6.2.4 Containment Isolation System

The containment isolation system (CIS) provides the means for isolating fluid systems that pass through containment penetrations to confine radioactivity that may be released into the containment following a postulated accident. The CIS is not a discrete system, but is comprised of isolation barriers (e.g., valves, closed systems, blind flanges), system piping between the isolation barriers, and the associated instrumentation and control circuitry for fluid systems that penetrate the reactor building containment.

6.2.4.1 Design Bases

The CIS components are designed to quality standards commensurate with the importance of the safety functions to be performed (GDC 1) and to withstand the effects of natural phenomena without loss of capability to perform safety functions (GDC 2). The CIS components are designed to accommodate the effects of and to be compatible with environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, and are protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids (GDC 4). The CIS components isolate fluid system piping that penetrates the Reactor Building to prevent the discharge of radioactivity from containment following a postulated accident (GDC 16).

Piping systems penetrating the containment are provided with leak detection, isolation, and containment capabilities having redundancy, reliability, and performance capabilities, which reflect the importance to safety, and are designed with the capability to periodically test for valve operability and to determine valve leakage (GDC 54). Piping that is part of the reactor coolant pressure boundary (RCPB) and penetrates containment is provided with containment isolation valves according to GDC 55. Piping that connects directly to the containment atmosphere and penetrates containment is provided with containment isolation valves according to GDC 56. Piping that penetrates containment and is neither part of the RCPB nor connected directly to the containment atmosphere is provided with containment isolation valves according to GDC 57.

CIS components, including associated control systems, are designed in accordance with 10 CFR 50.34(f)(2)(xiv) and 10 CFR 50.34(f)(2)(xv) and conform to the requirements of RG 1.141 through adherence to ANSI/ANS–56.2 (Reference 7).

The containment isolation valve power supplies satisfy station blackout requirements, in accordance with 10 CFR 50.63.

Instrumentation and control lines that penetrate containment are designed to the requirements of RG 1.11.

6.2.4.2 System Design

6.2.4.2.1 General System Design

The containment isolation system provides the means of isolating fluid systems that pass through containment penetrations to confine radioactivity in the containment. Following a postulated accident, the containment isolation system isolates non-essential fluid systems penetrating the containment. The containment isolation system is comprised of the integrated functioning of selected elements of other physical systems, and isolation design is achieved by applying acceptable common criteria to the containment isolation portions of those systems, and by using containment pressure, high containment activity, or a safety injection actuation signal to generate a containment isolation actuation signal to close the appropriate valves. ESF actuation is described in Section 7.3.

Containment isolation is typically provided by two valves at each containment penetration, with one valve inside and one valve outside the containment. Table 6.2.4-1—Containment Penetration, Isolation Valve, and Actuator Data lists the containment isolation penetrations and provides a summary of the valve and actuator data. In addition to the penetrations for mechanical lines, Table 6.2.4-1 also lists containment openings for the personnel airlocks, equipment hatch, and fuel transfer tube. Sealed closed barriers are maintained under administrative control.

Isolation valves outside containment are located as close as practical to the containment or shield building walls considering required access for:

- In-service inspection of non-isolable welds.
- 10CFR50 Appendix J, Containment Leakage Testing.
- Cutout and replacement of isolation valves using standard pipe fitting tools and equipment.
- In-place valve seat resurfacing.

Valves that may require local manual operation are located, taking into account accessibility and radiation levels resulting from postulated accidents.

Sumps in the Safeguard Buildings, Fuel Building, and Reactor Building are monitored and alarms or indications are provided to the operator to detect the presence of water in these areas. Sump monitoring provides an indication to the control room operator that remote manual containment isolation valves may need to be closed.

The functional arrangements of containment isolation valves are shown on system piping and instrumentation diagrams. Section 1.7 provides a list of piping and instrumentation diagrams. Figure 6.2.4-1—Representative Containment Isolation

Valve Arrangement displays representative valve arrangements and shows the relationships of the containment, annulus, shield building wall, and the outside environment.

Containment isolation system components are classified with regard to safety, quality group, and seismic category. Isolation valves, valve actuators, and penetration piping are designated safety related, Quality Group B, and Seismic Category I. Table 3.2.2-1 provides the seismic and other design classifications of the components in the containment isolation system. Systems used for accident mitigation or required for safe shutdown are identified as essential systems in Table 6.2.4-1.

