BWR OWNERS' GROUP

MODEL CONTAINMENT INSPECTION PROGRAM

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BWROG MODEL CONTAINMENT INSPECTION PROGRAM

TABLE OF CONTENTS

BWROG MODEL CONTAINMENT INSPECTION PROGRAM

1.0 PURPOSE

This report provides a model containment inspection program (CIP) for Boiling Water Reactor (BWR) Mark I and II containment systems. Addressed in this report are containment integrity, containment failure modes and probabilities, recommended inspections, and evaluation of inspection results. It is the BWROG's position that implementation of this CIP will fully address all viable containment integrity issues in a manner which will provide for appropriate corrective action long before a potential containment failure is credible.

This program was developed in response to NRC concerns for potential degradation of containment integrity due to corrosion incidents in the drywell shell and suppression pool that occurred at two U.S. BWRs. In 57 Federal Register 54860, dated November 20, 1992, the NRC proposed augmented inspection requirements for Mark I and Mark II steel containments, refueling cavities, and associated drainage systems. The BWROG provided comments on the NRC's proposed inspection program and suggested an alternate approach which would achieve the NRC's goals and be more cost effective. In subsequent discussions with the NRC, the BWROG agreed to prepare a model CIP, which this document represents. Implementation of this program is recommended as an alternative to the NRC proposed augmented inspection requirements and the requirements of the ASME Boiler & Pressure Vessel Code, Section XI, Subsection IWE. Applicability of the BWROG CIP to ASME Section XI, Subsection IWE requirements is included in Attachment C.

2.0 APPLICABILITY

This model CIP is applicable to all BWR Mark I and II containments which have an air gap between the outside of the containment shell and the concrete shield wall. This CIP is also applicable to Mark I and II suppression pools. This report includes several examples and comparisons which are applicable to Mark I containments. Similar write-ups for Mark II containments have not been included as they would be repetitive and would not add any technical merit to the methodology applied by the BWROG.

Each individual licensee is not bound by this document unless they specifically choose to apply it to address containment inspection. Licensees can and should take credit for activities performed prior to this document which address the issue of containment integrity.

3.0 DESIGN BASES AND MARGINS

3.1 SUMMARY DESCRIPTION OF TYPICAL CONTAINMENT SYSTEM

The containment system provides a multiple barrier, pressure suppression containment employing containment-in-depth principles:

- o The fuel cladding and reactor pressure vessel form barriers to the release of fission products.

- The primary containment consists of a drywell and a pressure suppression chamber, as well as a connecting vent system between the drywell and pressure suppression chamber, and isolation valves.

- The reactor building, enclosing the primary containment system, provides secondary containment.

The containment system is designed to condense the steam released during a safety-relief valve discharge or a postulated loss-of-coolant accident (LOCA), to limit the release of the fission products associated with the accident, and to serve as a source of water for the emergency core cooling systems (ECCS).

The containment system consists of a drywell, which encloses the reactor vessel, the reactor coolant recirculation system, and other branch connections of the reactor coolant system; a pressure-suppression chamber, containing a large volume of water; and a vent system, which connects the drywell to the water space of the suppression chamber.

In the event of a postulated LOCA, reactor water and steam would expand into the containment atmosphere. As a result of the increasing drywell pressure, a mixture of drywell atmosphere, steam, and water would be forced through the vent system into the pool of water which is stored in the suppression chamber. The steam vapor would condense in the suppression pool, thereby reducing the drywell pressure. Non-condensible gases and fission products would be collected and contained in the suppression chamber. Initially, the drywell atmosphere is transferred to the suppression chamber and pressurizes the chamber. At the end of the blowdown, when ECCS water spills out of the break and rapidly reduces the drywell pressure, the suppression chamber is vented to the drywell through installed vacuum breakers to equalize the pressure between the two vessels. The ECCS cools the reactor core and transports the heat to the water in the suppression chamber, thus providing a continuous path for the removal of decay heat from the primary system.

3.2 DESIGN BASES

3.2.1 Performance Objectives

The primary performance objectives of the primary containment system are:

a. To provide a barrier which, in the event of a LOCA, controls release of fission products to the secondary containment; and

b. To reduce the pressure in the containment resulting from the LOCA.

3.2.2 Internal Design Pressure

Typically, the containment system for a BWR was designed for a pressure which exceeds that which would result from the design basis accident. For a typical Mark I containment this pressure was 62 psig to provide a conservative means of meeting this objective. This value is based on LOCA simulation tests conducted in 1962 to confirm the pressure suppression containment design of the Bodega Bay BWR. The Bodega Bay containment design had 112 vent pipes directing flow from the drywell into the suppression pool. The test facility was a full-scale mockup of a 1/112th segment of the Bodega Bay containment suppression chamber with one full-scale vent pipe. The maximum containment pressure from the tests which were applicable to the Bodega Bay design was 52 psig. To establish the containment design pressure for Bodega Bay, 10 psig was added for margin. This resulted in a 62 psig design pressure which was applied to later BWRs.

