A piping system which penetrates the containment and is a closed loop either inside or outside the containment. Under normal operating conditions or loss-of-coolant accident conditions for closed systems inside containment, the fluid in the system does not communicate directly with either primary coolant or containment atmosphere.

containment, primary containment, or reactor containment. For the purpose of this standard, a structure or vessel that encloses the reactor vessel and other components of the reactor coolant

pressure boundary and which provides an essentially leaktight barrier against the uncontrolled release of fission products to the environment.

containment atmosphere. Free volume enclosed by the primary containment.

containment isolation. Closure of mechanical barrier(s) in appropriate fluid systems penetrating the containment which could otherwise represent open paths to the environment from inside the containment for fission products.

containment isolation signal. A signal which serves to automatically initiate the containment isolation function.

containment isolation valve. A valve that is relied upon to perform a containment isolation function.

engineered safety feature(s). For the purpose of this standard, system(s) which is (are) required to prevent, arrest, or mitigate the consequences of an accident or loss-of-coolant accident.

general design criteria. The set of design criteria given in Title 10, Code of Federal Regulations, Part 50, "Licensing of Production and Utilization Facilities," Appendix A, "General Design Criteria for Nuclear Power Plants"[1].¹

greater safety. Preferred configuration of a system or position of an isolation valve from the overall safety viewpoint in the event of a loss-of-coolant accident or any other accident having the same containment isolation requirements as the loss-of-coolant accident.

isolation barrier(s). Mechanical means for preventing passage or release of fluid through fluid systems which penetrate the containment, e.g., valves, closed systems, blind flanges.

isolation barrier protection. Protection provided to the isolation barrier against loss of function from external events such as missiles, pipe whip, jet force, or natural phenomena.

¹Numbers in brackets refer to corresponding numbers in Section 8, References.

isolation valve seal system. A system which provides for control of leakage through the isolation barrier(s).

loss-of-coolant accident. The loss of reactor coolant at a rate in excess of the reactor coolant normal makeup rate, from breaks or openings in the reactor coolant pressure boundary inside primary containment up to, and including, a break equivalent in size to the largest justified pipe rupture (or in the absence of justification, a double-ended rupture of the largest pipe) in the reactor coolant pressure boundary.

manual. Operation of an isolation barrier by manual physical force, such as turning a hand wheel on a valve.

may. Denotes permission, neither a requirement nor a recommendation.

missile barrier. A physical barrier that protects the containment isolation barriers from missiles created by, or that could cause, an event that would require containment isolation.

missile protection. The protection afforded structures, systems or components against missiles (including jet forces and pipe whip) by physical barriers, restraints, or design configuration.

motive power failure. A loss of actuating power.

non-essential systems. Those systems which are neither engineered safety feature systems nor systems which accomplish a function similar to an engineered safety feature system.

other defined basis. A method of meeting the requirements of the General Design Criteria 55 and 56 for specific classes of lines where the arrangement differs from the explicit requirements of the General Design Criteria.

passive component. A component in which mechanical movement need not occur in order for the component to perform its intended safety function.

penetration assembly. An assembly that allows fluid lines or electric circuits to pass through a single aperture (nozzle or other opening) in the containment.

phased isolation. The sequential isolation of groups of fluid systems penetrating the reactor containment. The actuation of containment isolation is by different values of, or different combinations of measured parameters based on the ability of their fluid system to mitigate the consequences of an accident or their usefulness in maintaining the plant in safe configuration.

positive acting check valve. A check valve which can also be remote manually closed when isolation is required.

power operator. A device which uses air (air operator), electric (motor or solenoid operator), hydraulic power or spring force for mechanical actuation of the valve.

power operated valve. A valve actuated by means of a power operator.

protection system. For the purposes of this standard, all electrical and mechanical devices and circuitry (from sensors to valve operator input terminals) for the generation of signals that initiate automatically the operation of containment isolation provisions.

reactor coolant pressure boundary. All those pressure containing components, such as pressure vessels, piping, pumps, and valves that are:

- (a) part of the reactor coolant system, or
- (b) connected to the reactor coolant system up to and including any or all of the following:
 - (1) the outermost primary containment isolation valve in system piping that penetrates the primary containment,
 - (2) the second of two valves normally closed during normal reactor operation in system piping that does not penetrate primary containment, or
 - (3) the reactor coolant system safety and relief valves.

redundant system. For the purpose of this standard, the provisions of two or more systems or subsystems such that the function is duplicated to the extent that either may perform the function regardless of the state of operation or failure of the other.

remote manual actuation. Initiation of a power operated component by a discrete manual action such as operation of a control switch, predominantly

in response to intelligence or signals indicating requirement of such action.

