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ATTENTION: T. R. QUAY

SUBJECT: CONTAINMENT COATINGS INFORMATION

Attached are responces to questions related to the use of nonsafety-related coatings inside containment and on the exterior of the containment shell. These informal questions were provided in a telecopy on January 27, 1998, and subsequently documented in a letter dated January 30, 1998. These responses are provided to support our meeting on February 11, 1998, to discuss paint and other coatings in the AP600 containment.

These items are identified in the Open Item Tracking System (OITS) as Items 6590, 6591, 6592, and 6593. These issues were previously addressed in an NRC Letter to Westinghouse dated July 30, 1997, and in a response from Westinghouse in letter DCP/NRC1151 dated November 21, 1997. Since OITS #969 (DSER Open Item 6.1.2-1) and #5750 (Item 2 from NRC letter of July 30, 1997) are superseded by the questions in the January 30, 1998 letter, the Westinghouse status will be changed to Closed. With this transmittal, OITS #6590 through #6593 will be statused as noted below.

OTIS #	Westinghouse Status
6590	Confirm W
6591	Confirm W
6592	Action N
6593	Action N

I look forward to our meeting on Wednesday.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/bms

Attachments

E004

cc: G. M. Holahan, NRC/NRR/DSSA
J. R. Strosnider, NRC/NRR/DE
B. W. Sheron, NRC/NRR/ADT
J. W. Roe, NRC/NRR/DRPM
N. J. Liparulo, Westinghouse (w/o Attachments)
J. Sebrosky, NRC/NRR/DRPM

OITS #6590

Westinghouse has not provided a quantitative or experimental bases which demonstrate why failure of the containment coatings will not prevent functioning of the engineering safety features. Calculations are required to determine if failure of the coatings will result in blockage of strainers. The analysis must be reviewed by the NRC staff since there is uncertainty in the calculations. Even if Westinghouse were to perform a transport analysis, the staff is not likely to accept it without additional experimental validation

Response:

The response to this open item is made in three parts:

Part 1 - A commitment is added to the SSAR to procure nonsafety-related coating materials used inside containment (on walls, floors and major structures) and on the exterior of the containment shell to 10 CFR 50, Appendix B quality assurance requirements

Part 2 - Results of calculations are presented which demonstrate that complete failure of nonsafety-related coatings does not block any portion of the AP600 containment recirculation screens

Part 3 - A COL commitment is added to the SSAR to perform a confirmatory calculation of the coating debris transport resulting from failure of nonsafety-related coatings. This analysis must be supported by appropriate experimental data.

Part 1:
In areas close to the recirculation screens the coatings used are safety-related in conformance with the intent of Regulatory Guide 1.54. SSAR subsection 6.3.2.2.7.3 describes where safety-related coatings are used inside the containment. The standards referenced in Regulatory Guide 1.54 are not current. The draft revision to Standard Review Plan identifies that the quality assurance standards of ASTM D3842 and ASTM D3911 should be followed. The discussion of Regulatory Guide 1.54 in Appendix 1A of the SSAR will be changed to reflect this. The quality assurance requirements for safety-related paint manufacture, procurement, application, and testing are subject to the quality assurance requirements of Appendix B to 10 CFR Part 50.

Plant design features and the type of coating selected for the majority of other coatings used inside containment permit the use of nonsafety-related coatings. Debris resulting from failure of these nonsafety-related coatings will not have a negative impact on the performance of safety-related, post-accident cooling systems. To avoid the use of inappropriate types of coatings inside containment and to provide coating material traceability, 10 CFR Part 50, Appendix B quality assurance requirements will be applied to the manufacture and procurement of the majority of nonsafety-related paint inside containment. The Appendix B coating material will be used on walls, floors, ceilings, structural steel and major structures and components.

Providing coating materials that are subject to 10 CFR Part 50, Appendix B quality assurance allows the coating material information used in settling calculations is valid. This change increases the probability that the coatings will not fa. even through their application and inservice inspections are not subject to this quality assurance. A revision to SSAR subsection 6.1.2.1.1 is attached that implements this change.