Therefore, conservative margin is included in the maximum internal pressure containment design limit itself. In addition, plant-specific evaluations of peak containment pressure documented in plant Final Safety Analysis Reports (FSARs) demonstrate considerable margin exists to the limit. These evaluations take three forms: 1) estimation of the peak containment pressure based on a correlation of the Bodega Bay test values for peak containment pressure as a function of the ratio for drywell-to-wetwell vent area to break area; 2) FSAR calculation of the peak containment pressure from analysis of the design basis LOCA; and 3) calculation of the containment pressure response as part of the Mark I Containment Long Term Program. These evaluations typically resulted in calculated peak containment pressures of less than 50 psig, and sometimes substantially less.

3.3 CONTAINMENT MARGINS

There are many conservatisms and margins against failure included in the design of Mark I and II containments. Among these are:

- o Code allowable stress intensities are much less than material yield/tensile strengths.
- o Design pressure and temperature are typically higher than calculated maximum values.
- o Analyses in the past have been conservatively performed using linear elastic techniques. Elastic-plastic analysis of local areas would result in stresses substantially lower than those determined using linear elastic techniques.
- o Material toughness is established at temperatures well below those encountered during any postulated accident event.
- o Allowable stress criteria is based upon minimum specified tensile properties; actual material properties are expected to be somewhat higher.
- o Actual supplied material is typically thicker than the nominal thickness specified.
- o Certified mill reports in many cases have higher tensile strength than the nominal.

- o Results documented in stress reports are generally bounding, and envelope all postulated design conditions. If more detailed evaluations are performed, more accurate and more realistic results may be determined, and additional margins are likely.

The Mark I Containment Owners' Group completed a state-of-the-art analysis of a typical Mark I containment structure in 1987 (reference: "Mark I Containment Severe Accident Analysis," April 1987). This analysis included features which contributed to the accuracy of the results. The failure criteria adopted for the analysis are when the containment shell material reached 1% membrane strain or 2% surface strain. The first point on the containment boundary which reached 1% membrane strain is the upper portion of the suppression chamber torus, when the pressure in the primary containment system is 159 psig. Based on these results, it is estimated that a breach of containment is not likely until the internal pressure reaches or exceeds 159 psig.

This evaluation also demonstrated that, at the time the pressure reaches 159 psig, the largest value of membrane strain in the drywell is 0.45%. When the membrane strain reaches a value of 0.72%, the steel shell would be in contact with the reinforced concrete drywell shield wall and no additional accumulation of strain is expected with pressure. An independent evaluation of the concrete drywell shield wall has shown that it has more capacity than needed to support the drywell shell.

Considering the conservatisms included in the design of Mark I and II containments as discussed above, a typical plant probabilistic risk assessment (PRA) of containment failure would be very similar to that shown in Attachment E. As this attachment shows, the most probable containment failure mechanisms are failure of the drywell head gasket or cracking of the containment penetration bellows. The contribution to failure of the containment steel structure is negligible; meaning the current industry emphasis on establishing containment integrity through 10 CFR 50, Appendix J testing is appropriate and effective.

4.0 CONTAINMENT INTEGRITY ISSUES

4.1 CORROSION OF CONTAINMENT EXTERIOR SURFACES DUE TO MOISTURE IN SAND CUSHION

General corrosion of the containment exterior surface was first identified as a concern when water was observed leaking from the sand cushion drains at Oyster Creek, a Mark I containment. Subsequent investigations revealed containment wall thinning in the sand cushion region. The source of the water was determined to be a leaking gasket in a mechanical joint between the refueling bellows cavity drain line and the cavity liner plate. The result was leakage of water down through the containment air gap to the sand cushion area where the wet, moist environment corroded the containment wall. The remaining wall thickness was documented to be between 65% and 75% of the nominal thickness in localized areas. The design of the containment did not include a seal plate over the sand cushion to prevent intrusion of moisture, and the plant also operated for a period of time with the associated drains being clogged.

The concern is that without a regularly scheduled inspection program to look for the signs of water or moisture, corrosion might occur unknowingly at other BWRs as at Oyster Creek. It is the position of the BWROG that performance of the recommended inspection/testing in accordance with Attachment A, existing utility surveillance procedures, and deficiency reporting processes would identify problems in sufficient time that the integrity of the containment will not be jeopardized.

4.2 CORROSION OF CONTAINMENT EXTERIOR SURFACES DUE TO GAP-FORMING MATERIAL

During the construction of the concrete shield walls a non-structural gap-forming material may have been used to separate the metal shell from the concrete shield wall. Different methods were used at each site to secure the gap-forming material. The material was not removed at some plants and remains adjacent to the steel surface. Over time and aided by thermal expansion cycles, the gap-forming material may have shifted and the exact locations are unknown.

As part of the Oyster Creek containment corrosion investigation, wall thinning was identified in areas above the sand cushion where gap-forming material was suspected to remain. The corrosion was attributed to wetted gap-forming material holding moisture to the uncoated containment steel surface.

The concern is that without a regularly scheduled surveillance program for functional testing of drains and looking for indications of water, plants with gap-forming material left in place may have a similar corrosion problem.