safety class. Classification of structures, systems, or components based on their nuclear safety function. Safety Classes are given in American National Standards Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants, ANSI/ANS-51.1-1983, for PWRs[2]; and Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants, ANSI/ANS-52.1-1983, for BWRs[3].

safety related (function). For the purposes of this standard, those plant features necessary to assure the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safely shutdown condition, or the capability to prevent or mitigate the consequences of accidents that could result in offsite exposures comparable to the guideline exposures of Title 10, Code of Federal Regulations, Part 100, "Reactor Site Criteria"[4].

sealed closed isolation valve. A valve that is maintained in a closed position by administrative controls using one of the following methods:

(1) A mechanical device sealing or locking the valve in the closed position.

(2) A normally closed valve with a seal² or lock on any manual override if present.

(3) A seal or lock on the power breaker or power source in a manner that prevents power from being supplied to the valve.

severe natural phenomena. Those conditions postulated as the most severe that can reasonably be derived from the history and properties of the site and surroundings, e.g., probable maximum flood, probable maximum hurricane, tornado, tsunami, seiche, earthquake, minimum water availability.

shall. Denotes a requirement.

should. Denotes a recommendation.

simple check valve. A valve which closes upon reverse fluid flow only. (Includes testable check valves.)

structural integrity test. A test in which the

containment is pressurized to at least 1.15 times the containment design pressure, as specified in American National Standard Containment System Leakage Testing Requirements, ANSI/ANS-56.8-1981[5].

test connection or test vent. Connection to valves or connecting piping which is provided so that isolation valves can be tested for leakage tightness.

valve closure time. Time it takes for a power-operated valve to be in the fully closed position after the actuation power has reached the operator assembly; this does not include the delay time for instruments and controls.

3. Design Criteria

3.1 General. This section addresses design criteria for containment isolation provisions. The basic design criteria for the fluid systems which penetrate the containment, including their containment isolation provisions, are in 10 CFR 50, Appendix A [1]. Amplification of these criteria and additional guidance is contained in American National Standards ANSI/ANS-51.1-1983[2] and ANSI/ANS-52.1-1983[3].³

³Additional guidance is available in the following applicable U.S. Nuclear Regulatory Commission (NRC) Regulatory Guides: 1.7, Control of Combustible Gas Concentrations in Containment Following a Loss of Coolant Accident (Revision 2, November 1978); 1.11, Instrument Lines Penetrating Primary Reactor Containment (Safety Guide 11, March 10, 1971). Supplement to Safety Guide 11, Backfitting Considerations (February 17, 1972); 1.22, Periodic Testing of Protection System Actuation Functions (Safety Guide 22, February 17, 1972); 1.26, Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants (Revision 3, February 1976); 1.29, Seismic Design Classification (Revision 3, September 1978); 1.33, Quality Assurance Program Requirements (Operation), (Revision 2, February 1978); 1.46, Protection Against Pipe Whip Inside Containment (May 1973); 1.48, Design Limits and Loading Combinations for Seismic Category I Fluid System Components (May 1973); 1.57, Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components (June 1973); 1.73, Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants (January 1974); 1.75, Physical Independence of Electric Systems (Revision 2, September 1978); 1.89, Qualification of Class 1E Equipment for Nuclear Power Plants (November 1974); 1.96, Design of Main Steam Isolation Valve Leakage Control Systems for Boiling Water Reactor Nuclear Power Plants (Revision 1, June 1976); 1.100, Seismic Qualification of Electric Equipment for Nuclear Power Plants (Revision 1, August 1977).

²A seal is a physical restraint such as a lead seal.

3.2 Containment Isolation Barriers. For the isolation function, one isolation barrier is required after the occurrence of a single active failure in the isolation provisions. Normally, this is accomplished by providing two isolation barriers in series. Spare pipe penetrations having at least one end capped and welded, thereby providing a solid sealless barrier to the outside environment shall be considered to be part of, or an extension to, the containment liner, and do not require additional isolation barriers or test connections. The General Design Criteria present criteria for the isolation barriers which include valves, closed systems, and blind flanges.

3.3 General Design Criteria. General Design Criteria 54 through 57 apply to the containment isolation function and are given in this section. Illustrations of these criteria are shown in Figures 1 and 2.

3.3.1 Criterion 54, "Piping Systems Penetrating Containment"

"Piping systems penetrating primary reactor containment shall be provided with leak detection, isolation, and containment capabilities having redundancy, reliability, and performance capabilities which reflect the importance to safety of isolating these piping systems. Such piping systems shall be designed with a capability to test periodically the operability of the isolation valves and associated apparatus and to determine if valve leakage is within acceptable limits."

