Westinghouse Electric Corporation

Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

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U.S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: T. R. QUAY

SUBJECT: AP600 DESIGN CERTIFICATION; REVISION TO RESPONSE FOR RAI 410.17 AND CLARIFICATION OF COMPLIANCE WITH REGULATORY GUIDE 1.45

Dear Mr. Quay:

This provides the attached revision to our response to RAI 410.17. The attached revision is based upon a telephone conversation with the NRC and additional leak detection analysis. The SSAR markup included with the attachment also provides the requested compliance statements for Regulatory Guide 1.45. This submittal should close all remaining open items related to reactor coolant leakage detection.

If you have any questions, please contact me on 412-374-4334 or J. W. Winters on 412-374-5290.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

jml

Attachment: Revision 3 of Response to RAI 410.17

cc: W. C. Huffman, NRC (w/Attachment)
N. J. Liparulo, Westinghouse (w/o Attachment)

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Question 410.17 Revision 3

Position C.9 of RG 1.45 states that the technical specifications should address the availability of various types of instruments for RCPB leakage to ensure adequate coverage at all times. Describe how the AP600 design will meet this regulatory position (Section 5.2.5).

Response:

SSAR Chapter 16, Technical Specification 3.4.10 defines the operability requirements for RCS leakage detection instrumentation. This instrumentation, used to identify reactor coolant pressure boundary leakage, is designed so that its operability may be determined at all times. Should a detector fail (signal outside its calibrated range or self-detect trouble), the plant instrumentation system will alarm in the main control room that the specific leak detection display is questionable. The alarm prompts the operators to observe other sensors providing leak detection information. Technical Specification 3.4.10 requires instruments of diverse monitoring methods to be operable to provide a high degree of confidence that small leaks are detected in time to allow actions to place the plant in a safe condition when RCS leakage indicates possible reactor coolant pressure boundary degradation .

The primary methods of detecting leaks during stable plant operating conditions are sump level changes and reactor coolant inventory (pressurizer level) changes. The primary methods for detecting leaks during varying system conditions such as makeup and letdown operations and power transients are sump level changes and N13/F18 detection.

Table 410.17-1 summarizes the validity of the diverse methods of detecting RCPB leakage.

During a typical year of operation, the plant will normally be in steady state conditions with all three diverse methods of leak detection valid. The cumulative time for RCS transients such as power changes and letdown due to plant heatup, RCS boration or dilution operations will be less than 1% of the time. The RCS inventory leak detection method is invalid during these RCS transients. Table 410.17-2 summarizes estimates of the average cumulative times of RCS transients assuming a normal fuel cycle with one additional shutdown to hot standby (Mode 3) per year.

SSAR Revision: Revisions to SSAR Section 5.2.5 and Chapter 16 are attached. Revision 2 of this RAI response was submitted to provide the complete markup for SSAR Chapter 16. The Revision 1 markup included only the BASES changes for Technical Specification 3.4.10 whereas the LCO changes were included in Revision 2. Revision 3 added Table 410.17-2.

Table 410.17-1 Validity of RCPB Leak Detection Methods

MODES	TITLE	REACTIVITY CONDITION (K_{eff})	% RATED THERMAL POWER(a)	AVERAGE RCS TEMPERATURE (°F)	Validity of RCPB Leak Detection Method		
					Sump Level (d),(e)	N13/F18	RCS Inventory (g)
1	Power Operation	> 0.99	> 5	NA	Valid	Valid(f)	Valid
2	Startup	> 0.99	< 5	NA	Valid	Invalid	Valid
3	Hot Standby	< 0.99	NA	> 420	Valid	Invalid	Valid
4	Safe Shutdown(b)	< 0.99	NA	420 > T_{avg} > 200	Valid	Invalid	Valid
5	Cold Shutdown(b)	< 0.99	NA	< 200	NA	NA	NA
6	Refueling(c)	NA	NA	NA	NA	NA	NA

(a) Excluding decay heat.
(b) All reactor vessel head closure bolts fully tensioned.
(c) One or more reactor vessel head closure bolts less than fully tensioned.
(d) Sump level change detection of leaks not valid during extremely cold outside conditions when frost forms on interior of containment vessel.
(e) Leak detection method not valid during containment atmosphere purge operations or within 2 hours of end of purge.
(f) Power > 20%
(g) RCS at steady state; i.e. no temp. change, no pressure change, no makeup or letdown.

Table 410.17-2 Estimated Annual Cumulative Time of RCS Transients

Mode	Operation & Transition	Reactivity	Power Level %	Temperature	Hours	Fraction
1	Power Operation	> 0.99	> 5	NA		
	Power change				12.0	0.14%
	Letdown and makeup for dilution due to core burnup				10.0	0.11%
	Makeup for leaks (includes boron equalization in pressurizer)				12.0	0.14%
2	Startup	> 0.99	< 5	NA		
	Power change				2.0	0.02%
	Letdown and makeup for dilution and heatup, normal				8.1	0.09%
	Letdown and makeup for dilution and heatup, return from hot standby				5.4	0.06%
3	Hot Standby	< 0.99	NA	> 420		
	Makeup for leaks				2.0	0.02%
	Heatup, return from hot standby				0.9	0.01%

Table 410.17-2 (continued) Estimated Annual Cumulative Time of RCS Transients

Mode	Operation & Transition	Reactivity	Power Level %	Temperature	Hours	Fraction
4	Safe Shutdown	< 0.99	NA	420 > Tavg > 200		
	Transition between Modes 3 & 5, normal				7.0	0.08%
	Letdown and makeup for boration, normal				4.7	0.05%
	Letdown and makeup for boration, return from hot standby				1.6	0.02%
5	Cold Shutdown	< 0.99	NA	< 200		
6	Refueling	NA	NA	NA		
					Total 66 hours =	**0.73%**

5.2.4.4 Inspection Intervals

Inspection intervals are established as defined in Subarticles IWA-2400 and IWB-2400 of The ASME Code, Section XI. The interval may be extended by as much as one year so that inspections are concurrent with plant outages. It is intended that in-service examinations be performed during normal plant outages such as refueling shutdowns or maintenance shutdowns occurring during the inspection interval.