Upon loss of actuating power, automatic isolation valves, with the exception of motor-operated valves (MOV), are designed to fail to the position that provides greater safety, as identified in Table 6.2.4-1. For lines equipped with MOVs, a loss of actuating power may leave the affected valve in the “as-is” position, which may be the open position. In this case, the redundant isolation valve provides the isolation function for the penetration.

Section 3.6.2 of ANSI/ANS-56.2 (Reference 7) allows an additional basis for demonstrating the acceptability of the instrument lines penetrating the containment. Instrument lines with closed system both inside and outside of containment, such as containment pressure instrumentation, that 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 valve. The containment isolation provisions for instrumentation and control sensing lines that penetrate the containment are designed to the requirements of RG 1.11.

6.2.4.2.2 Isolation of Lines Serving as Part of the RCPB or Connected Directly to the Containment Atmosphere

Lines that penetrate containment and are part of the RCPB or directly connect to the containment atmosphere have one of the following isolation valve configurations:

- One locked closed isolation valve inside and one locked closed isolation valve outside containment.
- One automatic isolation valve inside and one locked closed isolation valve outside containment.
- One locked closed isolation valve inside and one automatic isolation valve outside containment. A simple check valve is not used as the automatic isolation valve outside containment.
- One automatic isolation valve inside and one automatic isolation valve outside containment. A simple check valve is not used as the automatic isolation valve outside containment.

Certain containment isolation valves in systems required for accident mitigation do not receive a containment isolation actuation signal because their systems are required for accident mitigation. However, the containment isolation function may be required postaccident; therefore, the valves can be closed remotely from the main control room (MCR).

The four safety injection system trains draw suction from the in-containment water storage tank (IRWST). These suction lines each contain only one remotely operated isolation valve located outside the containment. The isolation valves do not receive an automatic containment isolation signal. Rather, the valves remain open during a postulated accident to support the safety injection function. The section of piping located between the IRWST and each isolation valve is contained in a guard pipe, thus providing a double leak-tight penetration barrier. This arrangement provides a higher level of safety than the standard isolation valve arrangement. The SIS outside containment is protected from missiles and seismic events, is constructed to Quality Group B and Seismic Category I standards, and has a design temperature and pressure rating equal to that of the containment. The IRWST is provided with sump screens to prevent debris entrainment into the SIS, as described in Section 6.3.2.5.

The containment building ventilation system (CBVS) includes purge lines that connect directly to the containment atmosphere, as described in Section 9.4.7. Area radiation monitors provide a containment isolation signal on high radiation (see Table 11.5-1, Section 12.3, Table 12.3-3, and Table 12.3-4, Monitor R-9).

The severe accident heat removal system (SAHRS) draws suction from the IRWST. The piping inside containment is embedded in concrete and the penetration piping is protected by a guard pipe. Two remotely operated isolation valves outside containment receive an automatic containment isolation signal to close. An identical arrangement exists for the suction line from the IRWST to the chemical and volume control (CVCS) charging pumps.

The positions of the individual containment isolation valves depend on the plant's operating mode, and on the specific fluid system's functional requirements for that mode. The positions of each containment isolation valve under normal and accident conditions are listed in Table 6.2.4-1.

6.2.4.2.3 Closed System Isolation Valves

Lines that penetrate the containment and are neither part of the RCPB nor connected directly to the containment atmosphere have at least one isolation valve that is located outside the containment. The isolation valve is either automatic, or locked closed, or capable of remote manual operation. For these lines, simple check valves are not used as automatic isolation valves. The containment isolation valves of these systems provide the capability to detect leakage from the valve shaft or bonnet seals.

The positions of the individual containment isolation valves depend on the operating mode of the plant, and on the specific fluid system's functional requirements. The positions of the containment isolation valves for each penetration under normal and accident conditions are listed in Table 6.2.4-1.

Closed system piping inside containment that serves as one of the containment isolation barriers meets containment isolation design requirements, as discussed in Section 6.2.4.3.

6.2.4.2.4 System Actuation

When required by plant conditions, the protection system (PS) sends containment isolation signals that automatically isolate the non-essential process lines. The U.S. EPR senses diverse parameters to initiate redundant, train-oriented, isolation signals. While a variety of conditions trigger valve closure, the majority of process lines are closed when they receive a containment isolation signal that is generated by one of the following initiating conditions.