Part 2:
The AP600 has several unique characteristics that allow the use of nonsafety-related coating inside containment. Table 1 attached to this response provides a list of these characteristics. These characteristics include long settling times between the end of RCS blowdown during a LOCA and the beginning of recirculation; the large water volumes provided by the PXS and the shape of the containment lower volumes provides for high flood up levels. These high flood up levels allow the containment recirculation screens to be located relatively high. The bottom of the screens are located well above the lowest elevations of the containment which allows coating debris to settle out without challenging the bottom of the screens. The screens are very tall, which further reduces the chance that coating debris can reach the screens. The AP600 screens also have a unique feature (screen plates) that have been added to specifically prevent coating debris from entering the post accident containment water close to the screens and potentially blocking the screens. These screen plates are located above each recirculation screen and extend well out in front and to the sides of the screens.

Another AP600 characteristic that reduces the potential for coating debris blocking screens is that fibrous insulation is not used where it may be damaged by a LOCA. This eliminates the potential adverse interaction where fibrous debris acts like a fine filter and collects small particles of dust. coating debris, etc and possibly leads to unacceptable screen pressure drops.

As discussed in Part 1 of this response, the nonsafety-related coating material used in the containment will be procured with 10 CFR Part 50, Appendix B quality assurance requirements. As a result, the nonsafety-related coatings are not expected to fail. However, in order to provide a robust design, the failure of the nonsafety-related coatings is assumed. A calculation was performed to demonstrate that even with the failure of the nonsafety-related coatings inside containment that the recirculation screens are not blocked.

The application of 10 CFR Part 50, Appendix B quality assurance to the manufacture and procurement of nonsafety-related coating materials allows the characteristics of the paint to be identified in terms of density and failure mechanisms. This information makes it possible to bound the size and density of the debris that might be generated by failure of these coatings and have the potential for blocking the screens. The key inputs to this calculation are shown in Table 2.

Figure 1 shows the results of these calculations. This figure shows that coating debris entering the post accident flood up water at the edge of the protective plate will settle to an elevation that is below the bottom of the screens after drifting about 7 feet, which is at about 3 feet away from the screen. This calculation includes significant conservatisms, including the lightest/smallest coating debris. It assumes the maximum recirculation flow of 1600 gpm, consistent with the maximum flow from one RNS pump operating unthrottled with suction taken from one screen. Another area where significant margin has been applied is in the debris settling rates. AP600 uses debris settling rates that contain a factor of 2 margin compared to the reference settling data (Reference 1) which is sufficient to account for uncertainties. Without this added margin, the coating debris settles out very quickly in about 3 feet, as shown in Figure 1.

Several sensitivity studies have been performed to demonstrate the robustness of the AP600 design with respect to uncertainty in coating debris settling. The margin applied to settling rates was increased from a factor of 2 (base AP600) to a factor of 2.3 so that debris just started to reach the bottom of the screen. The margin factor has to increase to 3.2 before debris could block 50% of the screen and about 4.7 before debris could block 90% of the screen. Even with such extreme margins, the PXS recirculation would continue to function because the recirculation screen can tolerate significant blockage and still support RNS pump operation. Note that if screen blockage ever reached the point where the RNS pumps cavitated and stopped operating, the PXS would revert to gravity recirculation at its lower flow rate (< 700 gpm).

The debris settling calculation performed for the AP600 provides confidence that the plant can sustain complete failure of the nonsafety-related coatings located inside containment without blockage of the recirculation screens.

Part 3:
A COL action has been added to address the concern that some uncertainty exists in the coating debris settling rates used in the debris settling rate calculation. The COL item requires an analysis of the coating debris generation and transport that is based on appropriate test data.

References:

1. Gibbs and Hill Report, "Evaluation of Paint and Insulation Debris Effects on Containment Emergency Sump Performance", Revision 1, September 1994.

SSAR Change:

Revised SSAR sections are attached (6.1.2.1.1, 6.1.2.1.6, 6.1.3.2, Appendix 1A conformance 1.54)

ITAAC Change:

None

Table 1 - AP600 Post LOCA Recirculation Conditions

	AP600	
Time of Initiation of Recirculation		
- Large LOCA	5	hr
- DVI (8") LOCA	5	hr
- DVI (8") LOCA with max RNS operation	3	hr
Flood up level (water level)		
- above RV cavity floor	35	ft
- above loop compartment floor	24	ft
Screen elev.		
- Bottom screen above RV nearby floor	2	ft
- Bottom screen above RV cavity floor	15	ft
- Height screen	13	ft
Recirculation flow rates		
- Maximum total (no failures, all pumps, both screens)	2600	gpm
- Expected total (no failures, all pumps, both screens)	2000	gpm
- Maximum per screen (one RNS pump, one screen)	1600	gpm
- Maximum per screen (PXS, no failure, one screen)	700	gpm

