WISCONSIN MICHIGAN POWER COMPANY
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Posse - How does this compare with what we have

POINT BEACH nuclear plant
TWO CREEKS, WIS.

POSTAL ROUTE 3, TWO RIVERS, WISCONSIN 54241

March 1, 1973

Mr. Guy Arlotto
Directorate of Regulatory Standards
(Bethesda - 010)
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Arlotto:

As follow up to our telecon of February 26, 1973, please find attached information which describes our reactor coolant system leakage monitoring as follows:

1. PBNP 3.27, Reactor Coolant System Leakage Determination
2. Two six curve plots chosen at random showing trends for evaluation by operating people.
3. A March 1, 1972, letter to J. W. Stacey of the ANS subcommittee which describes our reactor coolant system leakage monitoring further.

If you have any further questions on our leakage monitoring, Mr. T. J. Rodgers or I would be most happy to oblige. In fact, since Mr. Stacey's ANS subcommittee is being phased out and Mr. Rodgers has been released as a member, he would be willing to expend some effort to orally transfer to you what he would have provided to the ANS subcommittee. Mr. Rodgers can be reached more easily in Milwaukee at 414-273-1234, Extension 2946, than at the Point Beach Nuclear Plant.

Very truly yours,

WISCONSIN MICHIGAN POWER COMPANY

Glenn A. Reed

Glenn A. Reed — Manager - Nuclear Power Division

ktw

50-266, 301

REACTOR COOLANT SYSTEM LEAKAGE DETERMINATION

1.0 PURPOSE

The purpose of this instruction is to detail the method for following trends of reactor coolant system leakage and to determine quantities, in conformance with Technical Specifications commitments, Section 15.3.1.D. Of first importance is the need to ascertain that there is no "exterior wall" leakage from the reactor vessel, reactor system piping, reactor system valve bodies, pressurizer, reactor coolant pump bodies, or the reactor coolant system side of the steam generators. Of second importance is to ascertain that if any leaks occur in gasketed closures or packings of the reactor coolant system they are well under control with quantities according to Technical Specifications commitments.

It is not the purpose of this instruction to quantitively determine reactor coolant system to other system cross-leakage or flow, such as primary-to-secondary steam generator tube leakage (evaluated by Chemistry and Health Physics), or reactor coolant system to component cooling leakage (under continuous evaluation by the component cooling radiation monitor), or reactor coolant system leakage to connecting systems such as reactor coolant drain or pressurizer blowdown or charging and volume control. Such uncontrolled leakages as these noted above must remain so small in quantity for reasons of other limits that the leakages are not significant in the first evaluation limit of the Technical Specifications at 1 gpm.

2.0 METHOD AND RESPONSIBILITY

2.1 As shown in the Technical Specifications Section 15.3.1.D, there are six methods of discovering or evaluating reactor coolant system leakage into the containment. They are as follows:

2.1.1 Air particle monitor

2.1.2 Radiogas monitor

2.1.3 Relative humidity

2.1.4 Sump A drainage

2.1.5 Chemistry and Health Physics water balance

2.1.6 In-containment physical inspection

2.2 In order to maintain evaluation type surveillance of reactor coolant system leakage, the following observations and actions shall take place:

2.2.1 During hot pressurized operation, the Control Operator shall periodically observe the air particle monitor reading, the radiogas monitor reading and the relative humidity reading.

2.2.2 During hot pressurized operation, the "eye ball" average readings or values of the following shall be plotted, if available, on a graph once per day:

2.2.2.1 Air particle monitor

2.2.2.2 Radiogas monitor

2.2.2.3 Relative humidity

2.2.2.4 Sump A drainage

2.2.2.5 Chemistry and Health Physics water balance leakage number

2.2.2.6 Service water temperature

2.2.3 The six line graph shall be reviewed once per day by the Duty Shift Supervisor for Technical Specifications compliance.

2.2.4 The six line graph shall be reviewed once per week by the Duty and Call Superintendent and the Operations Superintendent.

2.2.5 A physical inspection inside containment for leakage evaluation reasons may be ordered by the Duty Shift Supervisor, the Duty and Call Superintendent, or the Operations Superintendent, at any time felt necessary.

2.2.6 During hot pressurized operation, a physical inspection inside containment shall be made at intervals not greater than once every two weeks, with time and results noted in the station log.

2.2.7 The Operations Superintendent shall periodically review the primary-to-secondary leakage and determine that when added to Sump A leakage, the 1 gpm figure is not exceeded or that additional Technical Specifications evaluations occur as required.

3.0 EVALUATION

Some keys to evaluating in-containment leakage as itemized above are as follows:

3.1 A rising air particulate monitor reading (under steady-state conditions) can mean an increasing leak in the reactor coolant system, and, if it is the single leading indicator, may mean the leak is in the liquid phase of the reactor coolant system.

3.2 A rising radiogas monitor reading (under steady-state conditions) can mean an increasing leak in the reactor coolant system, and if it is the single leading indicator may mean the leak is in the gaseous phase of the reactor coolant system such as pressurizer steam space levels.

3.3 A rising relative humidity reading, under steady-state conditions, as the single leading indicator can mean an in-containment leak from systems other than the reactor coolant system, a reactor coolant system liquid leak, or can mean an increasing service water system temperature. Relative humidity readings should not exceed 50% if all in-containment systems are reasonably leaktight.

3.4 The gallons discharged from Sump A (under steady-state conditions) is the principal quantitative indicator and if rising in quantity can mean a leak from in-containment systems or the reactor coolant system.

3.5 The water balance calculation by Chemistry and Health Physics and Item 3.4 above, Sump A drainage, are the bases for correlating quantitively the readings of 3.1, 3.2 and 3.3 above to approximate gallons per minute. The correlations are important since items 3.1, 3.2 and 3.3 above are fast indicators of a change in leakage.

3.6 The service water system temperature is important to evaluating corrections to trends of Sump A drainage and relative humidity, and a decreasing service water temperature can cause a decreasing humidity and increasing Sump A drainage.

For convenience to the evaluation, Technical Specifications Section 14.3.1.D is attached to this instruction and follows.

D. LEAKAGE OF REACTOR COOLANT

Specification:

1. If leakage of reactor coolant is indicated to exceed 1 GPM by the means available such as water inventory balances, monitoring equipment or direct observation, a follow-up evaluation of the safety implications shall be initiated as soon as practicable but no later than within 4 hours. Any indicated leak shall be considered to be a real leak until it is determined that either (1) a safety problem does not exist or (2) that the indicated leak cannot be substantiated by direct observation or other indication. 2

2. If the indicated leakage is substantiated and is not evaluated as safe or is determined to exceed 10 GPM, reactor shutdown shall be initiated as soon as practicable but no later than within 24 hours after the leak was first detected.