5.2.4.5 Examination Categories and Requirements

The examination categories and requirements are established according to Subarticle IWB-2500 and Table IWB-2500-1 of the ASME Code, Section XI. The preservice examinations comply with IWB-2200.

5.2.4.6 Evaluation of Examination Results

Examination results are evaluated according to IWA-3000 and IWB-3000, with flaw indications according to IWB-3400 and Table IWB-3410-1. Repair procedures, if required, are according to IWB-4000 of the ASME Code, Section XI.

5.2.4.7 System Leakage and Hydrostatic Pressure Tests

System pressure tests comply with IWA-5000 and IWB-5000 of the ASME Code, Section XI. These system pressure tests are included in the design transients defined in Subsection 3.9.1. This subsection discusses the transients included in the evaluation of fatigue of Class 1 components due to cyclic loads.

5.2.5 Detection of Leakage Through Reactor Coolant Pressure Boundary

The reactor coolant pressure boundary (RCPB) leakage detection monitoring provides a means of detecting and to the extent practical, identifying the source and quantifying the reactor coolant leakage. The detection monitors perform the detection and monitoring function in conformance with the requirements of General Design Criteria 2 and 30 and the recommendations of Regulatory Guide 1.45. Leakage detection monitoring is also maintained in support of the use of leak-before-break criteria for high-energy pipe in containment. See subsection 3.6.3 for the application of leak-before-break criteria.

Leakage detection monitoring is accomplished using instrumentation and other components of several systems. Diverse measurement methods including level, flow, and radioactivity measurements are used for leak detection. The equipment classification for each of the systems and components used for leak detection is generally determined by the requirements and functions of the system in which it is located. There is no requirement that leak detection and monitoring components be safety-related. See Figure 5.2-1 for the leak detection approach. The descriptions of the instrumentation and components used for leak detection and monitoring include information on the system.

To satisfy position 1 of Regulatory Guide 1.45, reactor coolant pressure boundary leakage is classified as either identified or unidentified leakage. Identified leakage includes:

- Leakage from closed systems such as pump gasket or reactor vessel seal leaks that are captured and conducted to a sump or collecting tank

- Leakage into auxiliary systems and secondary systems (intersystem leakage) (This leakage is not considered to be part of the 10 gpm limit identified leakage in the bases of the technical specification 3.4.8. This additional leakage must be considered in the evaluation of the reactor coolant inventory balance.)

Other leakage is unidentified leakage.

5.2.5.1 Collection and Monitoring of Identified Leakage

Identified leakage other than intersystem leakage is collected in the reactor coolant drain tank. The reactor coolant drain tank is a closed tank located in the reactor cavity in the containment. The tank vent is piped to the gaseous radwaste system to prevent release of radioactive gas to the containment atmosphere. For positions 1 and 7 of Regulatory Guide 1.45, the liquid level in the reactor coolant drain tank and total flow pumped out of the reactor coolant drain tank are used to calculate the identified leakage rate. These parameters are available in the main control room. The reactor coolant drain tank, pumps, and sensors are part of the liquid radwaste system. The following sections outline the various sources of identified leakage other than intersystem leakage.

The identified leakage rate is automatically calculated by the plant computer. A lea as small as 0.1 gpm can be detected in one hour. The desig leak of 10 gpm will be detected in less than a minute.

5.2.5.1.1 Valve Stem Leakoff Collection

Valve stem leakoff connections are not provided in the AP600.

5.2.5.1.2 Reactor Head Seal

The reactor vessel flange and head flange are sealed by two concentric seals. Seal leakage is detected by two leak-off connections: one between the inner and outer seal, and one outside the outer seal. These lines are combined in a header before being routed to the reactor coolant drain tank. An isolation valve is installed in the common line. During normal plant operation, the leak-off valves are aligned so that leakage across the inner seal drains to the reactor coolant drain tank.

A surface-mounted resistance temperature detector installed on the bottom of the common reactor vessel seal leak pipe provides an indication and high temperature alarm signal in the main control room indicating the possibility of a reactor pressure vessel head seal leak. The temperature detector and drain line downstream of the isolation valve are part of the liquid radwaste system.

The reactor coolant pump closure flange is sealed with a welded canopy seal and does not require leak-off collection provisions.

Leakage from other flanges is discussed in subsection 5.2.5.3, Collection and Monitoring of Unidentified Leakage.

5.2.5.1.3 Pressurizer Safety Relief and Automatic Depressurization Valves

Temperature is sensed downstream of each pressurizer safety relief valve and each automatic depressurization valve mounted on the pressurizer by a resistance temperature detector on the discharge piping just downstream of each valve. High temperature indications (alarms in the main control room) identify a reduction of coolant inventory as a result of seat leakage through one of the valves. These detectors are part of the reactor coolant system. This leakage is drained to the reactor coolant drain tank during normal plant operation and vented to containment atmosphere or the in-containment refueling water storage tank during accident conditions. This identified leakage is measured by the change in level of the reactor coolant drain tank.

5.2.5.1.4 Reactor Coolant Pump Drain

Leakage from the reactor coolant pump drain is directed to the reactor coolant drain tank. This identified leakage is measured by the change in level in the reactor coolant drain tank.

5.2.5.1.5 Other Leakage Sources

In the course of plant operation, various minor leaks of the reactor coolant pressure boundary may be detected by operating personnel. If these leaks can be subsequently observed, quantified, and routed to the containment sump, this leakage will be considered identified leakage.