3.3.2 Criterion 55, "Reactor Coolant Pressure Boundary Penetrating Containment"

"Each line that is part of the reactor coolant pressure boundary and that penetrates primary reactor containment shall be provided with containment isolation valves as follows, unless it can be demonstrated that the containment isolation provisions for a specific class of lines, such as instrument lines, are acceptable on some other defined basis:

1. One locked closed isolation valve inside and one locked closed isolation valve outside containment; or
2. One automatic isolation valve inside and one locked closed isolation valve outside containment; or
3. One locked closed isolation valve inside and one automatic isolation valve outside containment. A simple check valve may not be used as the automatic isolation valve outside containment; or
4. One automatic isolation valve inside and

one automatic isolation valve outside containment. A simple check valve may not be used as the automatic isolation valve outside containment.

Isolation valves outside containment shall be located as close to containment as practical and upon loss of actuating power, automatic isolation valves shall be designed to take the position that provides greater safety.

Other appropriate requirements to minimize the probability or consequences of an accidental rupture of these lines or of lines connected to them shall be provided as necessary to assure adequate safety. Determination of the appropriateness of these requirements, such as high quality in design, fabrication, and testing, additional provisions for inservice inspection, protection against more severe natural phenomena, and additional isolation valves and containment, shall include consideration of the population density, use characteristics, and physical characteristics of the site environs."

3.3.3 Criterion 56, "Primary Containment Isolation"

"Each line that connects directly to the containment atmosphere and penetrates primary reactor containment shall be provided with containment isolation valves as follows, unless it can be demonstrated that the containment isolation provisions for a specific class of lines, such as instrument lines, are acceptable on some other defined basis:

1. One locked closed isolation valve inside and one locked closed isolation valve outside containment; or
2. One automatic isolation valve inside and one locked closed isolation valve outside containment; or
3. One locked closed isolation valve inside and one automatic isolation valve outside containment. A simple check valve may not be used as the automatic isolation valve outside containment; or
4. One automatic isolation valve inside and one automatic isolation valve outside containment. A simple check valve may not be used as the automatic isolation valve outside containment.

Isolation valves outside containment shall be located as close to the containment as practical and upon loss of actuating power, automatic isolation valves shall be designed to take the position that provides greater safety."