3. The nature of the leak as well as the magnitude of the leak shall be considered in the safety evaluation. If plant shutdown is necessary per specification 2 above, the rate of shutdown and the conditions of shutdown shall be determined by the safety evaluation for each case and justified in writing as soon thereafter as practicable. The safety evaluation shall assure that the exposure of off-site personnel to radiation from the primary system coolant activity is within the guidelines of 10CFR20.

4. If any reactor coolant leakage exists through a non-isolable fault in a reactor coolant system component (exterior wall of the reactor vessel, piping, valve body, pressurizer or steam generator head), the reactor shall be shut down, and cooldown to the cold shutdown condition shall be initiated within 24 hours of detection. 2

5. The reactor shall not be restarted until the leak is repaired or until the problem is otherwise corrected.

6. When the reactor is critical and above 2% power, two reactor coolant leak detection systems of different operating principles shall be in operation, with one of the two systems sensitive to radioactivity. The systems sensitive to radioactivity may be out-of-service for 48 hours provided two other means are available to detect leakage. 2

Basis:

Water inventory balances, monitoring equipment, radioactive tracing, boric acid crystalline deposits, and physical inspections can disclose reactor coolant leaks. Any leak of radioactive fluid, whether from the reactor coolant system primary boundary or not can be a serious problem with respect to in-plant radioactivity contamination and cleanup or it could develop into a still more serious problem; and therefore, first indications of such leakage will be followed up as soon as practicable.

Every reasonable effort will be made to reduce reactor coolant leakage to the lowest possible rate and at least below 1 gpm in order to prevent a large leak from masking the presence of a smaller leak. Although some leak rates 2

on the order of 1 gpm may be tolerable from a dose point of view, especially if they are to closed systems, it must be recognized that leaks in the order of drops per minute through any of the walls of the primary system could be indicative of materials failure such as by stress corrosion cracking. If depressurization, isolation and/or other safety measures are not taken promptly, these small leaks could develop into much larger leaks, possibly into a gross pipe rupture. Therefore, the nature of the leak, as well as the magnitude of the leakage, must be considered in the safety evaluation. The provision pertaining to a non-isolable fault in a reactor coolant system component is not intended to cover steam generator tube leakages, valve bonnets or packings, instrument fittings or similar primary system boundaries not indicative of major component exterior wall leakage.

When the source and location of leakage has been identified, the situation can be evaluated to determine if operation can safely continue. This evaluation will be performed by the Manager's Supervisory Staff according to routine established in Section 15.6. Under these conditions, an allowable leakage rate of 10 gpm has been established. This explained leakage rate of 10 gpm is also well within the capacity of one charging pump, and makeup would be available even under the loss of off-site power condition.

If leakage is to the containment, it may be identified by one or more of the following methods:

a. The containment air particulate monitor is sensitive to low leak rates. The rate of leakage to which the instrument is sensitive is 0.013 gpm within twenty minutes, assuming the presence of corrosion product activity.

b. The containment radiogas monitor is less sensitive but can be used as a backup to the air particulate monitor. The sensitivity range of the instrument is approximately 2 gpm to greater than 10 gpm.

c. The humidity detector provides a backup to a. and b. The sensitivity range of the instrumentation is from approximately 2 gpm to 10 gpm.

d. A leakage detection system which determines leakage losses from water and steam systems within the containment collects and measures moisture condensed from the containment atmosphere by cooling coils of the main recirculation units. This system provides a dependable and accurate means of measuring total leakage, including leaks from the cooling coils themselves which are part of the containment boundary. Condensate flows from approximately 1/2 gpm to 10 gpm can be measured by this system.

e. Indication of leakage from the above sources shall be cause to require a containment entry and limited inspection at power of the reactor coolant system. Visual inspection means, i.e., looking for steam, floor wetness or boric acid crystalline formations, will be used. Periodic inspections for indications of leakage within the containment will be conducted to enhance early detection of problems and to assure best on-line reliability.

If leakage is to another system, it will be detected by the plant radiation monitors and/or water inventory control.

<u>References</u>

FFDSAR Section 6.5, 11.2.3

WISCONSIN MICHIGAN POWER COMPANY
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POINT BEACH nuclear plant

POSTAL ROUTE 3, TWO RIVERS, WISCONSIN 54241

March 1, 1972

~~JPE~~
~~RAW~~
FJR

Mr. J. W. Stacey, Section Head
Mechanical Engineering Section
Yankee Atomic Electric Company
20 Turnpike Road
Westboro, Massachusetts 01581

plant 1.26.1
ICR 1.1.1

Dear Jim:

In reply to your letter of February 18, 1972, on Reactor Coolant Pressure Boundary Leakage Monitoring, the Point Beach Nuclear Plant reactors are two-loop, PWR, 500 MWe units with Westinghouse as the nuclear steam supply turnkey supplier and Bechtel Corporation as the architect-engineer for Westinghouse. Unit 1 began commercial service on December 21, 1970, and has generated about 4,300,000,000 kwh. Unit 2 was completed and the core loaded in late 1971, but has not produced power because of a public intervention.

The Point Beach Nuclear Plant units use five techniques for primary boundary leakage into containment monitoring. They are as follows:

1. <u>Containment Relative Humidity</u>

   This monitoring is considered quite accurate and capable of detecting leakage from the primary boundary at rates of one gpm or less. Some evaluation and follow of containment cooling equipment is necessary since humidity varies with dehumidification effects of this equipment.

2. <u>Containment Sump A Drainage</u>

   This monitoring is by small calibrated sump (12 gallons) located at the lowest point inside containment. All floor drains and recirculation cooler drain pans funnel to sump A, and thereby all system leakage or cooler drainage from dehumidification action is quickly collected and accurately measured and discharged to the primary auxiliary building at intervals. This monitoring technique is able to detect leakage at rates of 0.1 gpm or less, and detection is possible within a few minutes.

3. Containment Air Particle Monitor

This traveling filter paper radioactivity monitoring unit responds very quickly to leakage but correlation to gpm quantity requires comparison to sump A drainage monitoring. Increasing air particle monitor reading without a corresponding gas monitor reading normally indicates a leak from the liquid phase of the reactor coolant system.

4. Containment Gas Monitor

This radioactivity monitoring unit responds very quickly but correlation to gpm quantity requires comparison to sump A drainage. Increasing gas monitor readings without a corresponding increase in the air particle monitor readings normally indicates a reactor coolant system gaseous phase leak, such as the top of the pressurizer.