Table 2 - Inputs to Coating Debris Settling Calculation

Coating debris:	
- Shape	circular disk
- Diameter	> 200 mils
- Thickness	> 5 mils
- Density	> 100 lb/ft3
Screen geometry:	
- Height	13 feet
- Width	5.5 feet
- Distance off floor	2 feet
Protective plate:	
- Height above top screen	0 to 10 feet
- Distance plate extends out from screen	10 feet
Screen flow rates:	
- Maximum RNS flow per screen	1600 gpm (1)
- Maximum PXS flow per screen	700 gpm (2)

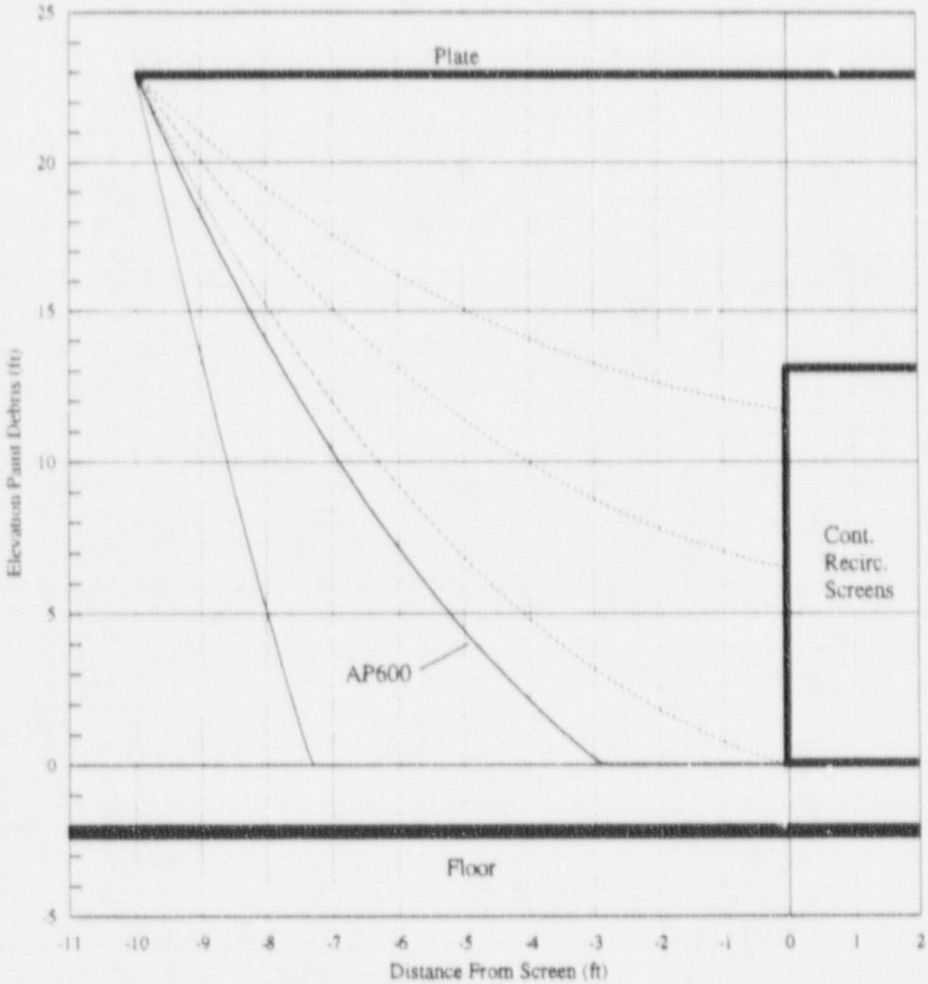
Notes:

(1) The following conservative assumptions are made in calculating the maximum RNS pump driven flow rates. One RNS pump is assumed to take suction from one recirculation screen. The RCS pressure is assumed to be equal to the containment pressure. The RNS pump is assumed to have a conservatively high head vs flow characteristics. Cavitation of the pump due to inadequate NPSHa is conservatively ignored. The piping and equipment flow resistances are assumed to be low.

(2) The following conservative assumptions are made in calculating the maximum PXS gravity driven flow rates. All PXS IRWST injection valves are assumed to open. Only one screen is assumed to operate. The one operable screen feeds both DVI lines. The pipe and equipment flow resistances are assumed to be conservatively low. The containment water level is assumed to be conservatively high. The RCS pressure is assumed to equal to the containment pressure.