- Containment Isolation Stage 1 on Containment Equipment Compartment Pressure > Max1p.
- Containment Isolation Stage 1 on Containment Service Compartment Pressure (NR) > Max2p.
- Containment Isolation Stage 1 on High Containment Activity > Max1p.
- Containment Isolation Stage 1 on SIS Actuation.
- Containment Isolation Stages 1 and 2 on Containment Service Compartment Pressure (WR) > Max3p.

Stage 1 and Stage 2 containment isolation functions are addressed in Section 7.3.1.2.9. The pressure setpoint Max1p is set to a minimum value compatible with normal operating conditions.

The PS automatically isolates containment. Each non-essential containment penetration has two isolation barriers in series, and each of the two barriers is actuated by a different PS division. Resetting the containment isolation signal does not automatically reopen the containment isolation valves. Deliberate operator action, consisting of two independent actions, is required to reopen the valves. Redundancy and reliability of the actuation system are addressed in Section 7.3.

Isolation valves have actuation features appropriate to the valve type and required closure time. Power-operated isolation valves can be remotely actuated from the MCR. These valves have one operator with two methods of actuation, a primary and secondary mode. For power-operated isolation valves that automatically operate upon receipt of a containment isolation signal, the automatic initiating signal provides the primary mode and a remote manual initiation from the MCR is the secondary mode. For power-operated isolation valves that do not receive a containment isolation signal, the primary actuation mode is a remote manual initiation signal from the MCR. For the power operated isolation valves outside the containment, a local secondary mode of operation is provided, such as a handwheel for manual operation.

Containment isolation valves that are capable of being operated remotely are operated from the MCR. The signal to initiate individual containment isolation valves is listed in Table 6.2.4-1.

6.2.4.2.5 Electrical Power Supplies

The MOV isolation valves inside the containment are supplied from Class 1E 480 Vac buses and are backed up by the Class 1E uninterruptible power supply system (EUPS) and emergency diesel generators. These buses are also supplied by the station blackout diesel generators (SBODG) during station blackout (SBO) conditions. To limit the peak load on the EUPS batteries and inverters a staggered closure sequence is provided by the PS for valves inside the containment that are powered by the EUPS and receive a containment isolation signal. The PS implementation of the containment isolation function is described in Section 7.3.1.2.9.

The MOV isolation valves outside the containment are supplied from Class 1E 480 Vac buses. The buses are backed up by the emergency diesel generators, and can also be supplied from the SBODGs during SBO conditions. Additionally, the 12-hour UPS can be manually connected to provide power to these buses.

The power supplies for containment isolation valves, and for valve position indication, satisfy station blackout requirements. Station blackout is addressed in Section 8.4.

Electrical alternate feeds, as described in Section 8.3.1.1.1 provide normal and standby power when certain electrical components are out of service. The alternate feeds create two divisional pairs in the emergency power supply system. Containment isolation valves that require electrical power to perform the containment isolation safety function are powered from separate divisional pairs to satisfy single failure criteria with respect to the electrical power supply. Valves that fail to reach their safety position, such as solenoid valves, may be powered from the same divisional pair to satisfy operational requirements.

The use of motor-operated valves that fail in the as-is position upon loss of actuating power is based on the consideration of what valve position provides for the plant safety requirements.

6.2.4.2.6 Isolation Valve Closure Times

Valve closure times consider the containment isolation requirements, the capabilities and requirements of the individual fluid system (e.g., water hammer), and the effect of closure time on the valve reliability. Isolation valve closure times, including detection and actuation time are such that the intended safety functions of the valves are achieved. Closure time requirements are as follows:

- In general, power operated valves $3^1/_2$ inches to 12 inches in diameter close at least within the time determined by dividing the nominal valve diameter by 12 inches per minute.
- Valves 3 inches and less close within 15 seconds.
- All valves larger than 12 inches in diameter close within one minute.
- Valves in the containment building ventilation system that are associated with containment purging operations close within five seconds. The shorter closure time requirement supports the radiological release evaluations in Section 15.0.3.
- An exception to the valve closing time requirements is the containment full flow ventilation subsystem. Supply and exhaust valves in the full flow portion of the system are maintained closed during normal plant operation (MODES 1, 2, 3, and 4). This portion of the system is used only during plant shutdown or refueling operations. No closure times are required to be listed for these valves.