It is the position of the BWROG that performance of the recommended inspection/testing in accordance with Attachment A, existing utility surveillance procedures and deficiency reporting processes would identify problems in sufficient time that the integrity of the containment will not be jeopardized.

In both Sections 4.1 and 4.2, the plant deficiency control process would result in an engineering evaluation that would determine the potential for containment integrity problems. Safety evaluations following the 10 CFR 50.59 format would be required for any design modifications implemented due to the engineering evaluation.

4.3 CORROSION OF CONTAINMENT INTERIOR SURFACES DUE TO MOISTURE AT THE CONCRETE-TO-METAL INTERFACE

A natural crevice that could trap water exists at the interface between the containment wall and containment floor in the BWR Mark I and II containment design. A moisture barrier is installed at the concrete to metal interface. The alkaline water chemistry in the crevice is not conducive to accelerated carbon steel containment corrosion and therefore this issue is of low concern.

It is the position of the BWROG that performance of the recommended inspection/testing in accordance with Attachment A, existing utility surveillance procedures, and deficiency reporting processes would identify problems in sufficient time that the integrity of the containment will not be jeopardized.

4.4 CORROSION OF SUPPRESSION POOL INTERIOR SURFACES

At Nine Mile Point Unit 1, general corrosion of the suppression pool containment interior surface below the water line was observed. The wall thickness was found to be near or below the required thickness in localized areas. The Nine Mile Point Unit 1 suppression pool was not constructed with a protective coating and is the only U.S. BWR Mark I containment without a coating. All other BWRs used quality class coatings or corrosion resistant materials (i.e. stainless steel) in the construction of the suppression pool.

The concern is that degradation of the coating could lead to corrosion of the base metal and challenge the containment integrity. Periodic examination of the submerged surfaces of the suppression pool would identify any degraded areas and obtain the information needed to evaluate the need for repairs.

It is the position of the BWROG that performance of the recommended inspection/testing in accordance with Attachment A, existing utility surveillance procedures, and deficiency reporting processes would identify problems in sufficient time that the integrity of the containment will not be jeopardized.

5.0 BWROG INSPECTION METHODOLOGY

In reviewing the proposed NRC augmented containment inspection requirements, it was recognized that an effective program should focus on identifying the potential causes of containment degradation and ensuring that actions were taken to prevent them from affecting containment integrity. It was desired that the program be reasonable, practical to perform and cost effective, and not include arbitrary examinations which require a significant effort to perform with no commensurate benefit to containment integrity. The methodology used in the development of this model containment inspection program is based on the following:

- Perform Appendix J test program.
- Confirm the presence or absence of moisture in the air gap or sand cushion that could affect the containment shell.
- If moisture is present in the air gap or sand cushion:
  - Verify that systems installed to prevent intrusion of moisture into the sand cushion (bellows seal rupture drains, refueling cavity mechanical joints, moisture barrier, etc.) are functional.
  - Determine the source of the leakage, evaluate the potential for degradation, and take appropriate corrective action per plant deficiency control procedures.

- Determine suppression pool interior condition and take appropriate corrective action if necessary.

The BWROG Model Containment Inspection Program is provided in Attachments A and B. Attachment A is a summary table of the examination method, extent of examination, and examination frequency for each item/area addressed by the program. Attachment B is a narrative description of each inspection requirement presented in Attachment A. This program addresses all of the issues identified in Section 4.0.

An evaluation of the BWROG CIP to the ASME Boiler & Pressure Vessel Code Section XI, Subsection IWE requirements is provided in Attachment C. The most notable difference between the two programs is that the BWROG CIP is focused on confirming that conditions which could lead to containment degradation are not present, and if they are that appropriate evaluations and/or repairs are instituted according to the existing plant deficiency control process.

6.0 CONCLUSIONS

- Substantial margins against failure exist in the containment pressure boundary due to conservatisms in the design codes and design calculation methods. These conservatisms provide adequate assurance that the CIP as described herein will detect and appropriately correct any degradation problem prior to it compromising containment integrity.

- The Oyster Creek containment corros[illegible]blem can be directly attributed to leakage from the react[illegible] and the presence of water in the air gap region for an exte[illegible]iod of time. In plants where these conditions are not present, [illegible]ainment corrosion should not be a concern.

- The Nine Mile Point 1 corrosion problem can be directly attributed to the lack of protective coating. Periodic inspection of suppression pool coatings to confirm their integrity and corrective maintenance of the coating is sufficient action to prevent similar problems in coated suppression pools.

- The BWROG Model Containment Inspection Program addresses all of the applicable issues, as identified in Section 4.0, and provides a practical alternative to the proposed NRC augmented containment inspection requirements and ASME Section XI, Subsection IWE inspection requirements.