GENERAL DESIGN CRITERIA 55 AND 56 ISOLATION VALVE CRITERIA

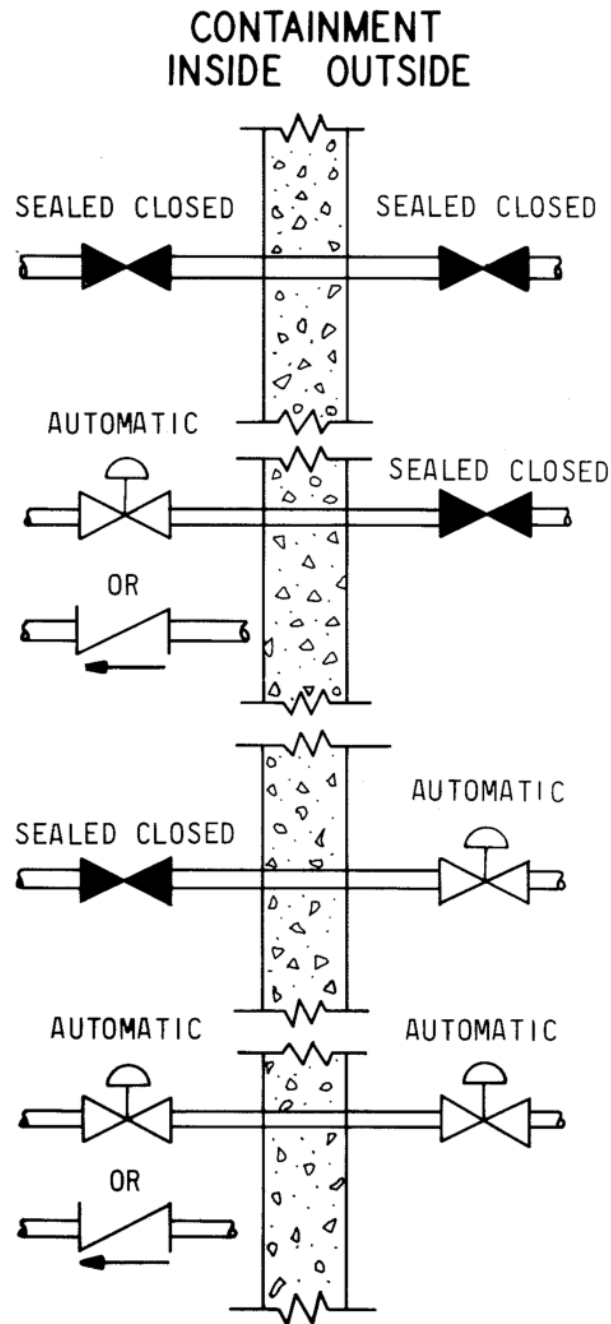


FIGURE 1

GENERAL DESIGN CRITERION 57 ISOLATION VALVE CRITERIA

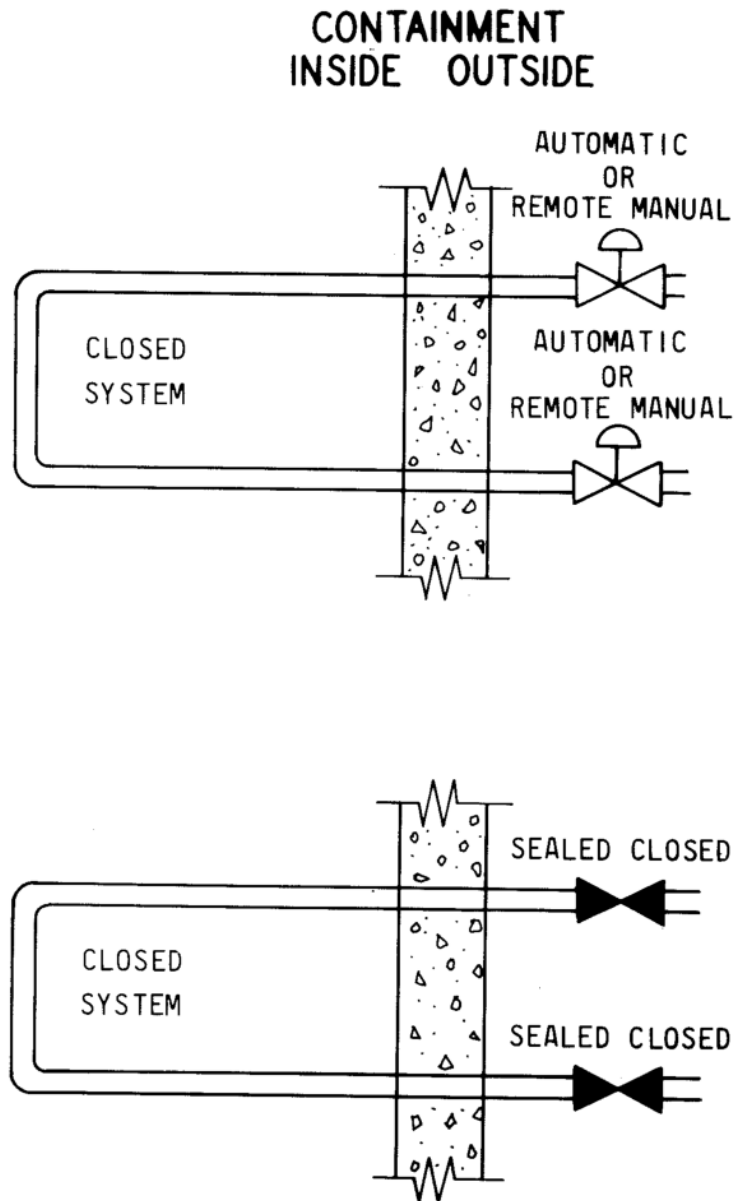


FIGURE 2

3.3.4 Criterion 57, "Closed System Isolation Valves"

"Each line that penetrates primary reactor containment and is neither part of the reactor coolant pressure boundary nor connected directly to the containment atmosphere shall have at least one containment isolation valve which shall be either automatic, or locked closed, or capable of remote manual operation. This valve shall be outside containment and located as close to the containment as practical. A simple check valve may not be used as the automatic isolation valve."

3.4 Valve Design Criteria. All containment isolation valves shall be capable of tight shutoff against leakage to meet the requirements of Title 10, Code of Federal Regulations, Part 50, "Licensing of Production and Utilization Facilities," Appendix J, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors"[6]. A containment isolation valve can be an automatic isolation valve, a sealed closed valve (see **sealed closed isolation valve**, Section 2, Definitions), a simple check valve outside containment, or a remote manual valve. Isolation valve closure times (including detection and actuation time) shall be such that the valve's intended safety functions are ensured (see 4.4.4).