5.2.5.2 Intersystem Leakage Detection

Substantial intersystem leakage from the reactor coolant pressure boundary to other systems is not expected. However, possible leakage points across passive barriers or valves and their detection methods are considered. In accordance with position 4 of Regulatory Guide 1.45, auxiliary systems connected to the reactor coolant pressure boundary incorporate design and administrative provisions that limit leakage. Leakage is detected by increasing auxiliary system level, temperature, flow, or pressure, by lifting the relief valves or increasing the values of monitored radiation in the auxiliary system.

The normal residual heat removal system and the chemical and volume control system, which are connected to the reactor coolant system, have potential for leakage past closed valves. For additional information on the control of reactor coolant leakage into these systems, see subsections 5.4.7 and 9.3.6 and the intersystem LOCA discussion in subsection 1.9.5.1.

5.2.5.2.1 Steam Generator Tubes

An important potential identified leakage path for reactor coolant is through the steam generator tubes into the secondary side of the steam generator. Identified leakage from the steam generator primary side is detected by one, or a combination, of the following:

- High condenser air removal discharge radioactivity, as monitored and alarmed by the turbine island vent discharge radiation monitor
- Steam generator secondary side radioactivity, as monitored and alarmed by the steam generator blowdown radiation monitor
- Secondary side radioactivity, as monitored and alarmed by the main steam line radiation monitors
- Radioactivity, boric acid, or conductivity in condensate as indicated by laboratory analysis

Details on the radiation monitors are provided in Section 11.5, Radiation Monitoring.

5.2.5.2.2 Component Cooling Water System

Leakage from the reactor coolant system to the component cooling water system is detected by the component cooling water system radiation monitor, by increasing surge tank level, by high flow downstream of selected components, or by some combination of the preceding. Refer to Section 11.5, Radiation Monitoring, and subsection 9.2.2, Component Cooling Water System.

5.2.5.3 Collection and Monitoring of Unidentified Leakage

Position 3 of Regulatory Guide 1.45 identifies three diverse methods of detecting unidentified leakage. AP600 use two of these three and adds a third method -

To detect unidentified leakage inside containment in accordance with position 3 of 2
2 Regulatory Guide 1.45, the following diverse methods may be utilized to quantify and assist in locating the leakage:

- Containment Sump Level
- Reactor Coolant System Inventory Balance
- Containment Atmosphere Radiation

Other methods that can be employed to supplement the above methods include:

- Containment Atmosphere Pressure, Temperature, and Humidity
- Visual Inspection

The reactor coolant system is an all-welded system, except for the connections on the pressurizer safety valves, reactor vessel head, pressurizer and steam generator manways, and reactor vessel head vent, which are flanged. During normal operation, variations in airborne radioactivity, containment pressure, temperature, or specific humidity above the normal level signify a possible increase in unidentified leakage rates and alert the plant operators that corrective action may be required. Similarly, increases in containment sump level signify an increase in unidentified leakage. The following sections outline the methods used to collect and monitor unidentified leakage.

5.2.5.3.1 Containment Sump Level Monitor

In conformance with position 2 of Regulatory Guide 1.45,

Leakage from the reactor coolant pressure boundary and other components not otherwise identified inside the containment will condense and flow by gravity via the floor drains and other drains to the containment sump.

A leak in the primary system would result in reactor coolant flowing into the containment sump. Leakage is indicated by an increase in the sump level. The containment sump level is monitored by two seismic Category I level sensors, in accordance with position 6 of Regulatory Guide 1.45. The level sensors are powered from a safety-related Class 1E electrical source. These sensors remain functional when subjected to a safe shutdown earthquake in conformance with the guidance in Regulatory Guide 1.45. The containment sump level and sump total flow sensors located on the discharge of the sump pump are part of the liquid radwaste system.

Failure of one of the level sensors will still allow the calculation of a 0.5 gpm in-leakage rate within 1 hour. The data display and processing system (DDS) computes the leakage rate and the plant control system (PLS) provides an alarm in the main control room if the average change in leak rate for any given measurement period exceeds 0.5 gpm for unidentified leakage. The minimum detectable leak is 0.02 gpm. Unidentified leakage is the total leakage minus the identified leakage. The leakage rate algorithm subtracts the identified leakage directed to the sump.

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To satisy positions 2 and 5 of Regulatory Guide 1.45, the measurement interval must be long enough to permit the measurement loop to adequately detect the increase in level that would correspond to 0.5 gpm leak rate, and yet short enough to ensure that such a leak rate is detected within an hour. The measurement interval is less than or equal to 1 hour.

When the sump level increases to the high level setpoint, one of the sump pumps automatically starts to pump the accumulated liquid to the waste holdup tanks in the liquid radwaste system. The sump discharge flow is integrated and available for display in the control room, in accordance with position 7 of Regulatory Guide 1.45.

Procedures to identify the leakage source upon a change in the unidentified leakage rate into the sump include the following:

- Check for changes in containment atmosphere radiation monitor indications,
- Check for changes in containment humidity, pressure, and temperature,

- Check makeup rate to the reactor coolant system for abnormal increases,
- Check for changes in water levels and other parameters in systems which could leak water into the containment, and
- Review records for maintenance operations which may have discharged water into the containment.

5.2.5.3.2 Reactor Coolant System Inventory Balance

Reactor coolant system inventory monitoring provides an indication of system leakage. Net level change in the pressurizer is indicative of system leakage. Monitoring net makeup from the chemical and volume control system and net collected leakage provides an important method of obtaining information to establish a water inventory balance. An abnormal increase in makeup water requirements or a significant change in the water inventory balance can indicate increased system leakage.