Figure 1 - AP600 Coating Debris Settling

This figure shows that the AP600 has significant margin to accommodate uncertainty in coating settling rates. The heavy solid line shows the AP600 design case, which includes a margin factor of 2.00 times the reference settling data (Reference 1). The light dashed lines represent sensitivity studies with greater margins. The margins applied were arbitrailly chosen to force the debris to settle out at the bottom of the screen (factor of 2.3), covering half of the screen (factor of 3.2) and covering 90% of the screen (factor of 4.7). Even with 90% of the screen blocked, the PXS would still be able to operate. The light solid line shows the reference settling data. All of these cases assume the maximum possible RNS flow assuming one RNS takes suction from one screen and is unthrottled (1600 gpm).



Revise the third paragraph of subsection 6.1.2.1.1 as follows:

The AP600 design considers the function of the coatings, their potential failure modes, and their requirements for maintenance. Local failure of the coatings on the exterior of the containment vessel and outside the containment does not prevent functioning of the engineered safety features required for safe shutdown of the plant during or after a design basis accident (DBA). Coatings inside the containment are evaluated to demonstrate that failure does not prevent functioning of the engineered safety features.

Coatings used in the vicinity of the containment recirculation screens are classified as safety-related. The requirements for the selection, application, and maintenance of safety-related coating are consistent with the guidance of Regulatory Guide 1.54 and Standard Review Plan 6.1.2. Refer to subsection 6.3.2.2.7.3 for the extent of safety-related coatings.

Other coatings inside containment are classified as nonsafety-related because their failure does not prevent functioning of the engineered safety features. If the nonsafety related coatings deteriorate by flaking, peeling, powdering etc., the solid debris they may form will not have a negative impact on the performance of safety-related post-accident cooling systems. See subsection 6.1.2.1.5 for a discussion of the factors including plant design features and low water flows that permit the use of nonsafety-related paint inside containment. Protective coatings are maintained to provide corrosion protection for the containment pressure boundary and for other system components inside containment.

The coatings on the outside of the containment vessel are maintained to provide corrosion protection for the containment pressure boundary and to support passive cooling through their wetting ability and heat transfer properties. The type of paint used on the containment shell is not expected to fail by flaking or peeling. The failure mechanism of the containment paint would not have an adverse effect on the wetting ability or heat transfer properties of the containment shell surfaces. Preservice testing and inservice testing that verifies the coverage of water over the containment shell and periodic visual inspection of the condition of the exterior containment paint demonstrate that the paint has not deteriorated to a point that it adversely affects the heat transfer function of the containment shell.

The corrosion protection, good housekeeping and decontamination functions of the coatings are nonsafety-related functions.

Revise the fourth paragraph of subsection 6.1.2.1.1 as follows:

For information on coating design features, quality assurance, material and application requirements, and performance monitoring requirements, see subsection 6.1.2.1.6.

Revise subsection 6.1.2.1.6 as follows:

6.1.2.1.6 Design Features

A number of design features provide confidence that the coating systems inside the containment, on the exterior of the containment vessel and in potentially contaminated areas outside containment will perform as intended. These features enhance the ALARA program and enhance corrosion resistance. The features include:

- Specification of qualified coating materials
- Provision of coating specifications
- Provision of coating procedures
- Use of qualified painters
- Use of qualified coatings inspectors
- Documentation of coatings work
- Performance of as much coating work as practical under controlled shop conditions
- Specification of coating performance monitoring
- Specification of coating inspection and maintenance

Safety-related coatings

Safety related coating meet the quality assurance requirements of Appendix B to 10CFR Part 50. The safety-related coating systems and their applications is consistent with the positions of Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants" and the quality assurance standards of ASTM D3842, "Selection of Test Methods for Coatings for Use in Light-Water Nuclear Power Plants," and ASTM D3911, "Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions."

Quality Assurance, Testing, and Application for Nonsafety-Related Coatings

The use of nonsafety-related coatings inside containment and on the exterior of the containment shell is based on the use of selected types of coatings and the properties of the coating if it deteriorates. To preclude the use of inappropriate coatings, appropriate quality assurance requirements will apply to the manufacture, procurement, handling, and storage of the nonsafety-related coating used inside containment on internal structures and on the exterior of the containment shell.