3.5 Criteria for Closed Systems Inside Containment. If a closed system inside containment is used as one of the two containment isolation barriers, it shall meet the criteria that follow. However, if these criteria cannot be fully met, then General Design Criterion 56 shall be met. A closed system inside containment shall:

- (1) Not communicate with either the primary coolant or the containment atmosphere,
- (2) Be missile, pipe whip, and jet force protected,
- (3) Meet Safety Class 2 design requirements,
- (4) Withstand temperature equal to containment design temperature,
- (5) Withstand external pressure equal to containment structural integrity test pressure,
- (6) Withstand loss-of-coolant accident transients and environment,
- (7) Meet Seismic Category I design requirements,
- (8) Be protected against overpressure from thermal expansion of contained fluid when isolated, if required (see 3.9), and
- (9) Be capable of being leak tested. The leakage testing requirements are satisfied by a Type A leakage rate test (see 5.3).

3.6 Other Defined Basis

3.6.1 Purpose. General Design Criteria 55 and 56 require that each line that penetrates the containment and is part of the reactor coolant pressure boundary or is connected directly to the containment atmosphere, have one isolation valve inside and one isolation valve outside containment "unless it can be demonstrated that the design is acceptable on some other defined basis." The purpose of this section is to present guidelines, supplementary to the explicit requirements of General Design Criteria 55 and 56, for specific classes of lines which are acceptable on the "other defined bases."⁴

3.6.2 Instrument Lines. A suitable basis for demonstrating the acceptability of instrument lines penetrating containment is available.⁵ In addition, instrument lines with closed systems both inside and outside of containment, such as containment pressure instrumentation, which are designed to withstand the maximum containment structural integrity test pressure, the containment design temperature, and are protected from missiles and dynamic effects are acceptable without isolation valves.

3.6.3 Remote Manual Valves. The isolation function associated with the following systems may be accomplished remote manually instead of automatically:

- (1) Engineered safety feature systems, or
- (2) Systems which are not required to function following a loss-of-coolant accident but, if available, can be used to accomplish a function similar to an engineered safety feature system. Examples of such systems are BWR feedwater systems and PWR fluid systems required for reactor coolant pump operation.

Remote manual closure of valves is acceptable when provisions are made to detect possible failure of the fluid lines inside or outside containment, or both, and the capability is maintained to remote manually isolate these lines (see 4.12).

3.6.4 Single Valve and Closed System Both Outside Containment. For the isolation function

⁴Appendices A and B illustrate some systems which are intended to follow the guidelines on the "other defined basis."

⁵See NRC Regulatory Guide 1.11 in footnote 3. Regulatory Guides are available from the U.S. NRC, Washington, D.C. 20555.

of an engineered safety feature or system required to test an engineered safety feature, one isolation barrier is required after the occurrence of a single active failure. Normally, this is accomplished by providing two isolation valves in series. If it can be shown that a single active failure can be accommodated with only one valve in the line and that fluid system reliability is enhanced by the single valve over two valves in series while still maintaining at least a single isolation barrier, and if the closed system outside containment is designed in accordance with the criteria of 3.6.7, then one valve is acceptable. The closed system shall be leak tested in accordance with 5.3 of this standard unless it can be shown that system integrity is being maintained for those systems operating during normal plant operation at a pressure equal to or greater than the containment design pressure.

The single valve and piping between the containment and the valve shall be enclosed in a protective leaktight or controlled leakage housing to prevent leakage to the atmosphere. Conservative design of the piping and valve to preclude a breach of piping integrity may be used instead of a housing, in which case the design of the valve or the piping compartment, or both, shall provide the capability to detect leakage from the valve shaft or bonnet seals, or both, and terminate the leakage. Design guidance for acceptable conservatism in the piping design is available in American National Standard Design Basis for Protection of Light Water Nuclear Power Plants Against Effects of Postulated Pipe Rupture, ANSI/ANS-58.2-1980 [7].⁶

3.6.5 Two Valves Outside Containment. If two valves in series are to be provided for the isolation function of an engineered safety feature or system required to test an engineered safety feature and it is not practical to locate one of the two valves inside containment, both valves may be located outside containment as close as practical to the containment wall. The valve nearest the containment wall and piping between the containment and that valve shall be enclosed in a protective leaktight or controlled leakage housing to prevent leakage to the atmosphere. Conser-

vative design of the piping and valve to preclude a breach of piping integrity may be used instead of a housing, in which case the design of the valve, or the piping compartment, or both, shall provide the capability to detect leakage from the valve shaft or bonnet seals, or both, and terminate the leakage. Design guidance for acceptable conservatism in the piping design is available. (See Ref. [7] and Footnote 6.) The piping between the two isolation valves shall meet the requirements of 3.7.