5. Water Balance Determination

Water balance determinations are made by chemistry personnel on a daily basis at present. As you can appreciate, the water balance method is not the most desirable due to the multiplicity of very large tanks and inherent limits on instrumentation accuracy. The water balance method becomes very complicated in a large plant such as Point Beach, and will become even more complicated when both units are operating. In addition, this method does not distinguish between "controlled leakage" (charging pump seals, sampling, etc.) and "uncontrolled leakage" (valve packings, cracks, etc.). Since the "uncontrolled leakage" is really the desired answer the water balance is of limited value only.

The use of the five techniques or systems above in an appropriate fashion allows one to predict what system in-containment leakage is coming from, such as steam, component cooling, etc., and forms the basis for scheduling in-containment inspections at power. Without any unusual indications on leakage, we normally schedule two in-containment inspections per week. It should be noted that for the most part the above techniques are dependent upon the principle of "closed" containment operation, which is the basis of operation at Point Beach Nuclear Plant.

The Point Beach Nuclear Plant units have three techniques for monitoring primary-to-secondary steam generator leakage. They are as follows:

1. Blowdown Radioactivity Monitor

   Steam generator liquid is continuously monitored for radioactivity in a composite radiation monitor. In the event of an increase in activity either steam generator sample can be isolated from the monitor. This monitor is more of a trend indicator than an absolute leakage rate indication since, for the same leak rate, the activity will change with blowdown rate, primary coolant activity, etc.

2. Air Ejector Monitor

   The air ejector monitor is probably the best indicator of primary-to-secondary leak rate although it cannot distinguish between steam generators. With a knowledge of primary coolant gaseous activity the total leak rate can be calculated. We find that we can get consistent and believable data at levels as low as 10 gallons per day.

3. Sample Radiochemical Analysis

   The laboratory analysis of steam generator blowdown samples yields isotopic data which can be used to calculate leak rates over a certain period of time. In general, however, we rely on the air ejector monitor data and only periodically do we calculate leak rates using steam generator blowdown analysis results. We find fairly good correlation between the two.

We have had discussions with the AEC about our in-containment leakage monitoring, and these were favorable. The AEC had no suggestions for improvement, and we believe, were surprised at the ability to quickly and accurately monitor in-containment leakage.

We have considered the subject of moisture sensitive tape monitoring of leakage and find it cannot be as accurate or as quickly responsive as combinations of relative humidity, sump drainage, air particle monitor, and gas monitor. Tape also suffers disadvantages in reliability, interference with in-service pipe and weld inspections, and the impossibility of locating tape at all the places required to detect a leak.

All Point Beach Nuclear Plant in-containment leaks thus far have occurred at valve packings and valve body-to-bonnet gasketed flanges.

