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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: T. R. QUAY

SUBJECT: CONTAINMENT SCREENS AND STRAINERS

Dear Mr. Quay:

During the review of the AP600 the NRC staff has asked a number of questions about the potential for clogging of strainers and screens in the AP600. This concern was raised by the staff in response to a number of occurrences at operating nuclear power plants (primarily boiling water reactors) in which debris was found in locations that were either clogging or had the potential to clog strainers in safety related systems.

The conclusion of the evaluation for AP600 was that the containment recirculation screens and IRWST screen are reliable and there is not a significant potential for clogging. This conclusion and justification supporting are outlined in the response to open items and requests for additional information attached to this letter. These items and the Westinghouse status in the open item tracking system are tabulated below.

Item Number	OITS Number	Status
Meeting March 3, 1994 Action item 3B	460	Action N
DSER OI50 #23	2019	Closed
RAI 260.77	2933	Closed
RAI 640.59 (ITAAC)	5241	Confirm W

The SSAR changes will be included in Revision 14 of the SSAR.

Please contact D. A. Lindgren at (412) 374-4856 if you have any additional questions.

Susan V Fanto for

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

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jml

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

Action item 3B, Meeting March 3, 1994 (OITS #460)

Meeting 3/94 Action Item 3B - Review information notice on clogging of wet well at Perry and confirm that the IRWST will not have a similar clogging issue.

Response:

A review of incidents related to BWR ECCS pump suction strainer plugging in the suppression pools indicates that the most significant factors affecting plugging are the use of fibrous insulation that can be swept into the suppression pool tanks and the use of carbon steel material for the suppression pool tanks and the associated piping. The suppression pools accumulate sludge, mostly iron oxide corrosion products from the carbon steel components in the BWR fluid systems. Fibrous insulation dislodges and has been swept into the suppression pool by post-accident forces and migrates to the suction strainers during ECCS pump operation. The fibrous insulation traps sludge particles causing plugging of the ECCS lines. Other incidents involve inadequate cleanliness programs which can result in blockage of the ECCS pump suction strainers in lines from the suppression pools or sumps.

AP600 IRWST Potential for Blockage:

The AP600 IRWST is not subject to the problems that have occurred in BWRs with respect to clogging in their suppression pool strainers. The IRWST and the connected systems are constructed of stainless steel which prevents the formation of significant amounts of corrosion products. The IRWST water is required to be maintained clean because it is used in the refueling canal during refueling operations. The use of stainless steel materials and the purification of the IRWST (filters and demineralizers) provided by the spent fuel cooling system during and following refueling operations maintains water cleanliness.

There are two inlets to the IRWST that return condensate from the containment shell to the IRWST from the IRWST gutter. The gutter is located at the top of the IRWST which is at the operating deck level. This level is well above the high energy process lines that can become LOCAs. The gutter has a trash rack covering its inlet. The gutter flow enters the IRWST through two 4" lines. The probability of significant insulation debris entering the IRWST is very low.

SSAR subsection 6.1.2.1 discusses the use of protective coatings inside containment. The inorganic zinc coating applied to the inside surface of the containment shell is one potential source of debris that may enter the gutter and the IRWST. As described in SSAR subsection 6.1.2.1.5, failure of this coating produces a heavy powder which if it enters the IRWST through the gutter will settle out on the bottom of the IRWST because of its high specific gravity. Settling is enhanced in the IRWST by low velocities in the tank and long tank drain down times (>5 hours).

Insulation is not used inside the IRWST. Air filters are not used in the IRWST vents or overflows. Because of the location and the size (4") of the two inlets to the IRWST from the IRWST gutter, the probability of significant amounts of insulation being swept into the tank is very low. Outside of the IRWST, the AP600 uses stainless steel reflective insulation in areas that are subject to LOCA damage to limit the amount of debris created by the LOCA.

The IRWST screens and containment recirculation screens are designed to provide a reliable source of safety injection water to the passive core cooling system. Consideration is given to the types and locations of insulation, coatings, corrosion products, and foreign materials. The screens are designed to Regulatory Guide 1.82, revision 2. The Combined License applicant is required (SSAR subsection 6.3.8.1) to have a cleanliness program, which controls foreign materials in the containment after refueling / maintenance

shutdowns. The AP600 Technical Specifications require visual inspections of the screens during every refueling outage.