3.6.6 Relief Valves. Relief valves in the backflow direction or forward (relief) flow direction may be employed as isolation valves provided they satisfy the requirements of this standard.

3.6.7 Criteria for Closed Systems Outside Containment. If a closed system outside containment is used as one of the two containment isolation barriers for an engineered safety feature or engineered safety feature related system, the closed system shall:

- (1) Not communicate with the outside atmosphere,
- (2) Meet Safety Class 2 design requirements,
- (3) Withstand temperature and internal pressure equal to the containment design conditions,
- (4) Withstand loss-of-coolant accident transient,
- (5) Meet Seismic Category I design requirements,
- (6) Be protected against overpressure from thermal expansion of contained fluid when isolated, if required,
- (7) Be protected against a high energy line break unless it can be demonstrated that the high energy line break will not result in the need for containment isolation,
- (8) Be protected against loss of function from missiles, and
- (9) Be capable of being leak tested.

3.7 Criteria for Piping. Piping which is outside the containment and is either between the containment and the outside isolation valve or between two isolation valves shall:

- (1) Meet Safety Class 2 design requirements,
- (2) Withstand the containment design temperature,
- (3) Withstand internal pressure equal to containment structural integrity test pressure,
- (4) Withstand loss-of-coolant accident transient and environment,
- (5) Meet Seismic Category I design requirements,
- (6) Be protected against a high energy line break unless it can be demonstrated that the high

⁶Also see "Postulated Break and Leakage Locations in Fluid System Piping Outside Containment," NUREG-75/087, and "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 3.6.2.

energy line break will not result in the need for containment isolation,

(7) Be protected against overpressure from thermal expansion of contained fluid when isolated, if required, and

(8) Be protected against loss of function from missiles.

Piping which is inside the containment and part of a closed system or is between the containment and the inside isolation valve shall:

(1) Meet Safety Class 2 design requirements,

(2) Withstand the containment design temperature,

(3) Withstand loss-of-coolant accident transient and environment,

(4) Meet Seismic Category I design requirements,

(5) Be protected against the effects (e.g., missiles, pipe whip, jet force) arising from the loss-of-coolant accident,

(6) Withstand external pressure equal to containment structural integrity test pressure, and

(7) Be protected against overpressure from thermal expansion of contained fluid when isolated, if required.

3.8 Criteria for Actuation of Containment Isolation. The design of the system providing the signals for containment isolation shall comply with the following requirements:

(1) The containment isolation signal shall take precedence over all other signals for actuation of containment isolation valves of nonessential systems.

(2) The designer shall determine if phased isolation is required. The basis for the decision shall be documented. Phased isolation allows the use of potentially beneficial fluid systems to mitigate the consequences of an accident and to help maintain the plant in a safe configuration.

(3) If the concept of phased isolation is not used, the containment isolation signal shall be initiated by diverse parameters. Examples of parameters that may be utilized for containment isolation are: initiation of emergency core cooling, containment pressure, and containment radiation. The containment isolation signal logic shall be such that each input parameter can independently initiate a containment isolation. In certain cases, depending on the nature of the incident and the plant response, some of the diverse parameters' input to the containment isolation signal logic may not reach their setpoint values or may reach

their setpoint values nonconcurrently. This shall constitute an acceptable level of parametric diversity for the purpose of this standard.

If the concept of phased isolation is used, diverse parameters shall be utilized to initiate all but the final phase of containment isolation. The final phase of containment isolation shall utilize diverse parameters, if possible.

(4) For pressurized water reactors, containment isolation shall occur coincident with, or earlier than, initiation of emergency core cooling. In the case of phased isolation, the first phase shall occur coincident with, or earlier than, initiation of emergency core cooling. For boiling water reactors, containment isolation shall occur coincident with the initiation of emergency core cooling or on earlier measured values of the same parameter(s) which initiate emergency core cooling.

(5) If phased isolation is utilized, all systems except the following shall be isolated automatically:

(a) Engineered safety feature systems, or

(b) Systems which are not required to function following a loss-of-coolant accident but, if available, can be used to accomplish a function similar to an engineered safety feature system. Examples of such systems are BWR feedwater systems and PWR fluid systems required for reactor coolant pump operation. Only those systems of this type which can be justified to remain operational shall not be isolated automatically during the initial phase.

If phased isolation is not used, all systems except engineered safety feature systems shall be isolated automatically.

(6) Consideration shall be given to automatically isolating those systems which are not engineered safety feature systems during the later phase(s) of isolation that are not isolated during the initial phase of isolation.