In determining appropriate valve closure times, a variety of factors are considered, including time delays due to loss of offsite power, valve stroke times, instrument and control delay times, motive power delay times (e.g., diesel start delays), and possible adverse transient conditions unique to isolating a given system.

Individual valve closure times (T3 and T4) are listed in Table 6.2.4-1. The valve closure times are for valve assembly only, and do not include sensor or I&C delays. The sensor and I&C delays are described in Section 7.3. The definition and allocation of the different portions of the total response time are described in Section 7.1. Valve testing requirements are described by the inservice testing program for valves in Section 3.9.6.

6.2.4.2.7 Penetrations Overpressure Protection

Overpressure protection is 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.

Mechanical system lines that use a check valve as one of the containment isolation valves have inherent overpressure protection. Other lines with gate, diaphragm, or butterfly valves have overpressure protection provided by either a bypass check valve or a pressure relief valve. The overpressure protection method utilized provides such protection at the maximum back pressure condition that could exist during a loss of coolant accident (LOCA). Containment penetration overpressure protection configurations are shown in Figure 6.2.4-2—Containment Isolation Valve Arrangements for Overpressure Protection.

6.2.4.3 Design Evaluation

Containment isolation valves are protected from the effects of external hazards by virtue of their placement in Seismic Category I structures. Protection from internal hazards is addressed in Section 3.4 (flooding), Section 3.6 (pipe rupture), and Section 9.5.1 (fire). Environmental qualification of CIS components is addressed in Section 3.11. Containment isolation valves are capable of tight shutoff against leakage to minimize radioactive material release following a postulated accident.

The CIS can perform its safety function in the event of any single active failure. The containment isolation system includes double isolation barriers at the containment penetrations. Redundant isolation valves are powered from separate electrical divisions to provide containment isolation in the event of a single active failure in the electrical system. Alternate electrical feeds, described in Section 8.3.1.1.1, maintain single failure criteria during conditions where certain electrical components are out of service. Alternate onsite power sources provide power to the valves to close in time to achieve safety functions in case of a loss of offsite power. Redundancy in the instrumentation and control systems is described in Section 7.3.

Closed system piping inside containment and piping between the containment and the inside isolation valve are designed to withstand the containment design temperature, an external pressure equal to the containment structural integrity test pressure, and the environmental effects resulting from a LOCA. The effects of a LOCA against which closed system piping are protected include missiles, pipe whip, and jet forces. The qualification of the inside isolation barriers considers differential pressure, peak pressure and temperature, maximum humidity, a steam-laden atmosphere, and the presence of chemical additives in the atmosphere following a LOCA.

Piping outside the containment that is either between the containment and the outside isolation valve or is between the two outside isolation valves is designed to withstand the containment design temperature, the internal pressure from the containment structural integrity test, and the LOCA environment. Containment isolation barriers located outside containment are designed to function under the most adverse anticipated environmental conditions to which they may be exposed. The outside isolation barrier is located as close as practical to the containment or shield building walls.

Containment isolation barriers remain capable of performing their intended function under the maximum integrated radiation doses to which they may be exposed during the service life in the plant. This capability includes exposure from lifetime operation of the plant combined with the maximum anticipated exposure that could occur following a LOCA.

6.2.4.4 Inspection and Testing Requirements

Refer to Section 14.2 (Test Abstract #027) for initial plant testing of the CIS. See Section 6.6 for inservice inspection requirements. Refer to Section 3.9.6 for inservice testing of containment isolation valves.

Containment leakage rate testing is performed to demonstrate the continued structural integrity of the containment and the continued adequacy of the isolation barriers in the containment isolation system. The containment leakage rate testing program is described in Section 6.2.6. Test connections are provided to allow the required testing of the valves, as shown on the system drawings.

6.2.4.5 Instrumentation Requirements

Power-operated isolation valves have indication showing open and closed positions in the MCR. Position indication is from a direct acting source (e.g., a limit switch), and single channel indication is sufficient for each valve. A failure of an indication circuit will not cause a failure of the actuation circuit. For systems equipped with remote-manual isolation valves, instrumentation is provided to alert the operators in the MCR to isolate systems when required.

The test instruments required for the Type A, B, and C tests are described in the containment leakage rate testing program in Section 6.2.6.

Next File