Based on these features the AP600 IRWST provides a reliable source of safety injection water following LOCAs.

Incidents:

Barseback Unit 2 (Sweden) - mineral wool (fibrous) insulation dislodged from relief valve partially plugs spray system suction strainers.
Perry - RHR strainers clogged by operation debris
Perry - RHR strainers covered by glass fibers from maintenance air filters debris. The finer air filters collected corrosion products int he suppression pool which reduced RHR flow.
Limerick Unit 1 - RHR strainer (in uncleaned suppression pool) covered by miscellaneous fibers and iron oxide sludge degrading RHR performance.

Potential Incidents:

Palisades - Maintenance use of plastic materials potential for plugging sumps.
Grand Gulf - Plastic covers inside containment could be dislodged during LOCA and plug sumps.
Browns Ferry Unit 2 - Cloth and paper towels (cleaning debris) in pool potential for plugging.
Grand Gulf - Low suction pressure in RHR line due to clogging of strainers by pool debris.
North Anna Unit 1 - steam generator and pressurizer paint failed on large sheets which could clog sumps.
LaSalle Unit 1 - Misc. debris in suppression pool including plastic bag on strainer.
Quad Cities Unit 1 - Plastic bag in RHR pump suction.

Reviewed Documents:

Reg Guide 1.82, Revision 2
NRCB 93-02 Supp. 1
NRCB 95-02
NRCB 96-03
IN 95-47
IN 95-06
IN 93-02 and Supp 1
IN 92-85
IN 88-28
IN 90-07
IN 92-71
IN 93-34 and Supp 1

DSER OI50 #23 (OITS 2019)

DSER-O150 #23 - Debris in IRWST and Containment Sumps
The staff is concerned that the strainers in the IRWST and containment sumps could be clogged by debris. Important factors are the use of non-safety related coatings in the AP600, and possible sensitivity in this design to screen clogging because of dependance on gravity-driven flows. (DSER Open Item 6.2.1.8-1).

Response:
The IRWST screens and the containment recirculation screens of the AP600 are designed and located to provide a reliable source of safety injection following LOCAs. Refer to responses to ITAAC RAI 640.59 Followup Question, Chapter 14 RAI Question 260.77, and Open Item 460 for additional information.

RAI 260.77 (OITS #2933)

Westinghouse will provide the method(s) that will be used to prevent strainer clogging in the passive safety systems.

Response:

The AP600 IRWST screens and the containment recirculation screens are designed to comply with NRC licensing criteria and to provide a reliable source of safety injection following LOCAs. The response to ITAAC RAI 640.59 followup question provides an additional SSAR subsection which describes the AP600 screens and the features that make them reliable. In addition, the response to Open Item 460 discusses events that have occurred at BWRs and their relevance to the AP600 IRWST design.

RAI 640.59, ITAAC Followup Question (OITS #5241)

The containment recirculation screens and IRWST strainers are designed in conformance with RG 1.82 and to address the technical concerns raised in Generis Safety Issue A-43, "Containment Emergency Sump Performance." The staff provided further clarification of these concerns in Bulletins 96-03 and 95-02. The staff disagrees with Westinghouse's assessment that these bulletins only apply to boiling water reactor designs and are not applicable to the AP600 strainer design. Westinghouse needs to document in the SSAR what actions will be taken to address the conditions described in these bulletins on the IRWST strainer design. Design commitments resulting from the review of RG 1.82, GSI-43, and the bulletins should be incorporated into the ITAAC.

Response:

The AP600 IRWST screens and the containment recirculation screens are designed to comply with NRC licensing criteria and to provide a reliable source of safety injection following LOCAs. Attached is an additional SSAR subsection which describes the AP600 screens and the features that make them reliable. Table 6.3-4 is revised to include the screens. Figures 6.3-6, 6.3-7, 6.3-8, and 6.3-9 are added to show the locations of the screens. Subsection 6.3.8 is revised to include the Combined License applicant information item for a cleanliness program. Sheet 3 of Table 6.3-5 is revised to remove the term "sump" which is not used in the AP600.

In addition, the response to March 3, 1994 meeting Action Item 3B (OITS #460) discusses events that have occurred at BWRs and their relevance to the AP600 IRWST design.