The reactor coolant system inventory balance is a quantitative inventory or mass balance calculation. This approach allows determination of both the type and magnitude of leakage. Steady-state operation is required to perform a proper inventory balance calculation. Steady-state is defined as stable reactor coolant system pressure, temperature, power level, pressurizer level, and reactor coolant drain tank and in-containment refueling water storage tank levels. The reactor coolant inventory balance is done on a periodic basis and when other indication and detection methods indicate a change in the leak rate. The minimum detectable leak is 0.13 gpm.

The mass balance involves isolating the reactor coolant system to the extent possible and observing the change in inventory which occurs over a known time period. This involves isolating the systems connected to the reactor coolant system. System inventory is determined by observing the level in the pressurizer. Compensation is provided for changes in plant conditions which affect water density. The change in the inventory determines the total reactor coolant system leak rate. Identified leakages are monitored (using the reactor coolant drain tank) to calculate a leakage rate and by monitoring the intersystem leakage. The unidentified leakage rate is then calculated by subtracting the identified leakage rate from the total reactor coolant system leakage rate.

Since the pressurizer inventory is controlled during normal plant operation through the level control system, the level in the pressurizer will be reasonably constant even if leakage exists. The mass contained in the pressurizer may fluctuate sufficiently, however, to have a significant effect on the calculated leak rate. The pressurizer mass calculation includes both the steam and water mass contributions.

Changes in the reactor coolant system mass inventory are a result of changes in liquid density. Liquid density is a strong function of temperature and a lesser function of pressure. A range of temperatures exists throughout the reactor coolant system all of which may vary over time. A simplified, but acceptably accurate, model for determining mass changes is to assume all of the reactor coolant system is at $T_{Average}$.

The inventory balance calculation is done by the data display and processing system with additional input from sensors in the protection and safety monitoring system, chemical and volume control system, and liquid radwaste system. The use of components and sensors in systems required for plant operation provides conformance with the regulatory guidance of position 6 in Regulatory Guide 1.45 that leak detection should be provided following seismic events that do not require plant shutdown.

5.2.5.3.3 Containment Atmosphere Radioactivity Monitor

Leakage from the reactor coolant pressure boundary will result in an increase in the radioactivity levels inside containment. The containment atmosphere is continuously monitored for airborne gaseous radioactivity. Air flow through the monitor is provided by the suction created by a vacuum pump. Gaseous and N_{13}/F_{18} concentration monitors indicate radiation concentrations in the containment atmosphere.

N_{13} and F_{18} are neutron activation products which are proportional to power levels. An increase in activity inside containment would therefore indicate a leakage from the reactor coolant pressure boundary. Based on the concentration of N_{13}/F_{18} and the power level, reactor coolant pressure boundary leakage can be estimated.

The N_{13}/F_{18} monitoring system will detect a 0.5 gpm leak when the reactor is operating at a power range higher than 20 percent. The N_{13}/F_{18} monitor is seismic Category I. Conformance with the position 6 guidance of Regulatory Guide 1.45 that leak detection should be provided following seismic events that do not require plant shutdown is provided by the seismic Category I classification. Safety-related Class 1E power is not required since loss of power to the radiation monitor is not consistent with continuing operation following an earthquake.

At full power, the minimum detectable leak is 0.082 gpm when the radionuclide concentration in containment reaches equilibrium. The N_{13}/F_{18} monitor can detect a 0.5 gpm leak when the plant is above 20 percent power and the concentration of radiogas in-containment is at equilibrium.

Radioactivity concentration indication and alarms for loss of sample flow, high radiation, and loss of indication are provided. Sample collection connections permit sample collection for laboratory analysis. The radiation monitor can be calibrated during power operation.

5.2.5.3.4 Containment Pressure, Temperature and Humidity Monitors

Reactor coolant pressure boundary leakage increases containment pressure, temperature, and humidity, values available to the operator through the plant control system.

An increase in containment pressure is an indication of increased leakage or a high energy line break. Containment pressure is monitored by redundant Class 1E pressure transmitters. For additional discussion see subsection 6.2.2, Passive Containment Cooling System.

The containment average temperature is monitored using temperature instrumentation at the inlet to the containment fan cooler as an indication of increased leakage or a high energy line break. This instrumentation as well as temperature instruments within specific areas including steam generator areas, pressurizer area, and containment compartments are part of the containment recirculation cooling system.

An increase in the containment average temperature combined with an increase in containment pressure indicate increased leakage or a high energy line break. The individual compartment area temperatures can assist in identifying the location of the leak.

Containment humidity is monitored using temperature-compensated humidity detectors which determine the water-vapor content of the containment atmosphere. An increase in the containment atmosphere humidity indicates release of water vapor within the containment. The containment humidity monitors are part of the containment leak rate test system.

The humidity monitors supplement the containment sump level monitors and are most sensitive under conditions when there is no condensation. A rapid increase of humidity over the ambient value by more than 10 percent is indication of a probable leak.

Containment pressure, temperature and humidity can assist in identifying and locating a leak. They are not relied on to quantify a leak.

5.2.5.4 Safety Evaluation

Leak detection monitoring has no safety-related function. Therefore, the single failure criterion does not apply and there is no requirement for a nuclear safety evaluation. The containment sump level monitors and the containment atmosphere monitor are seismic Category I. The components used to calculate reactor coolant system inventory balance are both safety-related and nonsafety-related components. The containment sump level monitors are powered from the Class 1E dc and UPS system (IDS). Measurement signals are processed by the data display and processing system and the plant control system (PLS).

5.2.5.5 Tests and Inspections

To satisfy position 8 of Regulatory Guide 1.45, periodic testing of leakage detection monitors verifies the operability and sensitivity of detector equipment. These tests include installation calibrations and alignments, periodic channel calibrations, functional tests, and channel checks in conformance with regulatory guidance.

5.2.5.6 Instrumentation Applications

The parameters tabulated below satisfy position 7 of Regulatory Guide 1.45 and are provided in the main control room to allow operating personnel to monitor for indications of reactor coolant pressure boundary leakage. The containment sump level, containment atmosphere radioactivity, reactor coolant system inventory balance, and the flow measurements are provided as gallon per minute leakage equivalent.