The testing, application, and monitoring of nonsafety-related coatings are controlled by a program prepared by the Combined License applicant. The specified coatings used inside containment are tested for radiation tolerance per ASTM D4082 (Reference 1), for decontaminability per ASTM D4256 (Reference 2) and for performance under design basis accident conditions per ASTM D3911 (Reference 3). The coatings used in radiologically controlled areas outside containment are tested for radiation resistance and decontaminability but are not specified to be design basis accident tested. Where practical, the same coating materials are used in radiologically controlled areas outside containment as are used inside containment. This provides a high level of quality and optimizes maintenance painting over the life of the plant. The coatings used on the outside of the containment shell are not required to be tested for radiation tolerance, decontaminability, or performance under design basis accident conditions.

Appendix B to 10 CFR Part 50 applies to manufacture of coatings used inside containment on internal structures, including walls, floor slabs, structural steel, the containment shell, and major components, and on the exterior of the containment shell. The coating manufacturer is required to manufacture the coatings under a suitable quality assurance program and to provide a product identity certification record.

Coating specifications also require that the surfaces to be coated are properly prepared, coated, inspected and documented. For coatings used inside containment, radiologically controlled areas outside containment, and on the outside of the containment shell, the coating applicator submits and follows acceptable procedures to provide confidence that correct coating practices are used, that the painters are qualified and certified in accordance with ASTM D4227 (Reference 4) and ASTM D4228 (Reference 5), and that the inspectors are qualified and certified in accordance with ASTM D4537 (Reference 6). Appendix B to 10 CFR 50 quality assurance requirements do not apply to the application and inspection of nonsafety-related coatings.

Due to the modularized construction, a significant portion of the containment coatings are shop applied to the containment vessel and to piping, structural and equipment modules. Fewer coating applicators are needed than would be if many individual items were coated by a wide variety of manufacturers and applicators and shipped to the site for individual installation. This restricted application of the coatings under controlled shop conditions provides additional confidence that the coatings will perform as designed and as expected.

Performance Monitoring

The performance of the installed coatings is monitored. The coatings performance monitoring program includes periodic inspections of the coatings inside containment and the exterior of the containment vessel during planned outages. Periodic inspections are also specified for coatings installed in the radiologically controlled areas outside containment. The monitoring program includes the planning of maintenance painting schedules so that the installed coatings can be maintained to perform as intended. The maintenance painting inside containment and on the exterior of the containment vessel is conducted during scheduled outages using qualified maintenance coating systems applied and inspected by qualified personnel.

Revise subsection 6.1.3.2 as follows:

The Combined License applicants referencing the AP600 will address preparation of a program to control testing, application, and monitoring of nonsafety-related coatings. The program for the control of manufacture, procurement, handling and storage of the coating material for use inside containment and on the exterior containment shell will satisfy the 10 CFR Part 50 Appendix B quality assurance requirements. A coating debris transport analysis will be performed that demonstrates that no more than 25 % of the containment recirculation screens are plugged following complete failure of nonsafety-related coating inside containment. The analysis will be based on appropriate experimental data for coating failure and transport.

Revise the conformance with Reg. Guide 1.54 in Appendix 1A as follows:

Reg. Guide 1.54, Rev. 0, 6/73 - Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants

Criteria Section	Referenced Criteria	AP600 Position	Clarification/Summary Description of Exceptions
General	ANSI N101.4-1972	Exception	Some Ccoatings inside containment and the coating on the exterior shell of the containment are nonsafety-related and satisfy appropriate ASTM Standards. See subsection 6.1.2 for additional information. Application is controlled by procedures using qualified personnel to provide a high quality product. The paint materials for nonsafety-related coatings inside the containment and on the containment exterior shell are subject to 10CFR Part 50 Appendix B Quality Assurance requirements. The standards referenced are not current. Appropriate current standards including the quality assurance standards of ASTM D3842 and ASTM D3911 are followed for safety related coatings and for procurement of nonsafety-related coatings inside containment and on the exterior of the containment shell. An evaluation is made to show that failure of the nonsafety-related coatings does not prevent the function of safety-related systems.