6.3.2.2.7 IRWST and Containment Recirculation Screens

The passive core cooling systems has two different sets of screens that are used following a LOCA; IRWST screens and containment recirculation screens. These screens prevent debris from entering the reactor and blocking core cooling passages during a LOCA. These screens are designed to comply with applicable licensing regulations including:

- GDC 35 of 10 CFR 50 Appendix A
- Regulatory Guide 1.82
- NUREG-0897

The operation of the passive core cooling system following a LOCA is described in subsection 6.3.2.1.3. Proper screen design, plant layout, and other factors prevent clogging of these screens by debris during accident operations.

General Screen Design Criteria:

1) Screens are designed to Regulatory Guide 1.82 including:
   - Redundant screens are provided for each function
   - Separate locations are used for redundant screens
   - Screens are located well below containment floodup level. Each screen has a coarse and a fine screen, and a debris curb
   - Floors slope away from screens (not required for AP600)
   - Drains do not impinge on screens
   - Screens can withstand accident loads and credible missiles
   - Screens have conservative flow areas to account for plugging. Operation of the non-safety-related normal residual heat removal pumps with suction from the IRWST and the containment recirculation lines is considered in sizing screens.
   - System and screen performance are evaluated
   - Screens have solid top cover
   - Screens are seismically qualified
   - Screen openings are sized to prevent blockage of core cooling
   - Screens are designed for adequate pump performance. AP600 has no safety-related pumps.
   - Corrosion resistant materials are used for screens
   - Access openings in screens are provided for screen inspection
   - Screens are inspected each refueling
2) Low screen approach velocities limit the transport of heavy debris even with operation of normal residual heat removal pumps.
3) Use of stainless steel reflective insulation limits debris generated by high energy line breaks.
4) Use of coatings designed for post accident conditions. Refer to subsection 6.1.2.1.6.
5) The IRWST is enclosed which limits debris egress to the IRWST screens.
6) Containment recirculation screens are located above lowest levels of containment.
7) Long settling times (> 5 hours) are provided before initiation of containment recirculation.

8) Air ingestion by safety-related pumps is not an issue in the AP600 because there are no safety-related pumps. The normal residual heat removal system pumps are evaluated to show that they can operate with minimum water levels in the IRWST and in the containment.
9) A COL commitment for cleanliness program to limit debris in containment is provided.

IRWST Screens:
The IRWST screens are located inside the IRWST at the bottom of the tank. Figure 6.3-6 shows a plan view and Figure 6.3-72 shows a section view of these screens. Two separate screens are provided in the IRWST, one at either end of the tank. The IRWST is closed off from the containment; its vents and overflows are normally closed by louvers. The potential for introducing debris inadvertently during plant operations is limited. A COL cleanliness program (refer to 6.3.8.1) controls foreign debris from being introduced into the tank during maintenance and inspection operations. The Technical Specifications require visual inspections of the screens during every refueling outage.

The IRWST design eliminates sources of debris from inside the tank. Insulation is not used in the tank. Air filters are not used in the IRWST vents or overflows. Wetted surfaces in the IRWST are corrosion resistant such as stainless steel or nickel alloys; the use of these materials prevents the formation of significant amounts of corrosion products. In addition, the water is required to be clean because it is used to fill the refueling cavity for refueling; filtering and demineralizing by the spent fuel pit cooling system is provided during and after refueling.

During a LOCA, steam vented from the reactor coolant system condenses on the containment shell, drains down the shell to the operating deck elevation and is collected in a gutter. It is very unlikely that debris generated by a LOCA can reach the gutter because of its location. The gutter is covered with a trash rack which prevents larger debris from clogging the gutter or entering the IRWST through the two 4 inch drain pipes. The inorganic zinc coating applied to the inside surface of the containment shell is one potential source of debris that may enter the gutter and the IRWST. As described in subsection 6.1.2.1.5, failure of this coating produces a heavy powder which if it enters the IRWST through the gutter will settle out on the bottom of the IRWST because of its high specific gravity. Settling is enhanced in the IRWST by low velocities in the tank and long tank drain down times (>5 hours).

The design of the IRWST screens reduces the chance of debris reaching the screens. The screens are orientated vertically such that debris that settles out of the water does not fall on the screens. A debris curb located at the base of the IRWST screens prevents high density debris from being swept along the floor by water flow to the IRWST screens. The IRWST screens are made up of a trash rack and a fine screen. The trash rack prevents larger debris from reaching the finer screen. The fine screen prevents debris larger than 0.25" from being injected into the reactor coolant system and blocking fuel cooling passages.