ATTACHMENT A

BWROG MODEL CONTAINMENT INSPECTION PROGRAM

DRYWELL AND SUPPRESSION POOL INSPECTIONS AND TESTS

ATTACHMENT A

BWROG MODEL CONTAINMENT INSPECTION PROGRAM

DRYWELL AND SUPPRESSION POOL INSPECTIONS AND TESTS

ITEM NO.	ITEM	EXAMINATION METHOD	EXTENT OF EXAMINATION	EXAMINATION FREQUENCY[8]	REMARKS
1.	Drywell air gap drain lines	Functional test[1]	All drain lines	First refueling outage after 6/1/94 and once every 10 years thereafter.[8]	See Attachment B, Section 3.1
2.	Drywell shell exterior surface assessment	Visual condition assessment[2][4][7]	Air gap region adjacent to drain lines	First refueling outage after 6/1/94 and once every 10 years thereafter.[8]	See Attachment B, Section 3.2
3.	Sand cushion drain lines	Functional test[1]	All drain lines	First refueling outage after 6/1/94 and once every 10 years thereafter.[8]	See Attachment B, Section 3.3
4.	Sand cushion assessment	Visual condition assessment[2][3][4][7]	Each drain location of the sand cushion region	First refueling outage after 6/1/94 and once every 10 years thereafter.[8]	See Attachment B, Section 3.4
5.	Normally open air gap and sand cushion drains	Visually inspect for water[2][4]	All drain lines	First refueling outage after 6/1/94 and once each 40-month interval when reactor cavity is flooded.[8]	See Attachment B, Section 3.5
6.	Normally closed air gap and sand cushion drains (valved)	Visually inspect for water[2][4]	All drain lines	Once every fuel cycle.	See Attachment B, Section 3.6
7.	Refueling bellows seal rupture drains	Functional test[9]	Drain line flow path	When leakage from refueling bellows or pool liners is suspected.	See Attachment B, Section 3.7
8.	Refueling cavity mechanical joints	Visual or functional test	All mechanical joints	When moisture is found in air gap or sand cushion and leakage from refueling bellows or pool liners is suspected.	See Attachment B, Section 3.8

ATTACHMENT A

BWROG MODEL CONTAINMENT INSPECTION PROGRAM

DRYWE L AND SUPPRESSION POOL INSPECTIONS AND TESTS

ITEM NO.	ITEM	EXAMINATION METHOD	EXTENT OF EXAMINATION	EXAMINATION FREQUENCY[8]	
9.	Drywell shell interior surfaces	Visual[2][7]	Moisture barrier and adjacent surfaces (10% sample)	First refueling outage after 6/1/94 and once each 40-month period thereafter. [9]	See Attachment B, Section 3.9
10.	Suppression pool interior surface	Visual[6][7][10]	Interior surfaces above and below waterline	First refueling outage after 6/1/94 and every 4th refueling outage thereafter.	See Attachment B, Section 3.10
11.	Containment vessel	10 CFR 50, App. J Type A test	Pressure retaining boundary	Per 10 CFR 50, App. J.	See Attachment B, Section 3.11
12.	Penetration bellows	10 CFR 50, App. J Type B test	Pressure retaining boundary	Per 10 CFR 50, App. J.	See Attachment B, Section 3.12
13.	Airlocks, manways & hatches	10 CFR 50, App. J Type B test	Pressure retaining boundary	Per 10 CFR 50, App. J.	See Attachment B, Section 3.13

Notes:

(1) Verify flow is not blocked for each drain.

(2) If any moisture or leakage is found, an engineering evaluation shall be performed to determine its significance and any corrective actions.

(3) Examinations for water in the sand cushion area at all sand cushion drain locations shall be performed using moisture detection devices, sand sampling, moisture sensitive specimens or any other method which provides evidence of the existence or absence of moisture.

(4) Where gap-forming material remains in inaccessible areas, an engineering evaluation shall be performed to determine the potential degradation effects on the drywell shell in the event the gap-forming material is affected by moisture. If this evaluation determines that degradation of the drywell shell could occur, then appropriate actions shall be taken to verify degradation has not occurred (such as the use of remote visual inspection devices, thickness measurements, removing a sample of the gap-forming material for testing, etc.).

ATTACHMENT A

BWROG MODEL CONTAINMENT INSPECTION PROGRAM

DRYWELL AND SUPPRESSION POOL INSPECTIONS AND TESTS

Notes (Continued):

(5) If pitting and/or general corrosion are identified, an engineering evaluation shall be performed to determine the root cause and need for additional action, such as repairs, replacements, thickness measurements, increased inspection frequency based on degradation rates, or other corrective action.

(6) The inspection period may be extended by as much as 1 year to enable an inspection to coincide with a plant outage. The inspection period may also be extended if a modification to the drain lines is needed to perform the examinations for items 2 and 4.

(7) Visual examination shall be conducted to determine the general condition. Presence of water, corrosion products, debris, flaking and blistering of the coating and degree of cleanliness shall be noted and evaluated. The examination should be performed by individuals familiar with the degradation mechanisms.

(8) Licensee can and should take credit for activities performed prior to 6/1/94.

(9) Drains shall be inspected/tested to confirm unrestricted flow of any water that might leak into the area under the bottom of the refueling cavity to the drainage collection system and not into the drywell air gap region.

(10) Visual examination of a sample of the interior surface below the water line should be performed utilizing submersibles, underwater camera equipment, divers trained to perform underwater visual inspections, or by draining the suppression pool allowing access to the interior surface.