Very truly yours,

WISCONSIN MICHIGAN POWER COMPANY

ORIGINAL SIGNED BY

GLENN A. REED

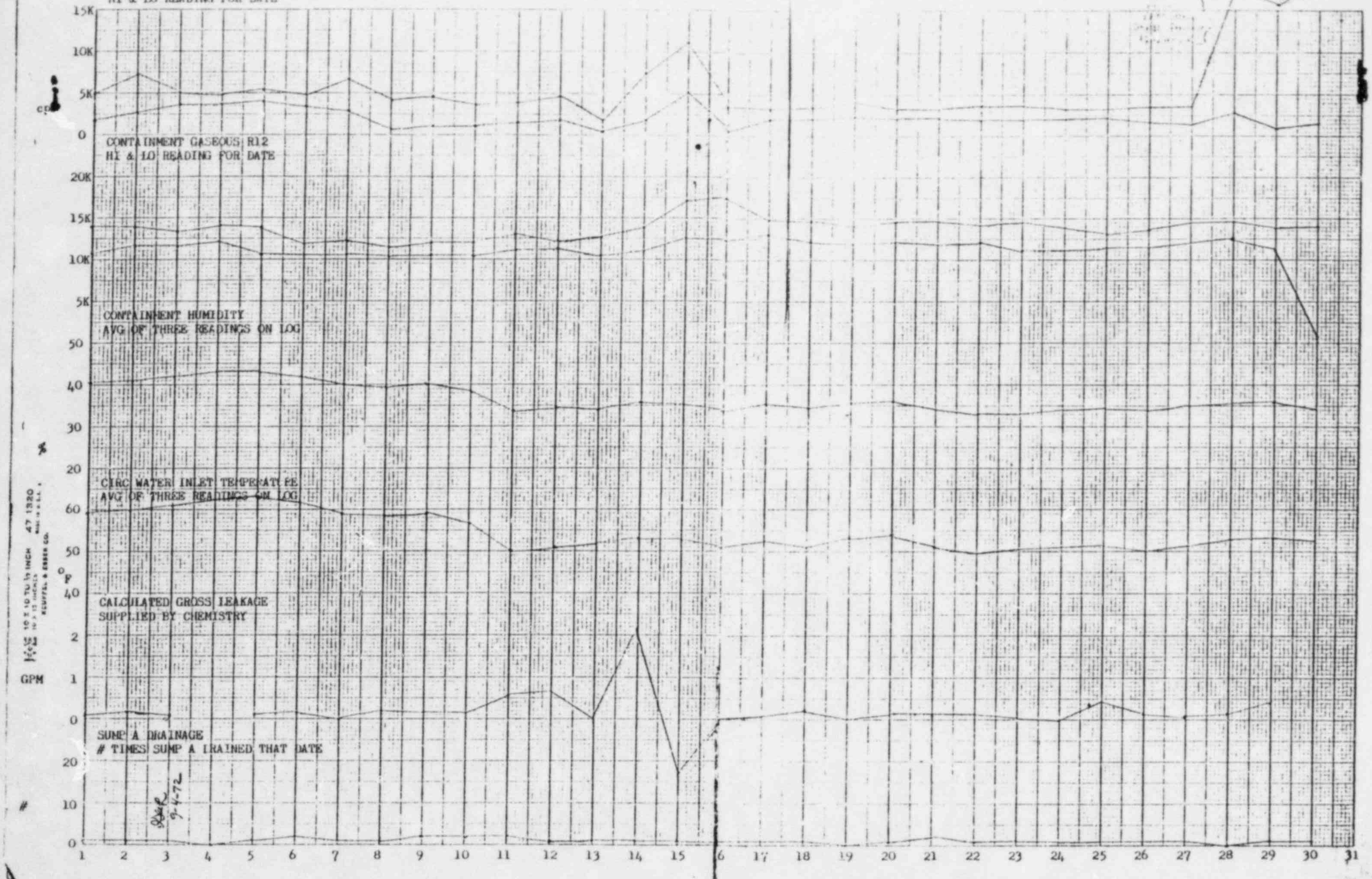
Manager - Nuclear Power Division

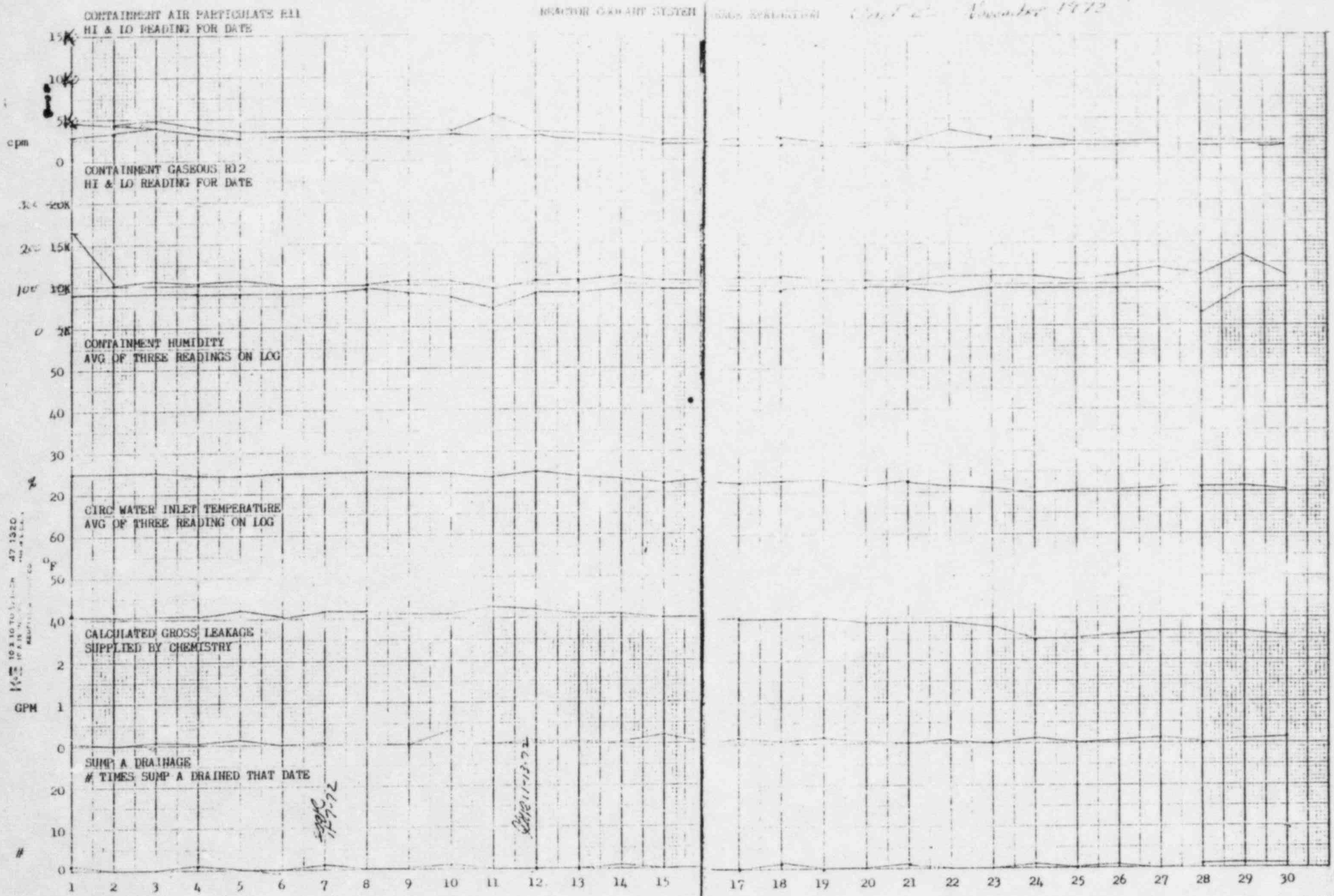
Glenn A. Reed

faf

bcc: Mr. Sol Burstein
Mr. C. W. Fay
Mr. G. A. Reed - Plant: 1.26.1, 1.1.1

REACTOR COOLANT SYSTEM LEAKAGE




REACTOR COOLANT SYSTEM LEAK EVALUATION
Chart 2 November 1972
CONTAINMENT AIR PARTICULATE R11
HI & LO READING FOR DATE
cpm
CONTAINMENT GASEOUS R12
HI & LO READING FOR DATE
20K
15K
10K
5K
CONTAINMENT HUMIDITY
AVG OF THREE READINGS ON LOG
%
CIRC WATER INLET TEMPERATURE
AVG OF THREE READING ON LOG
°F
CALCULATED GROSS LEAKAGE
SUPPLIED BY CHEMISTRY
GPM
SUMP A DRAINAGE
TIMES SUMP A DRAINED THAT DATE
#
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 21 22 23 24 25 26 27 28 29 30

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~~12/26/72~~
2/~~8~~/73
?-19-73

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REGULATORY GUIDE ~~1.XX~~ 1.45

~~SAFETY GUIDE~~

REACTOR COOLANT PRESSURE BOUNDARY

LEAKAGE DETECTION SYSTEMS

A. Introduction

General Design Criterion 30, "Quality of Reactor Coolant Pressure Boundary," of Appendix A to 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants," requires that means be provided for detecting and, to the extent practical, identifying the location of the source of reactor coolant leakage. This ~~safety~~ guide describes acceptable methods of implementing this requirement with regard to the selection of leakage detection systems for the reactor coolant pressure boundary. This guide applies to light water reactors.

B. Discussion

The safety significance of leaks from the reactor coolant pressure boundary (RCPB) can vary widely depending on the [~~nature~~] source of the leak as well as the leakage rate and duration. Therefore, the detection and monitoring of [~~unanticipated~~] leakage of reactor coolant into the containment area is [~~important~~] necessary. In most cases, methods for separating the [~~expected~~] leakage from [~~unanticipated~~] an identified source from the leakage from an unidentified source are necessary to provide prompt and quantitative information to the operators to permit them to take immediate corrective action

should a leak be detrimental to the safety of the facility. Identified leakage is: (1) leakage into closed systems, such as pump seal or valve packing leaks that are captured, flow metered and conducted to a sump or collecting tank, or (2) leakage into the containment atmosphere from sources that are both specifically located and known not to either interfere with the operation of unidentified leakage monitoring systems nor to be from a flaw in the RCPB. Unidentified leakage is all other leakages.