Parameter	System(s)	Alarm or Indication
Containment sump level and sump total flow	WLS	Both
Reactor coolant drain tank level and drain tank total flow	WLS	Both
Containment atmosphere radioactivity	PSS	Both
Reactor coolant system inventory balance parameters	PCS, PXS, RCS, VCS, WLS	Both
Containment humidity	VUS	Indication
Containment atmospheric pressure	PCS	Both
Containment atmosphere temperature	VCS	Both
Reactor vessel head seal leak temperature	WLS	Both
Pressurizer safety relief valve leakage temperature	RCS	Both
Reactor coolant pump flange leakoff temperature	RCS	Both
Steam generator blowdown radiation	BDS	Both
Turbine island vent discharge radiation	TDS	Both
Component cooling water radiation	CCS	Both
Main steam line radiation	SGS	Both
Component cooling water surge tank level	CCS	Both

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5.2.5.7 Technical Specification

Limits which satisfy position 9 of Regulatory Guide 1.45 for identified and unidentified reactor coolant leakage are identified in the technical specifications, Chapter 16. LCO 3.4.8 addresses leakage limits. LCO 3.4.10 addresses leak detection instrument requirements.

3.4 REACTOR COOLANT SYSTEM (RCS)

3.4.8 RCS Operational LEAKAGE

LCO 3.4.8 RCS operational LEAKAGE shall be limited to:

a. No pressure boundary LEAKAGE

b. 0.5 gpm unidentified LEAKAGE,

c. 10 gpm identified LEAKAGE from the RCS,

d. 1000 gallons per day total primary to secondary LEAKAGE through both steam generators (SGs),

e. 500 gallons per day primary to secondary LEAKAGE through any one SG, and

f. 500 gallons per day primary to IRWST LEAKAGE through the passive residual heat removal heat exchanger (PRHR HX).

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. RCS LEAKAGE not within limits for reasons other than pressure boundary LEAKAGE.	A.1 Reduce LEAKAGE to within limits.	4 ~~8~~ hours
B. Required Action and associated Completion Time not met. OR Pressure boundary LEAKAGE exists.	B.1 Be in MODE 3. AND B.2 Be in MODE 5.	6 ~~8~~ hours 36 ~~48~~ hours

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.4.8.1	-----------------NOTE------------------ Not required to be performed in MODE 3 and 4 until 12 hours of steady state operation. --------------------------------------- Perform a RCS water inventory balance.	-----NOTE----- Only required to be performed during steady state operation. -------------- 72 hours
SR 3.4.8.2	Verify steam generator tube integrity is in accordance with the Steam Generator Tube Surveillance Program.	In accordance with the Steam Generator Tube Surveillance Program

B 3.4 REACTOR COOLANT SYSTEM (RCS)

B 3.4.8 RCS Operational LEAKAGE

BASES

BACKGROUND

Components that contain or transport the coolant to or from the reactor core comprise the RCS. Component joints are made by welding, bolting, rolling, or pressure loading, and valves isolate connecting systems from the RCS.

During plant life, the joint and valve interfaces can produce varying amounts of reactor coolant LEAKAGE, through either normal operational wear or mechanical deterioration. The purpose of the RCS Operational LEAKAGE LCO is to limit system operation in the presence of LEAKAGE from these sources to amounts that do not compromise safety. This LCO specifies the types and amounts of LEAKAGE.

10 CFR 50, Appendix A, GDC 30 (Ref. 1), requires means for detecting and, to the extend practical, identifying the source of reactor coolant LEAKAGE. Regulatory Guide 1.45 (Ref. 2) describes acceptable methods for selecting leakage detection systems.

The safety significance of RCS LEAKAGE varies widely depending on its source, rate, and duration. Therefore, detecting and monitoring RCS LEAKAGE into the containment area is necessary. Quickly separating the identified LEAKAGE from the unidentified LEAKAGE is necessary to provide quantitative information to the operators, allowing them to take corrective action should a leak occur that is detrimental to the safety of the facility and the public.

A limited amount of LEAKAGE inside containment is expected from auxiliary systems that cannot be made 100% leaktight. LEAKAGE from these systems should be detected, located, and isolated from the containment atmosphere, if possible, to not interfere with RCS LEAKAGE detection.

This LCO deals with protection of the reactor coolant pressure boundary (RCPB) from degradation and the core from inadequate cooling, in addition to preventing the accident analyses radiation release assumptions from being exceeded. The consequences of violating this LCO include the possibility of a loss of coolant accident (LOCA).

(continued)

BASES (continued)

APPLICABLE SAFETY ANALYSES

Except for primary to secondary LEAKAGE, the safety analyses do not address operational LEAKAGE. However, other operational LEAKAGE is related to the safety analyses for LOCA. The amount of LEAKAGE can affect the probability of such an event. The safety analysis for an event resulting in steam discharge to the atmosphere assumes a 1000 gpd primary to secondary LEAKAGE as the initial condition.

Primary to secondary LEAKAGE is a factor in the dose releases outside containment resulting from a steam line break (SLB) accident. To a lesser extent, other accidents or transients involve secondary steam release to the atmosphere, such as a steam generator tube rupture (SGTR). The leak contaminates the secondary fluid.

The SSAR (Ref. 3) analyses for the accidents involving secondary side releases assume 500 gpd primary to secondary LEAKAGE in each generator as an initial condition. The dose consequences resulting from the accidents are reported in Reference 3.

The design basis radiological consequences resulting from a postulated SLB accident and SGTR are provided in Sections 15.1.5 and 15.6.3 of the AP600 SSAR (Ref. 3).

The RCS operational LEAKAGE satisfies Criterion 2 of the NRC Policy Statement.