C.1	ANSI N101.4-1972 ANSI N45.2-1971	Exception	The standards referenced are not current. Appropriate current standards including ASME NQA-1 are followed to develop the quality assurance program for safety related coatings and for procurement of nonsafety-related coatings inside containment and on the exterior of the containment shell.
C.2	ANSI N101.4-1972	Exception	The standard referenced is not current. Appropriate current standards are followed.
C.3	ANSI N101.4-1972	Exception	The standard referenced is not current. Appropriate current standards including the quality assurance standards of ASTM D3842 and ASTM D3911 are followed for safety related coatings.
C.4	ANSI N101.4-1972	Conforms	The standard referenced is not current. Guidance for the control of cleaning and other material used on stainless steel material is provided in Regulatory Guides 1.37 and 1.44. Subsections 5.2.3.4 and 6.1.1.2 address the control of processes used on stainless material for safety-related piping and components.

OITS #6591

Westinghouse provides some qualitative discussions on wh... it believes will occur upon failure of containment coatings (e.g., assumes only localized failure of coatings, assumes coating material will settle on the bottom of various compartments and will not get transported in sufficient quantities - which are undefined - to the intake screens) but has not provided any evidence of this mechanism besides engineering judgment.

Response:

As discussed in response to OITS #6590, the coatings used inside containment and on the outside of the containment shell will be procured to 10 CFR 50, Appendix B quality assurance requirements. This approach minimizes the chance that coatings will fail. It also ensures that the characteristics of the coatings are known. The coatings used in the AP600 are greatly simplified as compared with operating plants, both in terms of number of different coatings and in terms of the ease of mixing and applying the coatings. This simplification reduces the chance of improper application.

The nonsafety-related inorganic zinc coating used on the outside of the containment shell is assumed not to fail as discussed in response to OITS #6592. The nonsafety-related coatings used inside containment are assumed to completely fail, as discussed in response to OITS #6590, even though that is unlikely. The unique characteristics of the AP600 allows the plant to tolerate this failure.

The discussion of coating failure modes contained in the SSAR is based on an understanding of the characteristics of the coatings and on experience with their use. For example, inorganic zinc has a relatively low tensile strength and a chemically based bond which not challenged by accident conditions. As a result, if it is not properly applied its failure would be powdering. Experience with inorganic zinc coatings confirms this failure mode. On the other hand, epoxy has a high tensile strength and a mechanically based bond which may be challenged by accident conditions. As a result, if it is not properly applied its failure would be delamination or peeling. Experience with epoxy coatings confirms this failure mode.

The SSAR subsection 6.1.2.1.5 and 6.1.4 have been revised to add references for the coating failure modes discussed there.

SSAR Change:

Revised SSAR subsections 6.1.2.1.5 and 6.1.4 are attached.

ITAAC Change:

None

Revised SSAR Subsection 6.1.2

6.1.2 Organic Materials

6.1.2.1 Protective Coatings

6.1.2.1.1 General

The AP600 is divided into four areas with respect to the use of protective coatings. These four areas are:

- Inside containment
- Exterior surfaces of the containment vessel
- Radiologically controlled areas outside containment
- Remainder of plant.

The considerations for protective coatings differ for these four areas and the coatings selection process accounts for these differing considerations.

The AP600 design considers the function of the coatings, their potential failure modes, and their requirements for maintenance. Local failure of the coatings on the exterior of the containment vessel and outside the containment does not prevent functioning of the engineered safety features required for safe shutdown of the plant during or after a design basis accident (DBA). Coatings inside the containment are evaluated to demonstrate that failure does not prevent functioning of the engineered safety features. Coatings used in the vicinity of the containment recirculation screens are classified as safety-related, refer to 6.3.2.2.7.3 for the extent of safety-related coatings. Other coatings inside containment are classified as nonsafety-related because their failure does not prevent functioning of the engineered safety features. Protective coatings are maintained to provide corrosion protection for the containment pressure boundary and for other safety-related system components inside containment. The coatings on the outside of the containment vessel are maintained to provide corrosion protection for the containment pressure boundary and to support passive cooling through their wetting ability and heat transfer properties. These functions are in addition to other functions (such as enhancing decontamination inside the containment and assisting in general housekeeping). The corrosion protection and decontamination functions of the coatings are nonsafety-related functions.

For information on coating design features, material and application requirements, and performance monitoring requirements, see subsection 6.1.2.1.6.

6.1.2.1.2 Inside Containment

Carbon Steel

Inorganic zinc primer is the basic coating applied to the containment vessel, structural carbon steel, and carbon steel equipment/components inside containment that need coating. Below the operating floor, most of the inorganic zinc primer is top coated with epoxy to enhance decontamination. The epoxy top coat also extends above the operating floor on structural modules and to a wainscot height of 7 feet above the operating floor on the containment vessel. Where practical, miscellaneous carbon steel items (such as stairs, gratings, ladders, railings, conduit, duct, and cable tray) are hot-dip galvanized. Steel surfaces subject to immersion during normal plant operation (such as sumps and gutters) are stainless steel or are lined with epoxy or epoxy phenolic applied directly to the carbon steel without an inorganic zinc primer. Carbon steel structures and equipment are assembled in modules and the modules are coated in the shop under controlled conditions.