ATTACHMENT B

BWROG MODEL CONTAINMENT INSPECTION PROGRAM

DRYWELL AND SUPPRESSION POOL INSPECTIONS AND TESTS

NARRATIVE DESCRIPTION

ATTACHMENT B

BWROG MODEL CONTAINMENT INSPECTION PROGRAM

DRYWELL AND SUPPRESSION POOL INSPECTIONS AND TESTS NARRATIVE DESCRIPTION

1.0 SCOPE

This inspection program is applicable to all Boiling Water Reactor (BWR) Mark I and II Containment Systems.

2.0 PURPOSE

This is a narrative description of the inspection and test program described in Attachment A. Implementation of this program in conjunction with periodic testing in accordance with 10 CFR 50, Appendix J will provide an acceptable level of quality and safety to assure that the structural integrity of the primary containment is maintained.

3.0 DRYWELL INSPECTIONS

3.1 DRYWELL AIR GAP DRAIN LINE FUNCTIONAL TEST (Attachment A, Item 1)

3.1.1 By the end of the first refueling outage after June 1, 1994, and once each 10 years thereafter, the drain lines above the drywell sand cushion shall be confirmed to be functional. Any method which confirms that the drain lines are open and functional (e.g. insertion of a video probe) is acceptable.

3.1.2 If the drain lines are not functional, then corrective measures shall be implemented to restore functionality, or alternate measures shall be adopted to assure standing water does not exist against the drywell shell.

3.2 DRYWELL SHELL EXTERIOR SURFACE ASSESSMENT (Attachment A, Item 2)

3.2.1 By the end of the first refueling outage after June 1, 1994, and once each 10 years thereafter, visually inspect the air gap region at each drain location for the presence of water, corrosion products, debris, flaking and blistering of coatings, and cleanliness.

3.2.2 If moisture is present in the air gap region, then additional examinations and/or an engineering evaluation shall be performed to determine the origin of the moisture and, to the extent possible, the quantity of the moisture and the extent of any degradation that may have occurred. (These additional examinations may include visual inspections at containment penetrations which provide access to the air gap region at random elevations, inspections of the reactor cavity liner for leaks, or inspections at stabilizer hatches or other locations which provide access to the air gap region.)

If evidence of degradation is found an engineering evaluation shall be performed to determine the root cause and need for additional actions, such as repairs, replacements, thickness measurements, increased inspection frequency based on degradation rates, or other corrective action. The engineering evaluation should consider at least the following:

a) the source of the leakage and the chemistry of the water;

b) containment material properties;

c) coatings and their effectiveness;

d) the length of time the drywell shell was exposed to the water, the functionality of the drains, and the drains' leakage history;

e) any potentially mitigating factors (such as use of dehumidifiers or cathodic protection); and

f) any potentially contributing factors (such as location of gap forming materials).

3.2.3 If moisture is determined which could have originated from the refueling cavity, implement Sections 3.7 and 3.8 as applicable.

3.3 SAND CUSHION DRAIN LINE FUNCTIONAL TEST (Attachment A, Item 3)

3.3.1 By the end of the first refueling outage after June 1, 1994, and once each 10 years thereafter, the sand cushion drain shall be confirmed to be functional. Any method which confirms that the drain lines are open and functional (e.g. vacuum testing, insertion of a video probe) is acceptable.

3.3.2 If the drain lines are not functional, then corrective measures shall be implemented to restore functionality or alternate measures shall be adopted to assure that integrity of drywell shell is not being jeopardized.

3.4 SAND CUSHION ASSESSMENT (Attachment A, Item 4)

3.4.1 By the end of the first refueling outage after June 1, 1994, and once each 10 years thereafter, visually inspect at each drain location of the sand cushion for the presence of water, corrosion products, debris, flaking and blistering of coatings, and cleanliness.

3.4.2 If moisture is present in the sand cushion region, then additional examinations and/or an engineering evaluation shall be performed to determine the origin of the moisture and, to the extent possible, the quantity of the moisture and the extent of any degradation that may have occurred. (These additional examinations may include visual inspections at containment penetrations which provide access to the air gap region at random elevations, inspections of the reactor cavity liner for leaks, or inspections at stabilizer hatches or other locations which provide access to the air gap region.) The engineering evaluation should consider at least the following:

a) the source of the leakage and the chemistry of the water;

b) containment material properties;

c) coatings and their effectiveness;

d) the length of time the drywell shell was exposed to the water, the functionality of the drains, and the drains' leakage history;

e) any potentially mitigating factors (such as use of dehumidifiers or cathodic protection); and

f) any potentially contributing factors (such as location of gap forming materials).

3.4.3 If moisture is determined which could have originated from the refueling cavity, implement Sections 3.7 and 3.8 as applicable.

3.5 NORMALLY OPEN AIR GAP AND SAND CUSHION DRAIN LINES (Drain lines without isolation valves - Attachment A, Item 5)

3.5.1 By the end of the first refueling outage after June 1, 1994, and once each 40 month interval thereafter, visually examine each drain discharge line while the refueling cavity is flooded for evidence of water.