LCO

RCS operation LEAKAGE shall be limited to:

a. Pressure Boundary LEAKAGE

No pressure boundary LEAKAGE is allowed, being indicative of material deterioration. LEAKAGE of this type is unacceptable as the leak itself could cause further deterioration, resulting in higher LEAKAGE. Violation of this LCO could result in continued degradation of the RCPB. LEAKAGE past seals and gaskets are not pressure boundary LEAKAGE.

b. Unidentified LEAKAGE

N13/F18

0.5 gpm of unidentified LEAKAGE is allowed as a reasonable minimum detectable amount that the containment air radioactivity monitoring and containment sump level monitoring equipment, can detect within a reasonable time period. This leak rate supports leak before break (LBB) criteria. Violation of this LCO could result in continued degradation of the RCPB, if the LEAKAGE is from the pressure boundary.

(continued)

BASES

LCO (continued)

c. Identified LEAKAGE

Up to 10 gpm of identified LEAKAGE is considered allowable because LEAKAGE is from known sources that do not interfere with detection of unidentified LEAKAGE and is well within the capability of the RCS Makeup System. Identified LEAKAGE includes LEAKAGE to the containment from specifically known and located sources, but does not include pressure boundary LEAKAGE. Violation of this LCO could result in continued degradation of a component or system.

d. Primary to Secondary LEAKAGE through Both Steam Generators (SGs)

Total primary to secondary LEAKAGE through both SGs amounting to 1000 gpd produces acceptable offsite doses in the Steam Line Break (SLB) accident analysis. Violation of this LCO could exceed the offsite dose limits for this accident. Primary to secondary LEAKAGE must be included in the total allowable limit for identified LEAKAGE.

e. Primary-to-Secondary LEAKAGE through One SG

The 500 gpd limit from one SG is based on the assumption that a single crack leaking this amount would not propagate to a SGTR under the stress conditions of a LOCA or a main steam line rupture.

f. Primary to IRWST LEAKAGE through the PRHR Heat Exchanger HX

The 500 gpd limit from the PRHR HX is based on the assumption that a single crack leaving this amount would not lead to a PRHR tube rupture under the stress condition of an RCS pressure increase event. If leaked through many cracks, the cracks are very small, and the above assumption is conservative. This is conservative because the thickness of the PRHR HX tubes is approximately 60% greater than the thickness of the SG tubes. Furthermore, a PRHR HX tube rupture would result in an isolable leak and would not lead to a direct release of radioactivity to the atmosphere.

(continued)

BASES (continued)

APPLICABILITY

In MODES 1, 2, 3, and 4, the potential for RCPB LEAKAGE is greatest when the RCS is pressurized.

In MODES 5 and 6, LEAKAGE limits are not required because the reactor coolant pressure is far lower, resulting in lower stresses and reduced potentials for LEAKAGE.

ACTIONS

A.1

Unidentified LEAKAGE, identified LEAKAGE, or primary to secondary LEAKAGE in excess of the LCO limits must be reduced to within limits within 8 hours. This Completion Time is based on risk considerations and allows time to verify leakage rates and either identify unidentified LEAKAGE or reduce LEAKAGE to within limits before the reactor must be shut down. This action is necessary to prevent further deterioration of the RCPB.

B.1 and B.2

If any pressure boundary LEAKAGE exists, or if unidentified LEAKAGE, identified LEAKAGE, or primary to secondary LEAKAGE cannot be reduced to within limits within 8 hours, the reactor must be brought to lower pressure conditions to reduce the severity of the LEAKAGE and its potential consequences. It should be noted that leakage past seals and gaskets is not pressure boundary LEAKAGE. The reactor must be brought to MODE 3 within 8 hours and to MODE 5 within 48 hours. This action reduces the LEAKAGE and also reduces the factors which tend to degrade the pressure boundary.

The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without ACTIONS challenging plant systems. In MODE 5, the pressure stresses acting on the RCPB are much lower, and further deterioration is much less likely.

SURVEILLANCE REQUIREMENTS

SR 3.4.8.1

Verifying RCS LEAKAGE within the LCO limits ensures the integrity of the RCPB is maintained. Pressure boundary LEAKAGE would at first appear as unidentified LEAKAGE and can only be positively identified by inspection.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.4.8.1 (continued)

Unidentified LEAKAGE and identified LEAKAGE are determined by performance of a RCS water inventory balance. Primary to secondary LEAKAGE is also measured by performance of an RCS water inventory balance in conjunction with effluent monitoring within the secondary steam and feedwater systems.

The RCS water inventory balance must be met with the reactor at steady state operating conditions and near operating pressure. Therefore, this SR is not required to be performed in MODES 3 and 4 until 12 hours of steady state operation near operating pressure have been established.

Steady state operation is required to perform a proper inventory balance; calculations during maneuvering are not useful and a Note requires the Surveillance to be met when steady state is established. For RCS operational LEAKAGE determination by inventory balance, steady state is defined as stable RCS pressure, temperature, power level, pressurizer and makeup tank levels, and with no makeup ~~and~~ or letdown.

An early warning of pressure boundary LEAKAGE or unidentified LEAKAGE is provided by the automatic systems that monitor the containment atmosphere radioactivity and the containment sump level. It should be noted that LEAKAGE past seals and gaskets is not pressure boundary LEAKAGE. These LEAKAGE detection systems are specified in LCO 3.4.10, "RCS LEAKAGE Detection Instrumentation." NI3/F8

INSERT For SR 3.4.8.1

The 72 hour Frequency is a reasonable interval to trend LEAKAGE and recognizes the importance of early leakage detection in the prevention of accidents. A Note under the Frequency column states that this SR is required to be performed during steady state operation.