The screen flow area is conservatively designed considering the operation of the nonsafety-related normal residual heat removal system pumps which produce a higher flow than the

safety-related gravity driven IRWST injection / recirculation flows. As a result, when the normal residual heat removal system pumps are not operating there is a large margin to screen clogging.

Containment Recirculation Screens:
The containment recirculation screens are oriented vertically along walls above the loop compartment floor (elevation 83 feet). Figure 6.3-8 shows a plan view and Figure 6.3-9 shows a section view of these screens. Two separate screens are provided as shown in figure 3. The loop compartment floor elevation is significantly above the lowest level in the containment, the reactor vessel cavity, which is 11.5 feet below. The bottom of the recirculation screen is two foot above the floor, providing a curb function.

During a LOCA, the reactor coolant system blowdown will tend to carry debris created by the accident (pipe whip/jets) into the cavity under the reactor vessel which is located remote away from and below the containment recirculation screens. As the accumulators, core makeup tanks and IRWST inject, the containment water level will slowly rise up to the 108 foot elevation over at least 5 hours. The containment recirculation line opens when the water level in the IRWST drops to a low level setpoint a few feet above the final containment floodup level. When the recirculation lines initially open, the water level in the IRWST is higher than the containment and water flows from the IRWST backwards through the containment recirculation screen. This back flow tends to flush debris located close to the recirculation screens away from the screens.

The water level in the containment when recirculation begins is well above (~ 10 feet) the top of the recirculation screens. During the long containment floodup time (>5 hours), floating debris does not move toward the screens and heavy materials settle to the floors of the loop compartments or the reactor vessel cavity. During recirculation operation the containment water level will not change significantly nor will it drop below the top of the screens.

The amount of debris that may exist following an accident is limited. Reflective insulation is used to limit the debris that can be generated by a high energy line break and be postulated to reach the screens during recirculation. The nonsafety-related coatings used in the containment are designed to withstand the post accident environment. A COL evaluation (subsection 6.1.3.2) shows that these screens provide flow area margin considering the post accident generation and transport of debris from coatings inside containment.

A COL cleanliness program (refer to 6.3.8.1) controls foreign debris introduced into the containment during maintenance and inspection operations. The Technical Specifications require visual inspections of the screens during every refueling outage.

The design of the containment recirculation screens reduces the chance of debris reaching the screens. The screens are orientated vertically such that debris settling out of the water will not fall on the screens. The bottom of the screens are raised about 1 foot above the floor, instead of using a debris curb, to prevent high density debris from being swept along the floor by water flow to the containment recirculation screens. The containment recirculation screens are made up of a trash rack and a fine screen. The trash rack prevents larger debris from reaching the finer

screen. The fine screen prevents debris larger than 0.25" from being injected into the reactor coolant system and blocking fuel cooling passages.

The screen flow area is conservatively designed considering the operation of the normal residual heat removal system pumps which produce a higher flow than the gravity driven IRWST injection / recirculation flows. As a result, when the normal residual heat removal system pumps are not operating there is even more margin in screen clogging.

6.3.2.2.87 Valves (This Subsection Renumbered)

6.3.8 Combined License Information

~~This section has no requirement for additional information to be provided in support of the Combined License application.~~

6.3.8.1 Containment Cleanliness Program

The Combined License applicants referencing the AP600 will address preparation of a program to limit the amount of debris that might be left in the containment following refueling and maintenance outages.

Table 6.3-4 (Sheet 2 of 2)

COMPONENT DATA - PASSIVE CORE COOLING SYSTEM

IRWST	
Number	1
Type	Integral to containment internal structure
Volume (gallons)	567,000
Minimum required volume (gallons)	557,000
Design pressure (psig)	5
Design temperature (°F)	150 *
Material	Wetted surfaces are stainless steel
AP600 equipment class	C

Spargers	
Number	2
Type	Cruciform
Design pressure (psig)	600
Design temperature (°F)	500
Material	Stainless steel
AP600 equipment class	C

pH Adjustment Baskets	
Number	2
Type	Rectangular
Volume (cubic feet)	107
Material	Stainless steel
AP600 equipment class	C

Screens	IRWST	Containment Recirculation
Number	2	2
Surface Area (square feet)	70	70
Material	Stainless Steel	Stainless Steel
AP600 Equipment Class	C	C

* Several times during plant life, the refueling water could reach 240°F.