Concrete

Concrete surfaces inside containment are coated primarily to prevent concrete from dusting, to protect it from chemical attack and to enhance decontaminability. In keeping with ALARA goals, the exposed concrete surfaces are made as decontaminable as practical in areas of frequent personnel access and areas subject to liquid spray, splash, spillage or immersion.

As a minimum, exposed concrete surfaces inside containment are coated with a thin film epoxy sealer to help bind the concrete surface together and reduce dust that can become contaminated and airborne. Concrete floors inside containment are coated with a self-leveling epoxy. Exposed concrete walls inside containment are coated to a minimum height of 7 feet with a high-build epoxy applied over an epoxy surfacer that has been struck flush. The high-build epoxy is the same as that used as a top coat for the inorganic zinc primed carbon steel.

6.1.2.1.3 Exterior of Containment Vessel

The exterior of the containment vessel is coated with the same inorganic zinc as is used inside of the containment. The inorganic zinc coating enhances surface wetting of the exterior surface of the containment vessel. The inorganic zinc also provides corrosion protection to maintain the integrity of the pressure boundary. The coating on the exterior surface of the containment shell is not exposed to harsh environment and localized failure does not prevent accomplishing a safety-related function.

6.1.2.1.4 Radiologically Controlled Areas Outside Containment and Remainder of Plant

The coatings used in the radiologically controlled areas outside containment and in the remainder of the plant are also nonsafety-related. However, coatings are selected, specified and applied in a manner that optimizes performance and standardization. Wherever practical, the same coating systems are used in radiologically controlled areas outside containment as are used inside containment. The ALARA concept is carried through in areas subject to radiation exposure and possible radiological contamination. The remainder of the plant coating systems are commercial grade materials that are selected and applied according to the expected conditions in the specific areas where the coatings are applied.

The coatings used in radiologically controlled areas outside of containment are identified in the following.

Carbon Steel Surfaces

Carbon steel is coated with inorganic zinc. An epoxy top coat is used in areas subject to decontamination such as a 7 foot wainscot in high traffic areas or on surfaces subject to radiologically contaminated liquid spray, splash, or spills.

Concrete Floors

Floors subject to heavy traffic or contaminated liquid spills are coated with self-leveling epoxy. A high-build epoxy finish is applied a minimum of 1 foot up the wall where liquid spills might splash. Floors subject to light traffic and not subject to contaminated liquid spills are coated with high-build epoxy. The high-build epoxy is the same epoxy used as a top coat for the inorganic zinc-coated steel.

Concrete Walls

A 7-foot wainscot on exposed concrete walls in high-traffic areas and any surfaces of walls subject to spray, splash or spills of contaminated liquids are coated with high-build epoxy applied over an epoxy surfacer that has been struck flush. The high-build epoxy is the same as that used as a top coat for the inorganic zinc-coated steel. Remaining concrete walls are coated with a thin film epoxy sealer to reduce or eliminate dusting.

Concrete Ceilings

Exposed concrete ceilings are coated with a thin film epoxy sealer to reduce dusting.

6.1.2.1.5 Safety Evaluation

This subsection describes the basis for the extent of safety-related coatings and the basis for classifying coatings on other areas inside containment as nonsafety-related.

The AP600 has a number of design features that facilitate the use of nonsafety-related coatings. These features include a passive safety injection system that provides a long delay time (more than 5 hours) between a LOCA and the time recirculation starts. This time delay provides time for settling of debris. These passive systems also flood the containment to a high level which allows the use of containment recirculation screens that are located well above the floor and are relatively tall. Significant volume is provided for the accumulation of coating debris without affecting screen plugging. These screens are protected by plates located above the screens that extend out in front and to the side of the screens. Coatings used under these plates in the vicinity of the screens are classified as safety-related. The protective plates, together with low recirculation flow, approach velocity and the screen size preclude postulated coating debris above the plates from reaching the screens. Refer to subsection 6.3.2.2.7.3 for additional discussion of these screens, their protective plates and the areas utilizing safety-related coatings.