SR 3.4.8.2

This SR provides the means necessary to determine SG OPERABILITY in an operational MODE. The requirement to demonstrate SG tube integrity in accordance with the Steam Generator Tube Surveillance Program emphasizes the importance of SG tube integrity, even though this Surveillance cannot be performed at normal operating conditions.

(continued)

INSERT FOR SR 3.4.8.1

The containment atmosphere N13/F18 radioactivity leakage measurement during MODE 1 is valid only for plant power > 20% RTP.

The containment atmosphere N13/F18 radioactivity leakage measurement during MODE 1 is not valid while containment purge occurs or within 2 hours after the end of containment purge.

The containment sump level change method of leakage measurement during MODES 1, 2, 3 and 4 is not valid while containment purge occurs or within 2 hours after the end of containment purge.

The containment sump level change method of leakage measurement during MODES 1, 2, 3 and 4 is not valid during extremely cold outside ambient conditions when frost is forming on the interior of the containment vessel.

BASES

REFERENCES

1. 10 CFR 50, Appendix A GDC 30.
2. Regulatory Guide 1.45, May 1973.
3. AP600 SSAR, Chapter 15, "Accident Analysis."

3.4 REACTOR COOLANT SYSTEM (RCS)

3.4.10 RCS Leakage Detection Instrumentation

LCO 3.4.10 The following RCS leakage detection instrumentation shall be OPERABLE:

a. One containment sump level channel;

b. One containment atmosphere radioactivity monitor (gaseous N13/F18).

— NOTE —
The N13/F18 containment atmosphere radioactivity monitor is only required to be operable in MODE with RTR > 20%

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Required containment sump channel inoperable.	------------NOTE------------ LCO 3.0.4 is not applicable. ----------------------------	
	A.1 Perform SR 3.4.8.1 (RCS inventory balance).	Once per 24 hours
	AND	
	A.2 Restore containment sump channel to OPERABLE status.	30 Days ~~168 hours~~

(continued)

— NOTE —
containment sump level measurements cannot be used for leak detection if leakage is prevented from draining to the sump such as redirection of containment shell gutter drains to IRWST.

ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. Required containment atmosphere radioactivity monitor inoperable.	------------NOTE------------ LCO 3.0.4 is not applicable. ----------------------------	
	B.1.1 Analyze grab samples of containment atmosphere.	Once per 24 hours
	OR	
	B.1.2 Perform SR 3.4.8.1.	Once per 24 hours
	AND	
	B.2 Restore containment atmosphere radioactivity monitor to OPERABLE status.	30 days ~~168 hours~~
C. Required Action and associated Completion Time not met.	C.1 Be in MODE 3.	6 ~~8~~ hours
	AND	
	C.2 Be in MODE 4.	36 ~~24~~ hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.4.10.1	Perform a CHANNEL CHECK of required containment atmosphere radioactivity monitor.	~~24~~ 12 hours
SR 3.4.10.2	Perform ~~an CHANNEL OPERATIONAL TEST~~ a COT of required containment atmosphere radioactivity monitor.	92 days
SR 3.4.10.3	Perform a CHANNEL CALIBRATION of required containment sump monitor.	24 months
SR 3.4.10.4	Perform a CHANNEL CALIBRATION of required containment atmosphere radioactivity monitor.	24 months

B 3.4 REACTOR COOLANT SYSTEM (RCS)

B 3.4.10 RCS Leakage Detection Instrumentation

BASES

BACKGROUND

GDC 30 of Appendix A to 10CFR50 (Ref. 1) requires means for detecting, and, to the extent practical, identifying the source of RCS LEAKAGE. Regulatory Guide 1.45 (Ref. 2) describes acceptable methods for selecting LEAKAGE detection systems.

LEAKAGE detection systems must have the capability to detect significant reactor coolant pressure boundary (RCPB) degradation as soon after occurrence as practical to minimize the potential for propagation to a gross failure. Thus, an early indication or warning signal is necessary to permit proper evaluation of all unidentified LEAKAGE.

Industry practice has shown that water flow changes of 0.5 gpm can be readily detected in contained volumes by monitoring changes in water level, in flow rate, or in the operating frequency of a pump. The containment sump used to collect unidentified LEAKAGE, is instrumented to alarm for increases of 0.5 gpm in the normal flow rates. This sensitivity is acceptable for detecting increases in unidentified LEAKAGE.

Reactor coolant radioactivity used for leak detection is decay of N13 / F18

The reactor coolant contains radioactivity that, when released to the containment, can be detected by radiation monitoring instrumentation. Reactor coolant radioactivity levels will be low during initial reactor startup and for a few weeks thereafter, until activated corrosion products have been formed and fission products appear from fuel element cladding contamination or cladding defects. The production of N13 and F18 is proportional to the reactor power level. N13 has a short half life and comes to equilibrium quickly. F18 has a longer half life and is the dominant source used for leak detection Instrument sensitivities for gaseous monitoring are practical for these LEAKAGE detection systems. The Radiation Monitoring System includes monitoring N13/F18 gaseous activities to provide leak detection.

(continued)

BASES (continued)

APPLICABLE SAFETY ANALYSES

The need to evaluate the severity of an alarm or an indication is important to the operators, and the ability to compare and verify with indications from other systems is necessary. The system response times and sensitivities are described in the SSAR (Ref. 2). 3

The safety significance of RCS LEAKAGE varies widely depending on its source, rate, and duration. Therefore, detecting and monitoring RCS LEAKAGE into the containment area is necessary. Quickly separating the identified LEAKAGE from the unidentified LEAKAGE provides quantitative information to the operators, allowing them to take corrective action should a leak occur.

RCS LEAKAGE detection instrumentation satisfies Criterion 1 of the NRC Policy Statement.

LCO

One method of protecting against large RCS LEAKAGE derives from the ability of instruments to rapidly detect extremely small leaks. This LCO requires instruments of diverse monitoring principles to be OPERABLE to provide a high degree of confidence that small leaks are detected in time to allow actions to place the plant in a safe condition, when RCS LEAKAGE indicates possible RCPB degradation.