Table 6.3-5 (Sheet 3 of 5)

FAILURE MODE AND EFFECTS ANALYSIS - PASSIVE CORE COOLING SYSTEM ACTIVE COMPONENTS

Component	Failure Mode	Plant Condition	Effect on System Operation	Failure Detection Method	Remarks
IRWST gutter isolation valves V130A/B Normally open/fail closed	Failure to close	All design basis events	No safety-related effect since each valve has a redundant, series isolation AOV, actuated by a separate division, which closes to divert the gutter flow into the IRWST	Valve position indication alarm in MCR and at RSW	
Containment recirculation ~~sump~~ line check valves V119A/B Normally closed	Failure to open	All design basis events	No safety-related effect since each valve has a redundant flow path through a MOV and a squib valve, actuated by separate divisions, that open to provide recirculation through a parallel branch line. The other containment recirculation line is unaffected.	Valve position indication alarm in MCR and at RSW	
Containment recirculation ~~sump~~ line squib valves V120A/B Normally closed/ fail as is	Failure to open	All design basis events	No safety-related effect since each valve has a redundant flow path through a MOV and a squib valve, actuated by separate divisions, that open to provide recirculation through a parallel branch line. The other containment recirculation line is unaffected.	Valve position indication alarm in MCR and at RSW	
Containment recirculation ~~sump~~ line MOVs / squib valves V117A/B, V118A/B Normally closed / fail as is	Failure to open	All design basis events	No safety-related effect since each valve has a redundant flow path through a check valve and a squib valve, actuated by separate divisions, that independently open to provide recirculation through a parallel branch line. The other containment recirculation line is unaffected.	Valve position indication alarm in MCR and at RSW	
Accumulator fill / drain line isolation AOVs V232A/B Normally closed / fail closed	Spurious opening	All design basis events	No safety-related effect since each valve has either a normally closed redundant, series isolation valve or a check valve in each drain flow path, which prevents draining water from the accumulator.	Valve position indication alarm in MCR and at RSW	