Leakage Separation

A limited amount of leakage is expected from the RCPB and from auxiliary systems within the containment such as from valve stem packing glands, circulating pump shaft seals, and other equipment that cannot practically be made 100% leaktight. The reactor vessel closure seals and safety and relief valves [~~normally~~] should not significantly leak; however, if leakage occurs via these paths or via pump[~~s~~] and valve seals, it should be detectable and collectable and, to the extent [~~practicable~~] practical, isolated from the containment atmosphere so as not to mask any potentially serious leak should it occur. These leakages are known as "identified leakage" and should be piped to tanks or sumps so that the [~~normal~~] flow rate can be established and monitored during plant operation.

Uncollected ~~Non-collected~~ leakage to the containment [~~area~~] atmosphere from sources such as valve[~~s~~] [~~or leakage from abnormal causes such as through flaws in the RCPB or other system boundaries~~] and stem packing glands and other sources that are not collected increases the humidity of the containment. [~~and condenses out on cold components and in the containment air coolers.~~] The moisture removed from the atmosphere by air coolers together with any associated liquid leakage to the containment is known as "unidentified leakage" and should be collected in tanks or sumps where the [~~normal~~] flow rate can be established and monitored during plant operation. A small amount of unidentified leakage may be impractical to eliminate, but it should [~~It is important that the normal unidentified leakage~~] be reduced to a small flow rate, preferably less than one gallon per minute (gpm), to permit the [~~unidentified~~] leakage detection systems to detect positively and rapidly a small increase in flow rate. Thus a small unidentified leakage rate that is of concern will not be masked by a [~~large normal~~] larger acceptable identified leakage rate.

Substantial intersystem leakage from the RCPB to other systems across passive barriers or valves is [~~normally~~] not expected. However, should such leakage occur, it may not be detectable through the above-mentioned [~~collecting~~] detection systems, and other alarm and detection methods should be employed. For example, steam generator

leakage in pressurized water reactors (PWR's) should be monitored to detect tube or tube sheet leaks.

Acceptable Detection Methods

Although monitoring of both identified and unidentified leakage is important, the following descriptions and requirements are intended [~~primarily~~] for systems to detect and aid in locating unidentified leakage.

In addition to monitoring flow rate changes to tanks and sumps for liquid collection, other methods should be included to indicate when coolant is released to the containment atmosphere. For example, such additional detection methods would indicate and/or monitor changes in:

a. airborne particulate radioactivity,

b. airborne gaseous radioactivity,

c. containment atmosphere humidity,

d. containment atmosphere pressure and temperature,

e. condensate flow rate from air coolers.

Since intersystem leakage does not release reactor coolant to the containment atmosphere, detection methods should include monitoring of water radioactivity in the connected systems where the system flows through the containment boundary, and airborne radioactivity where such systems are vented outside the containment boundary. Another important method of obtaining indications of uncontrolled

or undesirable intersystem flow would be the use of a water inventory balance, designed to provide appropriate information such as abnormal water levels in tanks and abnormal water flow rates.

<u>Potential</u> discharges from closed safety and relief valves [~~should normally be~~] <u>are usually</u> piped to tanks or water pools and considered part of [~~the potential~~] identified leakage. Temperature sensors in the discharge path of safety and relief valves or flow meters in the leak-off lines would provide an acceptable method of signaling <u>small</u> leakage from these valves.

While the above-mentioned leakage detection systems [~~are presently acceptable~~] <u>reflect the present state of technology</u>, it is recognized that other detection methods may be developed and used in order to obtain operating experience with them. Among such methods are sonic indicators ~~(audible and supersonic)~~ and moisture sensitive tapes applied to RCPB component parts. The development and use of improved methods of leak detection [~~is~~] <u>are</u> encouraged.

It is not required that all of the above-mentioned leakage detection methods or systems be employed in a specific nuclear power plant. However, since the methods differ in sensitivity and response time, prudent selection of detection methods should include sufficient systems to assure effective monitoring during periods when some detection systems may be ineffective or inoperable. Some of these

systems should serve as early alarm systems signaling the operators that [a-need-for] closer examination of other detection systems is necessary to determine the extent of any corrective action that may be required.

Detector Sensitivity

A basic requirement of leakage detection systems is an ability to detect significant RCPB degradation as soon after occurrence as [practicable] practical to minimize the potential for a gross boundary failure. It is possible that some cracks might develop and penetrate the RCPB wall, exhibit very slow growth ~~and be favorably located so as to~~ and afford ample time for a safe and orderly plant shutdown after a leak is detected. On the other hand, leakage such as that resulting from [unidentified-leakage-such-as-could-be-caused by] stress-assisted corrosion in stainless steel or from a flaw at a high fatigue point in the RCPB would demand rapid detection and probable plant shutdown. [as-soon-as-possible] Therefore, an early warning signal is necessary to permit proper evaluation of all unidentified leakage.

Industry practice has shown that water flow rate changes of from 0.5 to 1.0 gpm can readily be detected in containment sumps by monitoring changes in sump water level, in flow rate[s], or in the operating frequency of pumps. Sumps and tanks used to collect unidentified

leakage and air cooler condensate should be instrumented to alarm for increases of from 0.5 to 1.0 gpm in the normal flow rates. This sensitivity would provide an acceptable performance for detecting increases in unidentified liquid leakage by this method.

An increase in humidity of the [normal] containment atmosphere [humidity] would indicate release of water vapor to the containment. Dew point temperature measurements can be used to monitor humidity levels of the containment atmosphere [air]. A 1° increase in dew point is well within the sensitivity range capability of available instruments. Since the humidity level is influenced by several factors, a quantitative evaluation of an indicated leakage rate may be questionable and should be compared to observed increases in liquid flow [to] from sumps and condensate flow from air coolers. Humidity level monitoring is considered most useful as an alarm or indirect indicating device to alert the operator to a potential problem.

Reactor coolant normally contains sources of radiation which, when released to the containment [area], can be detected by the monitoring systems. However, reactor coolant radioactivity should be low during initial reactor startup and for a few weeks thereafter until activated corrosion products have been formed and fission products may be available from failed fuel elements: during this period, [radiation] radioactivity monitoring instruments may be of limited value in

providing an early warning for very small leaks in the RCPB. Instrument sensitivit[y]ies of 10^{-9} µCi/cc [activity] radioactivity for air particulate monitoring and of 10^{-6} µCi/cc [activity] radioactivity for radiogas monitoring are practical for these leakage detection systems. Radioactivity monitoring systems should be included for every plant (especially particulate activity monitoring) because of [the] their sensitivity and rapid response [and-ability-to-preferentially-indicate] to leaks from the RCPB.