(7) Any system that is not an engineered safety feature system and which is not isolated shall be provided with a means to determine that it does not degrade containment isolation or the operation of engineered safety feature systems. If the system begins to degrade containment isolation or the operation of engineered safety feature systems, it shall be isolated. An analysis of the consequences of a leak or a line break in such systems that are not isolated shall be performed to determine how quickly a degraded system must be isolated. Guidance to permit the designer to

determine whether manual or automatic isolation is necessary has been formulated and exists in American National Standard Time Response Design Criteria for Nuclear Safety Related Operator Actions, ANSI/ANS-58.8-1984 [8].

3.9 Criteria for Overpressure Protection.

Overpressure protection shall be provided for liquid filled piping between containment isolation barriers to prevent damage when the piping is isolated unless it can be demonstrated that the pressure between the isolation barriers cannot exceed the design pressure of the isolation barriers or the piping between the isolation barriers. Certain isolation methods provide inherent overpressure protection such as the example shown in Figure 3 where a check valve provides pressure relief into the containment. Air-operated globe valves also provide inherent overpressure protection when at least one isolation valve is positioned so that trapped fluid applies pressure under the valve seat, and the valve spring is designed to allow the valve to open below the design pressure of the piping and valves. An example is shown in Figure 4 where both air-operated globe valves are positioned to allow pressure relief. Lines which do not have inherent overpressure protection, such as lines with gate, diaphragm, or butterfly valves, shall have overpressure protection provided. Bypass check valves or pressure relief valves are acceptable. Examples of these are shown in Figures 5 and 6 respectively. Any overpressure protection method utilized shall provide such protection at the maximum back pressure condition which could exist during a loss-of-coolant accident.

4. Design Requirements

4.1 General. Design criteria for containment isolation provisions are discussed in Section 3, Design Criteria. Design requirements are covered in this section.⁷

4.2 General Requirements

4.2.1. As a minimum, containment isolation provisions inside the containment shall be

⁷Appendices A and B of this standard present illustrative diagrams of systems which penetrate the containment. These diagrams show containment isolation provisions which illustrate a method of application of the standard but are not mandatory or part of the standard.

designed to withstand the maximum containment temperature and, nonconcurrently, the containment pressure resulting from the structural integrity test and the appropriate combinations of design conditions.

4.2.2. All power-operated isolation valves shall be capable of remote manual actuation from the main control room.

4.2.3. All power-operated isolation valves shall have provisions in the control room for indication of the status of the valve showing open and closed positions. Position indication shall be from a direct acting source, e.g., limit switch. A failure of an indication circuit shall not cause a failure of the actuation circuit. Single channel indication is sufficient for each valve. Additional design guidance is available in American National Standard Criteria for Accident Monitoring Functions in Light-Water-Cooled Reactors, ANSI/ANS-4.5-1980 [9]. All electric power-operated isolation valves shall have provisions in the control room for indication of the availability of power at the line side of the motor starter, e.g., status indicating lights energized from control power transformer. Sealed closed manual isolation valves are under administrative controls and do not require position indication in the control room for valve status.

4.2.4. Following receipt of an isolation signal, the isolation function shall be completed. Isolation valves shall not be returned to their normal (i.e., preaccident) condition either automatically when the isolation logic is reset or by a single containment isolation system override. Following isolation valve closure, valves shall not be capable of being reopened until (a) the isolation signal is cleared or overridden and (b) deliberate operator action is taken to open each valve (see 4.4.2).

4.2.5. Diverse parameters shall be utilized as specified in 3.8.3.

4.3 Actuation. Specific requirements for actuation of isolation valves are given in Section 3, Design Criteria. Loss of offsite power, closing times, instrument and control delay times, motive power delay times, and possible adverse transient conditions unique to isolating a given fluid system shall be considered in determining whether a particular sequence of valve actuation is required.