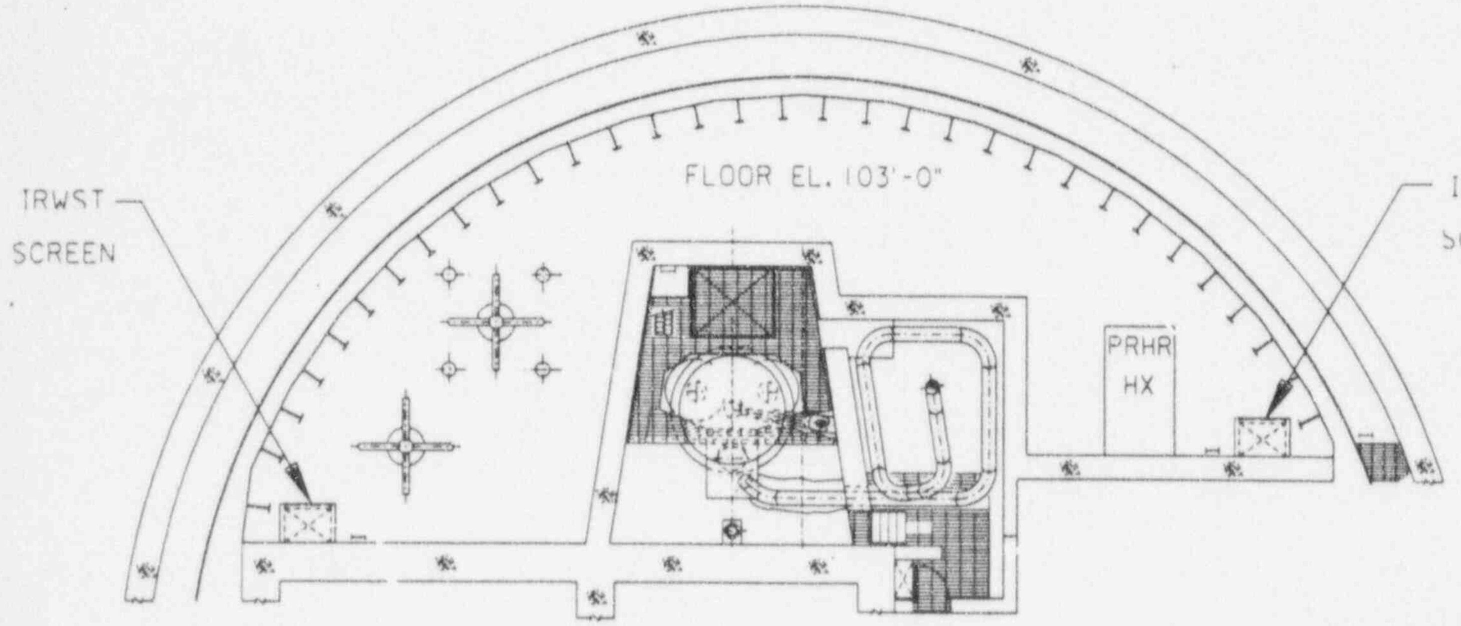

Figure 6.3-6 IRWST Screen Plan Location

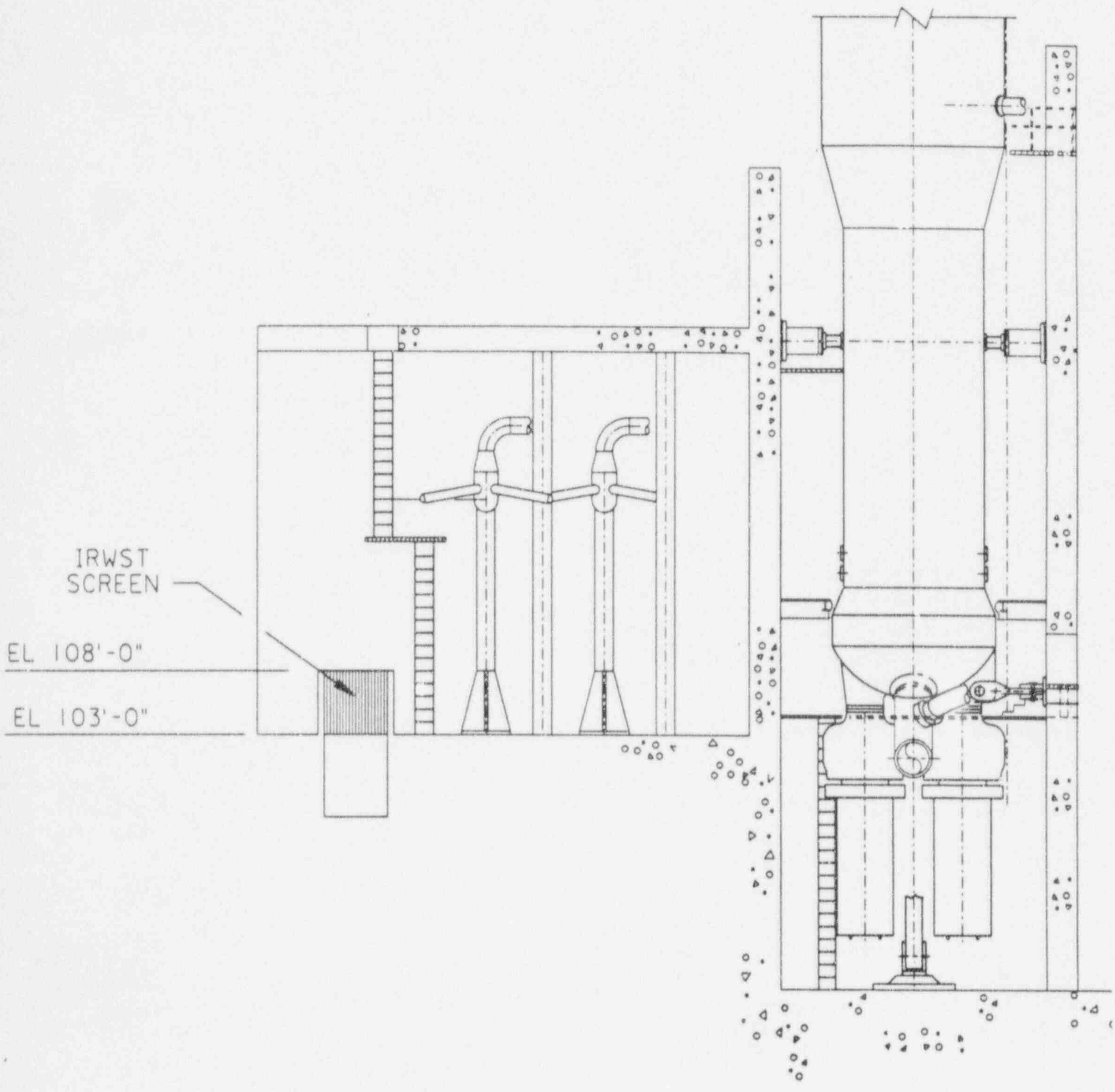