Air temperature and pressure monitoring methods may also be used to infer RCPB leakage to the containment. Containment temperature and pressure fluctuate slightly during plant operation, but a rise above the normally indicated range of values may indicate RCPB leakage into the containment. The [sensitivity] accuracy and relevance of temperature and pressure measurements is a function of containment free volume and detector location. Alarm signals from these instruments [are-primarily] can be valuable in recognizing rapid and sizable energy releases to the containment.

While the concern about instrument sensitivity applies to the lower range of service for which the instruments are selected, the upper instrument range limits should be established to prevent exceeding the saturation limits of instruments, thus making them useless as indicators of containment conditions.

Detector Response Time

The need to evaluate the severity of an alarm or indication is important to the operators, and the ability to compare with indications from other systems is necessary. The system response time should therefore be included in the functional requirements for leakage detection systems. Except for the limitations during the initial few weeks of plant operation[~~, when the reactor coolant may not contain activated corrosion products or fission products from failed fuel elements,~~] as discussed previously, all detector systems should respond to a one gpm, or its equivalent, leakage increase in one hour or less. Multiple instrument locations in monitored areas should be utilized if necessary to assure that the transport delay time of the leakage effluent from its source to the detector or instrument location will yield an acceptable overall response time. [~~Multiple sensor locations is also~~] A useful technique in identifying the general location of a leakage area [~~and this~~] is the placing of several sensors within the containment area and observing differences in response from the sensors, and this technique should be used [~~as necessary~~] to satisfy this requirement of General Design Criterion 30.

In analyzing the sensitivity of leak detection systems using airborne particulate or gaseous radioactivity, a realistic primary coolant

radioactivity concentration assumption should be used. The expected values used in the plant environmental report would be acceptable.

Signal Correlation and Calibration

It is important to be able to associate a signal or indication of a change in the normal operating conditions with a quantitative leakage flow [~~in gpm~~] rate. Except for flow rate or level change measurements fr m tanks, sumps or pumps, signals from other leakage detection systems do not provide information readily convertible to a common denominator. Approximate relationships converting these signals to units of water flow should be formulated to assist the operator in interpreting signals. Since operating conditions may influence some of the [~~converting~~] conversion procedures, [~~these~~] the procedures should be ~~altered and upgraded~~ revised during such periods. To assure the continued reliability of the leakage detection systems, the equipment should comply with paragraph 4.10 of IEEE Std. 279-1971,[1/] for tests and calibration.

Seismic Qualification

Since nuclear power plants ~~are intended to continue in operation~~ may be operating at the time an earthquake occurs and may continue to operate after ~~light or moderate~~ earthquakes, it is prudent to require the

[1/] Copies of IEEE Std. 279-1971, "IEEE Standard: Criteria for Protection Systems for Nuclear Power Generating Stations," may be obtained from the Institute of Electrical and Electronics Engineers, United Engineering Center, 345 East 47th Street, New York, N. Y. 10017.

leakage detection systems to function under the same conditions. If a seismic event [~~equal~~] <u>comparable</u> to a safe shutdown earthquake (SSE) occurs, it would be important for the operator to assess the condition within the containment [~~more~~] quickly. The proper functioning of at least one leakage detection system would assist in evaluating the seriousness of the condition within the containment in the event a leakage has developed in the RCPB. The airborne particulate radioactivity monitoring equipment ~~is required for all plants, it~~ has the desirable sensitivity to indicate RCPB leakage. ~~and its~~ Components should be qualified [~~as-seismic-Class-I-equipment~~] <u>to function through a SSE.</u>

C. <u>Regulatory Position</u>

<u>The source of reactor coolant leakage should be identifiable to the extent practical.</u> Reactor coolant pressure boundary leakage detection and [~~control~~] <u>collection</u> systems should be selected and designed to include the following:

1. Leakage to the primary reactor containment from [~~expected-leakage paths-that-have-been-anticipated-and-identified~~] <u>identified sources</u> should be collected or otherwise isolated so that:

   (a) [~~it-is-separated-from-unidentified-leakages,-and~~] <u>the flow rates are monitored separately from unidentified leakage, and</u>

   (b) the total flow rate[~~s~~] can be established and monitored.

2. [~~Liquid~~] Leakage to the primary reactor containment from [~~leakage paths~~] unidentified sources [~~that-have-not-been-anticipated-or identified~~] should be collected [~~to~~] and the [~~extent-practicable and-its~~] flow rate [~~established-and~~] monitored with an accuracy of one gallon per minute (gpm) or [~~less~~] better.

3. [~~The-conditions-of-the-containment-atmosphere-should-be-monitored for-changes-in-appropriate-parameters-selected-from-the-following:~~]
~~(a)--airborne-particulate-radioactivity,~~
~~(b)--airborne-gaseous-radioactivity,~~
~~(c)--humidity,~~
~~(d)--pressure-and-temperature,~~
~~(e)--condensate-flow-rate-from-air-coolers.~~]
At least three separate detection methods should be employed and two of these methods should be 1) sump level and flow monitoring and 2) airborne particulate radioactivity monitoring. The third method may be selected from the following:
(a) monitoring of condensate flow rate from air coolers,
(b) monitoring of airborne gaseous radioactivity.

Humidity, temperature or pressure monitoring of the containment atmosphere should be considered as alarms or indirect indication of leakage to the containment.

4. Provisions should be made to monitor systems connected to the RCPB for signs of intersystem leakage. Methods should include radioactivity monitoring and indicators to show abnormal water levels or flow in the affected area.

[~~5.--A-total-of-at-least-3-separate-detection-methods-for-unidentified leakage-should-be-employed-and-one-of-these-methods-should-be-for radioactive-particulate-monitoring.~~]

[~~6.~~]5. The sensitivity and response time of each leakage detection system in regulatory position 3.0 above employed for unidentified leakage should be adequate to detect a leakage rate, or its equivalent, of one gpm in less than one hour.

[~~7.~~]6. The leakage detection systems should be capable of performing their functions following seismic events that do not require plant shutdown. [~~Components-for~~] The airborne particulate radioactivity monitoring system should [~~be-seismic-Category-I.~~] remain functional when subjected to a SSE.

[~~8.~~]7. Indicators [~~or~~] and alarms for each leakage detection system should be provided in the main control room. Procedures for converting various indications to a common leakage equivalent[~~s~~] [~~in-gpm~~] should be available to the operators. The calibration of the indicators [~~date-as-conditions-change.~~] should account for ~~all~~ needed independent variables.