4.4 Containment Isolation Barrier Design

4.4.1 Valve Location. Specific requirements

EXAMPLE OF INHERENT OVER PRESSURE PROTECTION
CONTAINMENT
INSIDE OUTSIDE

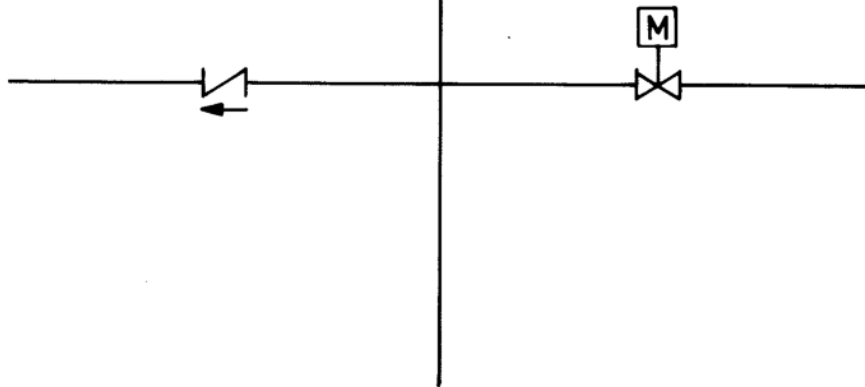


FIGURE 3

EXAMPLE OF INHERENT OVER PRESSURE PROTECTION
CONTAINMENT
INSIDE OUTSIDE

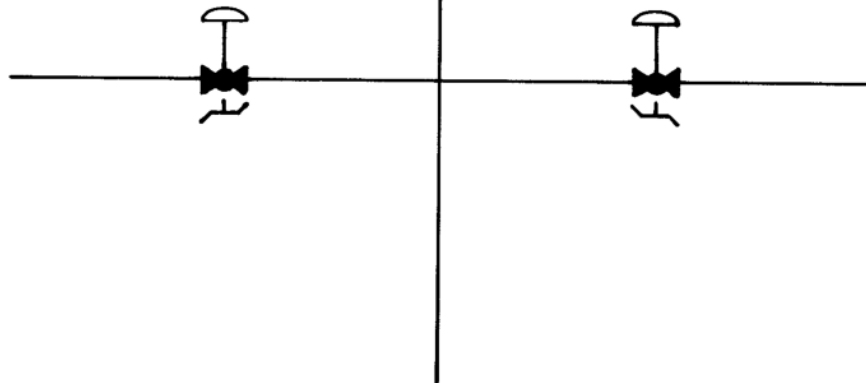


FIGURE 4

EXAMPLE OF PROVISION FOR OVER PRESSURE PROTECTION
CONTAINMENT
INSIDE | OUTSIDE

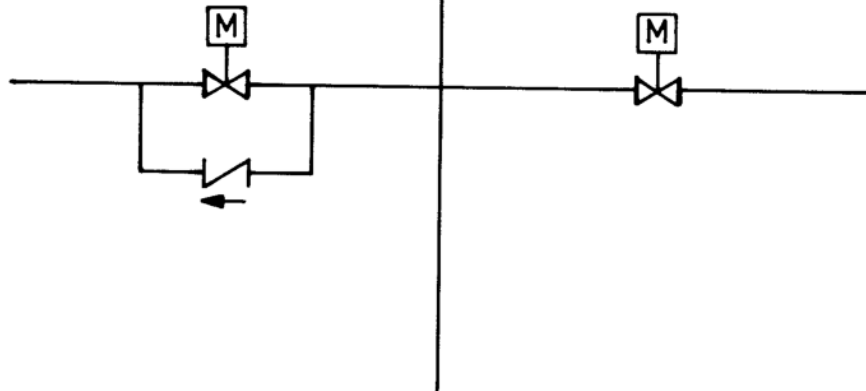


FIGURE 5

EXAMPLE OF PROVISION FOR OVER PRESSURE PROTECTION
CONTAINMENT
INSIDE | OUTSIDE

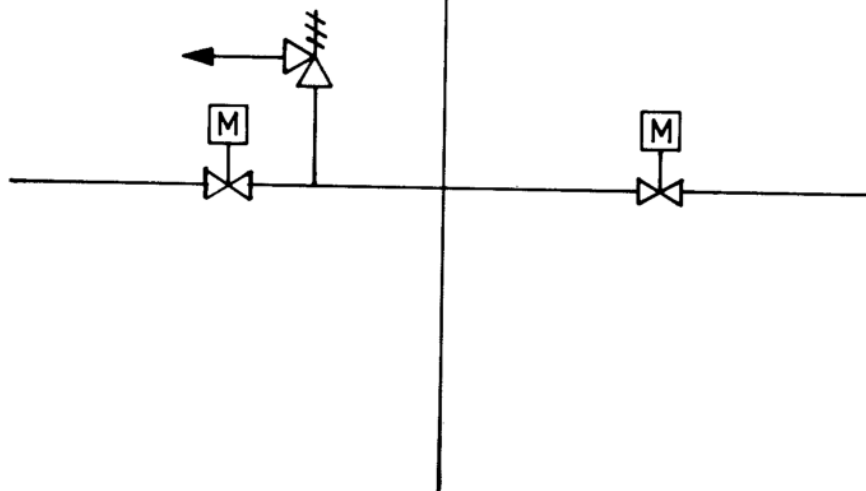


FIGURE 6