3.5.2 If water is observed leaking from drain lines, then additional examinations and/or an engineering evaluation shall be performed to determine the origin of the water and, to the extent possible, the quantity of the water and the extent of any degradation that may have occurred. (These additional examinations may include visual inspections at containment penetrations which provide access to the air gap region at random elevations, inspections of the reactor cavity liner for leaks, or inspections at stabilizer hatches or other locations which provide access to the air gap region.) The engineering evaluation should consider at least the following:

a) the source and chemistry of the water;

b) containment material properties;

c) coatings and their effectiveness;

d) the length of time the drywell shell was exposed to the water, the functionality of the drains, and the drains' leakage history;

e) any potentially mitigating factors (such as use of dehumidifiers or cathodic protection); and

f) any potentially contributing factors (such as location of gap forming materials).

3.5.3 If water is observed which could have originated from the refueling cavity, implement Sections 3.7 and 3.8 as applicable.

3.6 NORMALLY CLOSED AIR GAP AND SAND CUSHION DRAINS (Drain lines with normally closed isolation valves - Attachment A, Item 6)

3.6.1 By the end of the first refueling outage after June 1, 1994, and during each fuel cycle thereafter, visually examine each drain discharge for evidence of water with the isolation valve open.

3.6.2 If water is observed leaking from drain lines, then additional examinations and/or an engineering evaluation shall be performed to determine the origin of the water and, to the extent possible, the quantity of the water and the extent of any degradation that may have occurred. (These additional examinations may include visual inspections at containment penetrations which provide access to the air gap region at random elevations, inspections of the reactor cavity liner for leaks, or inspections at stabilizer hatches or other locations which provide access to the air gap region.) The engineering evaluation should consider at least the following:

a) the source and chemistry of the water;

b) containment material properties;

c) coatings and their effectiveness;

d) the length of time the drywell shell was exposed to the water, the functionality of the drains, and the drains' leakage history;

e) any potentially mitigating factors (such as use of dehumidifiers or cathodic protection); and

f) any potentially contributing factors (such as location of gap forming materials).

3.6.3 If water is observed which could have originated from the refueling cavity, implement Sections 3.7 and 3.8 as applicable.

3.7 REFUELING BELLOWS SEAL RUPTURE DRAINS FUNCTIONAL TEST (Attachment A, Item 7)

Functional testing of the refueling bellows seal rupture drains is **ONLY** necessary if inspections for Sections 3.2, 3.4, 3.5 and/or 3.6

indicate the presence of moisture that could have originated from the reactor refueling cavity, spent fuel pool or equipment pool.

The bellows seal rupture drains shall be inspected or tested to confirm that they are not restricted and to ensure that any water that leaks into the area under the bottom of the refueling cavity is routed to the drainage collection system and not the drywell air gap region. Such testing may require the use of trace gases, video probes or other methods to confirm the existence of an open drainage path.

3.8 REFUELING CAVITY MECHANICAL JOINT INTEGRITY (Attachment A, Item 8)

Refueling cavity mechanical joints shall be inspected or tested to confirm that they are not leaking water into the drywell air gap region. Any leakage shall be corrected in accordance with the plant deficiency control system.

3.9 DRYWELL SHELL INTERIOR SURFACE VISUAL INSPECTION (Attachment A, Item 9)

3.9.1 During the first refueling outage after June 1, 1994, and once each subsequent 40 month period, a 10% random sample of the total circumference of the moisture barrier at the concrete-to-metal interface shall be visually examined for evidence of degradation that may result in leakage past the barrier. Adjacent surfaces shall also be examined for evidence of corrosion that could result in wall thinning.

3.9.2 If evidence of degradation is found, an engineering evaluation shall be performed to determine the root cause and need for additional action, such as repairs, replacements, thickness measurements, increased inspection frequency based on degradation rates, or other corrective action.

3.10 SUPPRESSION POOL INTERIOR SURFACE VISUAL INSPECTION (Attachment A, Item 10)

3.10.1 During the first refueling outage after June 1, 1994, visually inspect the interior surfaces above and below the waterline for evidence of pitting, erosion, deposits or degradation of coating materials. Frequency of subsequent examinations shall be determined by engineering evaluation of interior surface conditions. (This inspection is not required if the suppression pool is constructed of corrosion-resistant material(s)).

Licensees can and should take credit for similar inspections performed prior to June 1, 1994.

3.10.2 If inspections indicate no pitting, erosion, deposits or degradation of coatings, re-examine the interior surfaces at a frequency determined by engineering evaluation.

3.10.3 If inspections indicate degradation of the interior surfaces, perform an engineering evaluation and take appropriate corrective actions in accordance with plant deficiency procedures. Frequency of subsequent visual examinations shall be determined by engineering evaluation of the interior surface conditions.

3.11 CONTAINMENT VESSEL TESTING (Attachment A, Item 11)

Containment vessel shall be leakrate tested in accordance with 10 CFR 50, Appendix J (Type A test).