[9.]8. The leakage detection systems should be equipped with provisions to readily permit testing for operability and calibration during plant operation.

[10.]9. The technical specifications should include the [~~limitation to~~] limiting conditions for identified and unidentified leakage and address the availability of various types of instruments to assure adequate coverage at all times.

corrected w. OGC comments

Draft 3, 2/8/73 May 1973

[illegible]

REGULATORY GUIDE 1.45

REACTOR COOLANT PRESSURE BOUNDARY

LEAKAGE DETECTION SYSTEMS

A. Introduction

General Design Criterion 30, "Quality of Reactor Coolant Pressure Boundary," of Appendix A to 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants," requires that means be provided for detecting and, to the extent practical, identifying the location of the source of reactor coolant leakage. This guide describes acceptable methods of implementing this requirement with regard to the selection of leakage detection systems for the reactor coolant pressure boundary. This guide applies to light water cooled reactors.

B. Discussion

The safety significance of leaks from the reactor coolant pressure boundary (RCPB) can vary widely depending on the source of the leak as well as the leakage rate and duration. Therefore, the detection and monitoring of leakage of reactor coolant into the containment area is necessary. In most cases, methods for separating the leakage from an identified source from the leakage from an unidentified source are necessary to provide prompt and quantitative information to the operators to permit them to take immediate corrective action should a leak be detrimental to the safety of

the facility. Identified leakage is: (1) leakage into closed systems, such as pump seal or valve packing leaks that are captured, flow metered and conducted to a sump or collecting tank, or (2) leakage into the containment atmosphere from sources that are both specifically located and known ~~not to either~~ either not to interfere with the operation of unidentified leakage monitoring systems ~~nor~~ or not to be from a flaw in the RCPB. Unidentified leakage is all other leakages.

Leakage Separation

A limited amount of leakage is expected from the RCPB and from auxiliary systems within the containment such as from valve stem packing glands, circulating pump shaft seals, and other equipment that cannot practically be made 100% leaktight. The reactor vessel closure seals and safety and relief valves should not leak significantly; however, if leakage occurs via these paths or via pump and valve seals, it should be detectable and collectable and, to the extent practical, isolated from the containment atmosphere so as not to mask any potentially serious leak should it occur. These leakages are known as "identified leakage" and should be piped to tanks or sumps so that the flow rate can be established and monitored during plant operation.

Uncollected leakage to the containment atmosphere from sources such as valve ~~and~~ or stem packing glands and other sources that are not

collected increases the humidity of the containment. The moisture removed from the atmosphere by air coolers together with any associated liquid leakage to the containment is known as "unidentified leakage" and should be collected in tanks or sumps where the flow rate can be established and monitored during plant operation. A small amount of unidentified leakage may be impractical to eliminate, but it should be reduced to a small flow rate, preferably less than one gallon per minute (gpm), to permit the leakage detection systems to detect positively and rapidly a small increase in flow rate. Thus a small unidentified leakage rate that is of concern will not be masked by a larger acceptable identified leakage rate.

Substantial intersystem leakage from the RCPB to other systems across passive barriers or valves is not expected. However, should such leakage occur, it may not be detectable through the above-mentioned detection systems, and other alarm and detection methods should be employed. For example, steam generator leakage in pressurized water reactors (PWR's) should be monitored to detect tube or tube sheet leaks.

Acceptable Detection Methods

Although monitoring of both identified and unidentified leakage is important, ~~the following descriptions and requirements are intended for systems to detect and aid in locating unidentified leakage~~.

effective systems for detecting and locating unidentified leakage are also needed. The following paragraphs describe some acceptable detection methods.

In addition to monitoring flow rate changes to tanks and sumps for liquid collection, other methods should be included to indicate when and where coolant is released to the containment atmosphere. For example, ~~such~~ these additional detection methods would indicate and/or monitor changes in:

a. airborne particulate radioactivity,

b. airborne gaseous radioactivity,

c. containment atmosphere humidity,

d. containment atmosphere pressure and temperature,

e. condensate flow rate from air coolers.

Since intersystem leakage does not release reactor coolant to the containment atmosphere, detection methods should include monitoring of water radioactivity in the connected systems where the system flows through the containment boundary, and monitoring of airborne radioactivity where such systems are vented outside the containment boundary. Another important method of obtaining indications of uncontrolled or undesirable intersystem flow would be the use of a water inventory balance, designed to provide appropriate information such as abnormal water levels in tanks and abnormal water flow rates.

Potential discharges from closed safety and relief valves are usually piped to tanks or water pools and considered part of identified leakage. Temperature sensors in the discharge path of safety and relief valves or flow meters in the leak-off lines would provide an acceptable method of signaling small leakage from these valves.

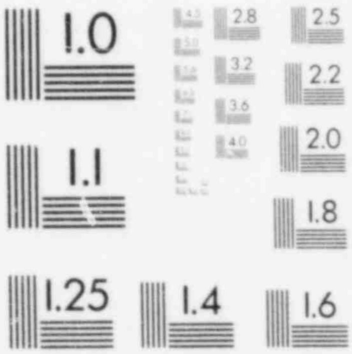
While the above-mentioned leakage detection systems reflect the present state of technology, it is recognized that other detection methods may be developed and used in order to obtain operating experience with them. Among such methods are sonic indicators and moisture sensitive tapes applied to RCPB component parts. ~~The development and use of~~ improved methods of leak detection are encouraged. Because of the potential importance of early leak detection and location in the prevention of accidents, continued improvements in leakage detection techniques should be sought.

It is not ~~required~~ necessary that all of the above-mentioned leakage detection methods or systems be employed in a specific nuclear power plant. However, since the methods differ in sensitivity and response time, prudent selection of detection methods should include sufficient systems to assure effective monitoring during periods when some detection systems may be ineffective or inoperable. Some of these systems should serve as early alarm systems signaling the operators that closer examination of other detection systems is necessary to determine the extent of any corrective action that may be required.

Detector Sensitivity

~~A basic requirement of~~ It is essential that leakage detection systems ~~is an ability to~~ have the capability to detect significant RCPB degradation as soon after occurrence as practical to minimize the potential for a gross boundary failure. It is possible that some cracks might develop and penetrate the RCPB wall, exhibit very slow growth and afford ample time for a

IMAGE EVALUATION TEST TARGET (MT-3)



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safe and orderly plant shutdown after a leak is detected. On the other hand, leakage such as that resulting from stress-assisted corrosion in stainless steel or from a flaw at a high fatigue point in the RCPB would demand rapid detection and probable plant shutdown. Therefore, an early warning signal is necessary to permit proper evaluation of all unidentified leakage.