The LCO is satisfied when monitors of diverse measurement means are available. Thus, the containment sump level monitor, in combination with an N13/F18 gaseous activity monitor provides an acceptable minimum.

INSERT 1 For B 3.4.10

APPLICABILITY

Because of elevated RCS temperature and pressure in MODES 1, 2, 3, and 4, RCS LEAKAGE detection instrumentation is required to be OPERABLE.

In MODE 5 or 6, the temperature is ≤ 200°F and pressure is maintained low or at atmospheric pressure. Since the temperatures and pressures are lower than those for MODES 1, 2, 3, and 4, the likelihood of leakage and crack propagation are much smaller. Therefore, the requirements of this LCO are not applicable in MODES 5 and 6.

INSERT 2 For B 3.4.10

(continued)

INSERTS FOR B 3.4.10

Insert 1

Containment sump level monitoring is performed by two redundant, seismically qualified level instruments which receive power from a Class 1E power supply. The LCO note clarifies that if leakage is prevented from draining to the sump, its level change measurements will not be valid for quantifying the leakage.

Insert 2

Containment sump level monitoring is a valid method of detecting leakage in MODES 1, 2, 3 and 4. The containment atmosphere N13/F18 radioactivity leakage measurement during MODE 1 is valid only for plant power > 20% RTP. RCS inventory monitoring via pressurizer level changes is valid in MODES 1, 2, 3 and 4 only when RCS conditions are stable; i.e. temperature is constant, pressure constant, no makeup and no letdown.

The containment sump level change method of leakage measurement during MODES 1, 2, 3 and 4 is not valid while containment purge occurs or within 2 hours after the end of containment purge.

The containment sump level change method of leakage measurement during MODES 1, 2, 3 and 4 is not valid during extremely cold outside ambient conditions when frost is forming on the interior of the containment vessel.

The containment atmosphere N13/F18 radioactivity leakage measurement during MODE 1 is not valid while containment purge occurs or within 2 hours after the end of containment purge.

BASES (continued)

ACTIONS

A.1 and A.2

With the required containment sump (level) channel inoperable, no other form of sampling can provide the equivalent information; however, the containment atmosphere radioactivity monitor will provide indications of changes in LEAKAGE. Together with the atmosphere monitor, the periodic surveillance for RCS inventory balance, SR 3.4.8.1, must be performed at an increased frequency of 24 hours to provide information that is adequate to detect LEAKAGE.

Restoration of the sump channel to OPERABLE status is required to regain the function in a Completion Time of ~~168 hours~~ 30 days after the monitor's failure. This time is acceptable, considering the frequency and adequacy of the RCS inventory balance required by Action A.1.

Required Action A.1 is modified by a Note that indicates that the provisions of LCO 3.0.4 are not applicable. As a result, a MODE change is allowed when the containment sump channel is inoperable. This allowance is provided because other instrumentation is available to monitor RCS Leakage.

B.1.1, B.1.2, and B.2

With one gaseous N13/F18 containment atmosphere radioactivity-monitoring instrumentation channel inoperable, alternative action is required. Either grab samples of the containment atmosphere must be taken and analyzed or RCS inventory balanced, in accordance with SR 3.4.8.1, must be performed to provide alternate periodic information.

With a sample obtained and analyzed or an RCS inventory balance performed every 24 hours, the reactor may be an RCS operated for up to 168 hours (30 days) to allow restoration of the radioactivity monitor.

The 24 hours interval for grab samples or RCS inventory balance provides periodic information that is adequate to detect LEAKAGE. The 168 hours (30 day) Completion Time recognizes at least one other form of leak detection is available.

(continued)

BASES

ACTIONS

B.1.1, B.1.2, and B.2 (continued)

Required Action B.1 and Required Action B.2 are modified by a Note that indicates that the provisions of LCO 3.0.4 are not applicable. As a result, a MODE change is allowed when the gaseous N13/F18 containment atmosphere radioactivity monitor channel is inoperable. This allowance is provided because other instrumentation is available to monitor for RCS LEAKAGE.

C.1 and C.2

If a Required Action of Condition A or B cannot be met within the required Completion Time, the reactor must be brought to MODE 4 where the probability and consequences of an event are minimized. To achieve this status, the plant must be brought to at least MODE 3 within 8 hours to MODE 4 within 24 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.4.10.1

SR 3.4.10.1 requires the performance of a CHANNEL CHECK of the containment atmosphere radioactivity monitor. The check gives reasonable confidence that the channel is operating properly. The Frequency of 24 hours is based on instrument reliability and risk and is reasonable for detecting off normal conditions.

SR 3.4.10.2

SR 3.4.10.2 requires the performance of a CHANNEL OPERATIONAL TEST (COT) on the atmosphere radioactivity monitor. The test ensures that the monitor can perform its function in the desired manner. The test verifies the alarm setpoint and relative accuracy of the instrument string. The Frequency of 92 days considers risks and instrument reliability, and operating experience has shown that it is proper for detecting degradation.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.4.10.3 and SR 3.4.10.4

These SRs require the performance of a CHANNEL CALIBRATION for each of the RCS Leakage detection instrumentation channels. The calibration verifies the accuracy of the instrument string, including the instruments located inside containment. The Frequency of 24 months is a typical refueling cycle and considers channel reliability. Again, operating experience has proven that this Frequency is acceptable.

REFERENCES

1. 10 CFR 50, Appendix A, Section IV, GDC 30.

2. Regulatory Guide 1.45, "Reactor Coolant Pressure Boundary LEAKAGE Detection Systems," U.S. Nuclear Regulatory Commission.

3. AP600 SSAR Chapter 15, "Accident Analysis."