3.12 PENETRATION BELLOWS TESTING (Attachment A, Item 12)

Containment penetration bellows shall be leakrate tested in accordance with 10 CFR 50, Appendix J (Type B test).

3.13 AIRLOCK, MANWAY AND HATCH TESTING (Attachment A, Item 13)

Containment airlocks, manways and hatches shall be leakrate tested in accordance with 10 CFR 50, Appendix J (Type B test).

4.0 <u>DOCUMENTATION</u>

The owner shall maintain a record of all examinations, inspections, tests and evaluations performed to satisfy the requirements of this program. These records shall include as a minimum the following:

(a) procedure data packages for all examinations, inspections and tests performed;

(b) copies of all evaluations performed to justify continued operation, containment structural integrity and recommendations for the deferral or implementation of supplemental examinations, inspections or tests;

(c) administrative control procedures which implement the overall containment inspection program; and

(d) documentation records for any repairs performed as a result of these examinations, inspection and tests.

It is permissible for the owner to include this containment inspection program in the existing ISI Program, but it is not a requirement. Any administrative structure which ensures satisfactory implementation of this program is acceptable.

ATTACHMENT C

APPLICABILITY OF

BWROG MODEL CONTAINMENT INSPECTION PROGRAM

TO

ASME SECTION XI, 1992 EDITION, SUBSECTION IWE

ATTACHMENT C

BWROG POSITION ON APPLICABILITY OF ASME SECTION XI, SUBSECTION IWE TO BWR MARK I AND II CONTAINMENTS

The attached table provides a comparison of ASME Section XI, 1992 Edition, Subsection IWE inspection and test requirements to the BWROG Model Containment Inspection Program.

The ASME Section XI approach appears to require visual and volumetric examination of generic components or areas of the containment structure without considering the credible failure mechanisms or whether the examinations will actually increase the confidence level in containment integrity. In comparison, the BWROG Model CIP is focused on inspecting "critical" areas for indications of moisture which could cause containment shell degradation. The Model CIP also acknowledges the importance of 10 CFR 50 Appendix J leakage rate testing to assure containment integrity is maintained. The selection of critical areas for the Model CIP is based on industry inspection/failure experience, probability of degradation affecting containment integrity, consequences of degradation, and the potential for degradation of other systems (e.g. refueling bellows) to containment degradation. Focusing inspections on critical areas and verifying operability of design features (e.g. sand cushion drains) ensures personnel radiation exposure is maintained in accordance with ALARA principles and that examinations which provide little benefit to ensuring/maintaining containment integrity are not undertaken.

The BWROG Model CIP provides a practical alternative to ASME Section XI, Subsection IWE requirements for BWR Mark I and II containment structures and should provide an adequate examination/testing program in the event that Class MC inspection requirements are adopted by the NRC in 10 CFR 50.

ATTACHMENT C

APPLICABILITY OF BWROG MODEL CONTAINMENT INSPECTION PROGRAM TO ASME SECTION XI, 1992 EDITION, SUBSECTION IWE

IWE ITEM NO.	IWE EXAM ITEM	IWE EXAM METHOD	IWE EXTENT & FREQUENCY	BWROG CIP ATTACH. A ITEM NO.	BWROG PROGRAM APPLICABILITY
E1.11	Containment vessel accessible surface areas	General visual	100% Prior to each Type A test	11	Same, inspection is required by 10 CFR 50, App. J prior to each Type A test.
E1.12	Containment vessel accessible surface areas	VT-3	100% each 10-yr. interval	11	Not justifiable(1).
E1.20	Vent system accessible surface areas	VT-3	100% each 10-yr. interval	11	Not justifiable(1).
E3.10	Containment penetration welds	VT-1	25% of total no. each 10-yr. interval	11	Not justifiable(2).
E3.20	Flange welds (Category D)	VT-1	25% of total no. each 10-yr. interval	11	Not justifiable(2).
E3.30	Nozzle-to-shell welds (Category D)	VT-1	25% of total no. each 10-yr. interval	11	Not justifiable(2).
E4.11	Containment surface areas visible surfaces - augmented examination	VT-1	100% of susceptible surface areas each 40-month period	1, 2, 3, 4, 5, 6, 8, 9, & 10	Primary examination methods include general visual inspection, functional testing of air gap/sand cushion drains and moisture content in sand cushion. Additional actions are based on engineering evaluation of inspections/tests results.
E4.12	Containment surface areas - surface area grid min. wall thickness locations	Volumetric	100% of monitored locations each 40-month period	2, 9	Not required unless determined necessary by engineering evaluation. Surface area grid dimensions based on findings. Alternatives to "volumetric" allowed, such as pit gages or ultrasonic thickness measurements (UT thickness is not a "volumetric" examination method).