Industry practice has shown that water flow rate changes of from 0.5 to 1.0 gpm can readily be detected in containment sumps by monitoring changes in sump water level, in flow rate, or in the operating frequency of pumps. Sumps and tanks used to collect unidentified leakage and air cooler condensate should be instrumented to alarm for increases of from 0.5 to 1.0 gpm in the normal flow rates. This sensitivity would provide an acceptable performance for detecting increases in unidentified liquid leakage by this method.

An increase in humidity of the containment atmosphere would indicate release of water vapor to the containment. Dew point temperature measurements can be used to monitor humidity levels of the containment atmosphere. A 1° increase in dew point is well within the sensitivity range capability of available instruments. Since the humidity level is influenced by several factors, a quantitative evaluation of an indicated leakage rate may be questionable and should be compared to observed increases in liquid flow from sumps

and condensate flow from air coolers. Humidity level monitoring is considered most useful as an alarm or indirect indicating device to alert the operator to a potential problem.

Reactor coolant normally contains sources of radiation which, when released to the containment, can be detected by the monitoring systems. However, reactor coolant radioactivity should be low during initial reactor startup and for a few weeks thereafter until activated corrosion products have been formed and fission products ~~may be~~ become available from failed fuel elements; during this period, radioactivity monitoring instruments may be of limited value in providing an early warning for very small leaks in the RCPB. Instrument sensitivities of 10^{-9} μCi/cc radioactivity for air particulate monitoring and of 10^{-6} μCi/cc radioactivity for radiogas monitoring are practical for these leakage detection systems. Radioactivity monitoring systems should be included for every plant (especially particulate activity monitoring) because of their sensitivity and rapid response to leaks from the RCPB.

Air temperature and pressure monitoring methods may also be used to infer RCPB leakage to the containment. Containment temperature and pressure fluctuate slightly during plant operation, but a rise above the normally indicated range of values may indicate RCPB leakage into the containment. The accuracy and relevance of temperature and pressure measurements is a function of containment free volume and

detector location. Alarm signals from these instruments can be valuable in recognizing rapid and sizable energy releases to the containment.

While the concern about instrument sensitivity applies to the lower range of service for which the instruments are selected, the upper instrument range limits should be established to prevent exceeding the saturation limits of instruments, thus making them useless as indicators of containment conditions.

Detector Response Time

The need to evaluate the severity of an alarm or indication is important to the operators, and the ability to compare with indications from other systems is necessary. The system response time should therefore be included in the functional requirements for leakage detection systems. Except for the limitations during the initial few weeks of plant operation as discussed previously, all detector systems should respond to a one gpm, or its equivalent, leakage increase in one hour or less. Multiple instrument locations in monitored areas should be utilized if necessary to assure that the transport delay time of the leakage effluent from its source to the detector or instrument location will yield an acceptable overall response time. A useful technique in identifying the general location of a leakage area is the placing of several sensors within the containment area and observing differences in

response from the sensors, and this technique should be used to satisfy this requirement of General Design Criterion 30.

In analyzing the sensitivity of leak detection systems using airborne particulate or gaseous radioactivity, a realistic primary coolant radioactivity concentration assumption should be used. The expected values used in the plant environmental report would be acceptable.

Signal Correlation and Calibration

It is important to be able to associate a signal or indication of a change in the normal operating conditions with a quantitative leakage flow rate. Except for flow rate or level change measurements from tanks, sumps or pumps, signals from other leakage detection systems do not provide information readily convertible to a common denominator. Approximate relationships converting these signals to units of water flow should be formulated to assist the operator in interpreting signals. Since operating conditions may influence some of the conversion procedures, the procedures should be revised during such periods. To assure the continued reliability of the leakage detection systems, the equipment should comply with paragraph 4.10 of IEEE Std. 279-1971,[1/] for tests and calibration.

[1/] Copies of IEEE Std. 279-1971, "IEEE Standard: Criteria for Protection Systems for Nuclear Power Generating Stations," may be obtained from the Institute of Electrical and Electronics Engineers, United Engineering Center, 345 East 47th Street, New York, N. Y. 10017.

Seismic Qualification

Since nuclear power plants may be operating at the time an earthquake occurs and may continue to operate after earthquakes, it is prudent to require the leakage detection systems to function under the same conditions. If a seismic event comparable to a safe shutdown earthquake (SSE) occurs, it would be important for the operator to assess the condition within the containment quickly. The proper functioning of at least one leakage detection system would assist in evaluating the seriousness of the condition within the containment in the event a leakage has developed in the RCPB. The airborne particulate radioactivity monitoring equipment has the desirable sensitivity to indicate RCPB leakage, and it should be included for all plants. Components for the airborne particulate radioactivity equipment should be qualified to function through a SSE.

C. Regulatory Position

The source of reactor coolant leakage should be identifiable to the extent practical. Reactor coolant pressure boundary leakage detection and collection systems should be selected and designed to include the following:

1. Leakage to the primary reactor containment from identified sources should be collected or otherwise isolated so that:
   (a) the flow rates are monitored separately from unidentified leakage, and

(b) the total flow rate can be established and monitored.

2. Leakage to the primary reactor containment from unidentified sources should be collected and the flow rate monitored with an accuracy of one gallon per minute (gpm) or better.

3. At least three separate detection methods should be employed and two of these methods should be 1) sump level and flow monitoring and 2) airborne particulate radioactivity monitoring. The third method may be selected from the following:

   (a) monitoring of condensate flow rate from air coolers,

   (b) monitoring of airborne gaseous radioactivity.

   Humidity, temperature or pressure monitoring of the containment atmosphere should be considered as alarms or indirect indication of leakage to the containment.

4. Provisions should be made to monitor systems connected to the RCPB for signs of intersystem leakage. Methods should include radioactivity monitoring and indicators to show abnormal water levels or flow in the affected area.

5. The sensitivity and response time of each leakage detection system in regulatory position 3.0 above employed for unidentified leakage should be adequate to detect a leakage rate, or its equivalent, of one gpm in less than one hour.

6. The leakage detection systems should be capable of performing their functions following seismic events that do not require plant shutdown. The airborne particulate radioactivity monitoring system should remain functional when subjected to a SSE.

7. Indicators and alarms for each leakage detection system should be provided in the main control room. Procedures for converting various indications to a common leakage equivalent should be available to the operators. The calibration of the indicators should account for needed independent variables.

8. The leakage detection systems should be equipped with provisions to readily permit testing for operability and calibration during plant operation.

9. The technical specifications should include the limiting conditions for identified and unidentified leakage and address the availability of various types of instruments to assure adequate coverage at all times.