Figure 6.3-7 IRWST Screen Section Location

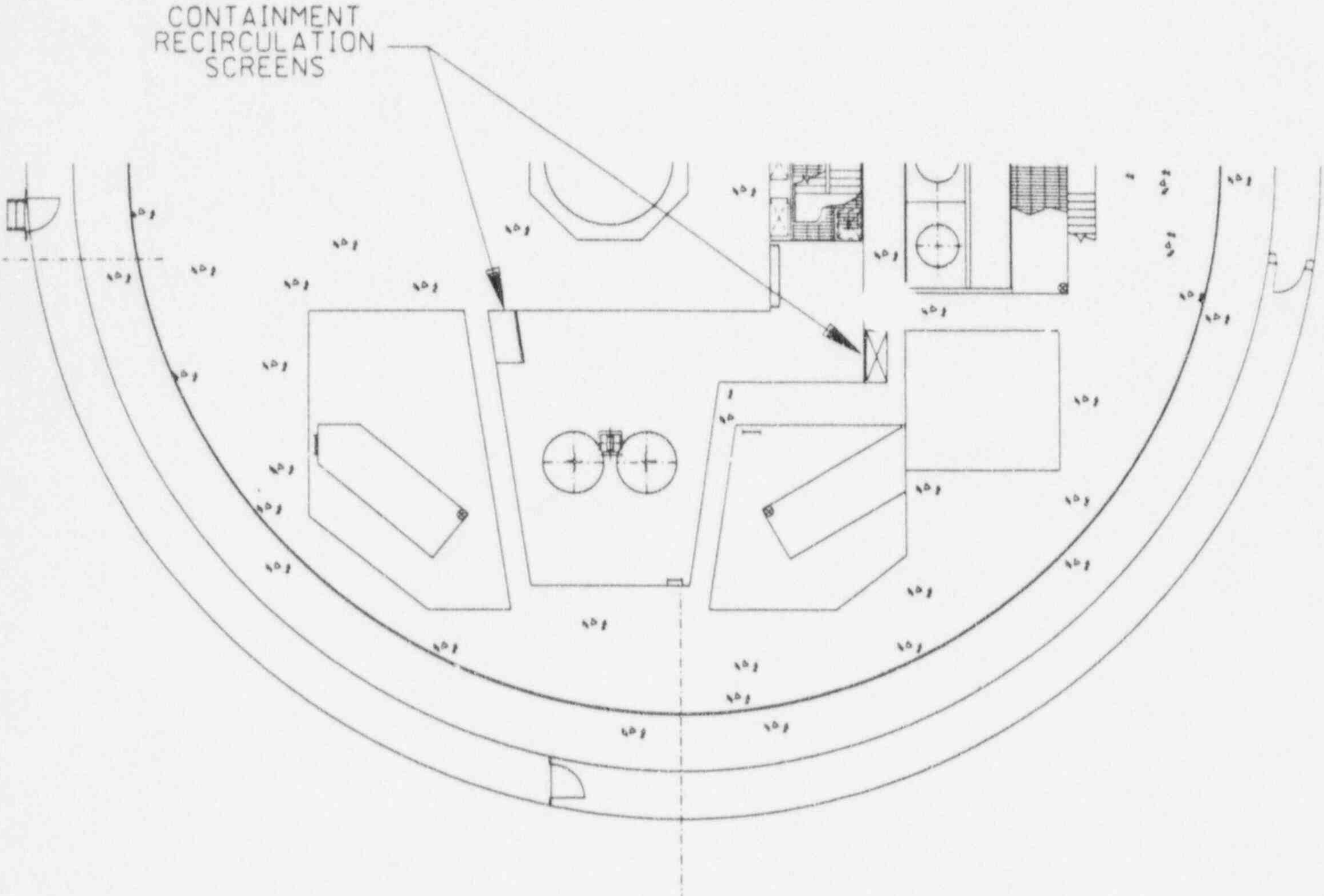

Figure 6.3-8 Containment Recirculation