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IWE ITEM NO.	IWE EXAM ITEM	IWE EXAM METHOD	IWE EXTENT & FREQUENCY	BWROG CIP ATTACH. A ITEM NO.	BWROG PROGRAM APPLICABILITY
E5.10	Seals	VT-3	100% each 10-yr. interval	13	Seal integrity verified by Type A & B tests.
E5.20	Gaskets	VT-3	100% each 10-yr. interval	13	Seal integrity verified by Type A & B tests.
E5.30	Moisture barriers	VT-3	100% each 10-yr. interval	2, 9	Increased examination frequency based on difficulty to repair if extensive degradation was found.
E7.10	Dissimilar metal welds	Surface (PT)	50% of total no. each 10-yr. interval	11	Not required; dissimilar metal welds in containment structure are no more susceptible to degradation than other welds.[1]
E8.10	Bolted connections	VT-1	100% each 10-yr. interval	N/A	Normally covered by plant maintenance practices and/or 10 CFR 50 App. J testing.
E8.20	Bolted connections	Torque or tension test	100% each 10-yr. interval	N/A	Not required.[1][3]
E9.10	Containment vessel pressure retaining boundary	System leakage test	Each repair, replacement, or modification	11	Same, as required by 10 CFR 50, App. J.
E9.20	Penetration bellows	10 CFR 50, App. J Type B test	10 CFR 50, App. J	12	Same, as required by 10 CFR 50, App. J.
E9.30	Airlocks	10 CFR 50, App. J Type B test	10 CFR 50, App. J	13	Same, as required by 10 CFR 50, App. J.

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ASME SECTION XI, 1992 EDITION, SUBSECTION IWE

IWE ITEM NO.	IWE EXAM ITEM	IWE EXAM METHOD	IWE EXTENT & FREQUENCY	BWROG CIP ATTACH. A ITEM NO.	BWROG PROGRAM APPLICABILITY
E9.40	Seals & gaskets	10 CFR 50, App. J Type B test	10 CFR 50, App. J	13	Same, as required by 10 CFR 50, App. J.

Notes:

(1) These areas are included in the general visual examination required by 10 CFR 50 Appendix J for evidence of structural deterioration, and Appendix J requires more frequent examination (3 times every 10 years). Examination in the detail required by IWE (structures, including stiffening rings, manhole frames, reinforcement around openings, and structural attachment welds) does not provide meaningful results, as it would not detect a flaw of the size that would cause the containment to fail the Type A test and provides no additional benefit over the general visual examination toward ensuring the structural integrity of the containment. Additionally, the probability of a failure occurring in these areas that would prevent the containment from performing its intended function during normal or upset conditions is 0% based on probabilistic risk assessment (See Attachments D and E).

(2) The probability of detecting a defect (crack or pinhole) of a size that would prevent obtaining acceptable Type A test results is extremely low using visual examination methods because of the tremendous surface area of the containment system compared to the defect size required for failure. Also, cracks would tend to propagate from the inside surface outward on penetrations, making visual detection unlikely until the flaw is through-wall. The most viable means of detecting such a problem remains the Appendix J, Type A and B tests.

(3) Assembly of bolted connections associated with the safety related systems is typically controlled by plant maintenance procedures which identify general visual inspection and torquing requirements. Bolted connections associated with the primary containment (e.g. drywell head, equipment hatch, CRD hatch, suppression pool manways) are typically disassembled on a frequency equivalent to refueling outages. Appendix J Type A and/or B testing ensures integrity of bolted connections after each reassembly.

ATTACHMENT D

BWROG MODEL CONTAINMENT INSPECTION PROGRAM

TYPICAL MARK I CONTAINMENT FAILURE ASSESSMENT

COMPONENT	DEGRADATION MECHANISM	BEST METHOD TO IDENTIFY PROBLEM	MOST PROBABLE FAILURE	CUMULATIVE PROB OF FAILURE (TOT. = 100%)	CONSERVATISMS	COMMENTS
CONTAINMENT SHELL	WALL THINNING	MOISTURE IN AIR GAP OR SAND CUSHION	- RUPTURE DURING DESIGN BASIS EVENT (DBE) DUE TO INTERNAL PRESSURE - BUCKLING DURING REFUELING	0	1. CODE MARGINS 2. NO CREDIT TAKEN FOR CONCRETE ENERGY ABSORPTION 3. ANALYSIS SIMPLIFIED BY BOUNDING	
CONTAINMENT SHELL	LOCALIZED THINNING	ILRT	- RUPTURE DURING DBE DUE TO INTERNAL PRESSURE	0	1. CODE MARGINS 2. NO CREDIT TAKEN FOR CONCRETE ENERGY ABSORPTION 3. ANALYSIS SIMPLIFIED BY BOUNDING	1. COULD NEVER FIND LOCALIZED PITTING USING UT. 2. SHOULD A HOLE PROGRESS TO THE POINT OF FAILING ILRT, PROBLEM WOULD HAVE TO BE RESOLVED WITH NRC PRIOR TO START-UP.
DRYWELL HEAD	IMPROPER INSTALLATION	LLRT/ILRT	GASKET FAILURE	20	N/A	ILRT IS MOST EFFECTIVE.
BELLOWS	CRACKING	LLRT/ILRT	CRACKING	80	N/A	LEAKRATE TESTING IS MOST EFFECTIVE.

ATTACHMENT E

TYPICAL MARK I CONTAINMENT FAILURE PRA