Screen Plan Location

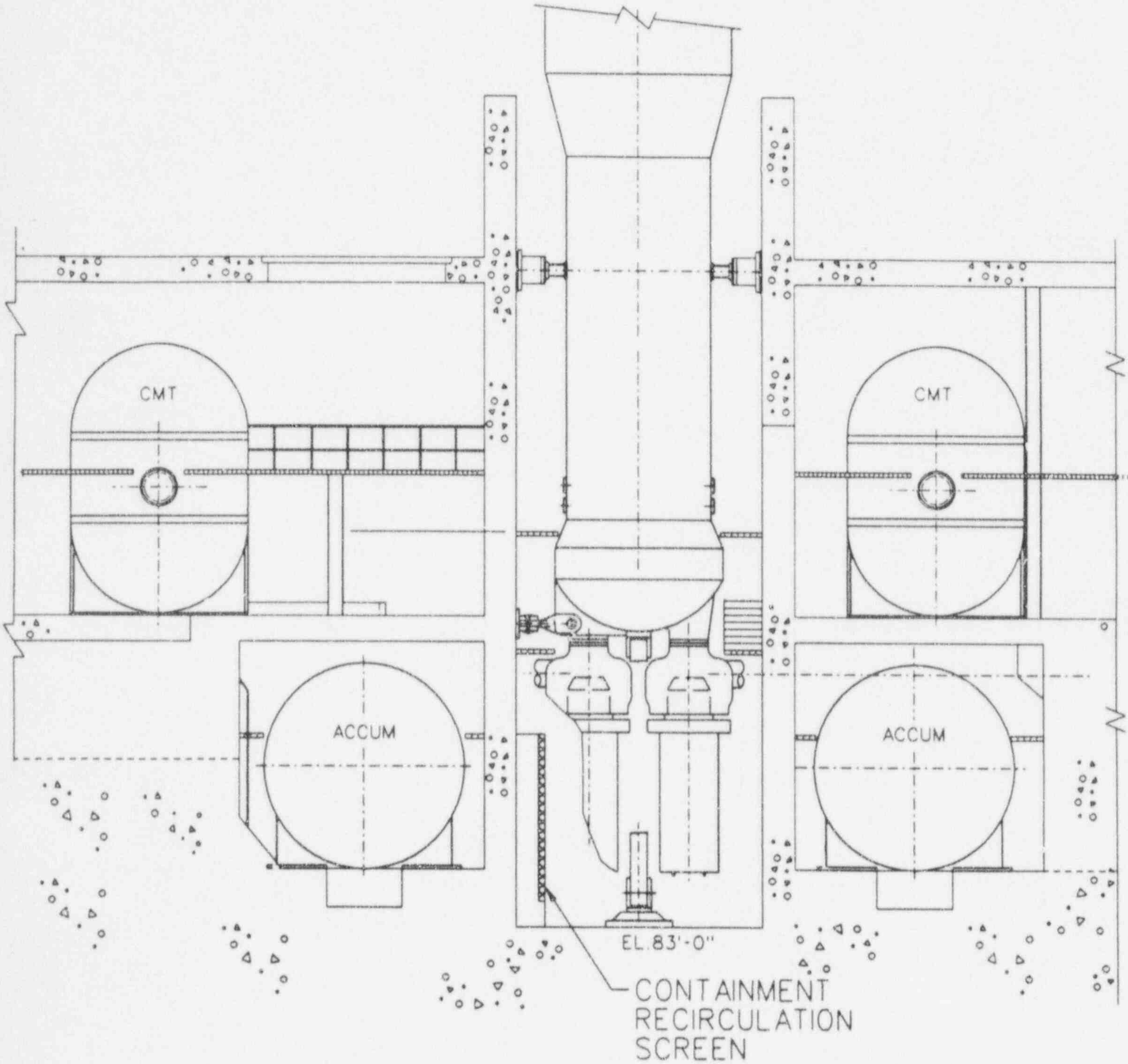

Figure 6.3-9 Containment Recirculation Screen Section Location