The recirculation inlets are screened enclosures located near the northwest and southwest corners of the east steam generator compartment (refer to the figures in Section 6.3.2.2.7.3). The enclosure bottoms are located above the surrounding floor which prevent ingress of heavy debris (specific gravity greater than 1.05). Additionally, the screens are oriented vertically and are protected by large plates located above the screens, further enhancing the capability of the screens to function with debris in the water. The screen mesh size and the surface area of the containment recirculation screens in the AP600, in conjunction with the large floor area for debris to settle on, can accommodate failure of coatings inside containment during a design basis accident even though the residue of such a failure is unlikely to be transported to the vicinity of the enclosures.

A large portion of the containment is painted with inorganic zinc applied without a top coat. Over 40 years of successful case histories in many industrial tank applications confirm that properly applied inorganic zinc does not fail by sudden delamination. Deterioration of the inorganic zinc (inside and outside containment) is very gradual over a period of years. Failure of the inorganic zinc coating produces a heavy zinc powder that will not plug the passive core cooling system flow paths or the upper annulus drains *(Reference 7)*. Inorganic zinc applied without a top coat is not used on the area coated with safety-related coatings.

The inorganic zinc on the outside of containment continues to provide good surface wetting and protection to the carbon steel during deterioration. Deterioration will be detected in the early stages of the process through periodic coating performance inspections. When deterioration is detected, maintenance painting can be deferred until scheduled outages without reducing confidence that the inorganic zinc coating will continue to provide corrosion protection and good wetting.

Coatings t... lack sufficient tensile strength to hold toge .er in large enough pieces to create large blisters or sh. ' delamination do not block the containn .nt recirculation screens or prevent the accomplishme . of safety-related functions *(References 7, 8, 9)*. These coatings are classified as nonsafety-related. This includes the thir film epoxy sealer for concrete where it is not top coated.

The AP600 does not have a safety-related containment spray system. The containment spray system provided in the AP600 is only be used in beyond design basis events. This reduces the chance that coatings will peel off surfaces inside containment because the thermal shock of cold spray water on hot surfaces combined with the rapid depressurization following spray initiation are recognized as contributors to coating failure. Parts of the containment below elevation 107'-2" are flooded and water is recirculated through the passive core cooling system. However, the volume of water moved in this manner is relatively small and the flow velocity is very low.

The coating systems used inside containment also include epoxy coatings. These are applied to concrete substrates, as top coats over the inorganic zinc primer, and directly to steel, as noted in subsection 6.1.2.1.2. The failure modes of these systems could include delamination or peeling if the epoxy coatings are not properly applied *(References 7, 8, 9)*. There are small items coated with various manufacturer's standard coating systems which may peel or delaminate under design basis accident conditions. The very high-build epoxy floor coatings and high-build epoxy carbon steel coatings are sufficiently heavy so that transport with the l..w water velocity in the AP600 containment is negligible.

Production of hydrogen as a result of zinc corrosion in design basis accident conditions, including the zinc in paints applied inside containment, is addressed in subsection 6.2.4.3.1.

Revised SSAR Subsection 6.1.4

6.1.4 References

1. ASTM-D4082, "Test Method for Effects of Radiation on Coatings Used in Light-Water Nuclear Power Plants."

2. ASTM-D4256, "Test Method for Determination of the Decontaminability of Coatings Used in Light-Water Nuclear Power Plants."

3. ASTM-D3911, "Test Method for Evaluating Coatings used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions."

4. ASTM-D4227, "Practice for Qualification of Journeyman Painters for Application of Coatings to Concrete Surfaces of Safety-Related Areas in Nuclear Facilities."

5. ASTM-D4228, "Practice for Qualification of Journeyman Painters for Application of Coatings to Steel Surfaces of Safety-Related Areas in Nuclear Facilities."

6. ASTM-D4537, "Guide for Establishing Procedures to Qualify and Certify Inspection Personnel for Coating Work in Nuclear Facilities."

7. *NUREG-0797, "Safety Evaluation Report related to the operation of Comanche Peak Steam Electric Station, Units 1 and 2."*

8. *Bolt, R.O. and J.G. Carroll, "Radiation Effects on Organic Materials", Academic Press, New York, 1963, Chapter 12.*

9. *Parkinson, W.W. and O. Sisman, "The Use of Plastics and Elastomers in Nuclear Radiation", Nuclear Engineering and Design 17 (1971), pp 247-280, North-Holland Publishing Co., Amsterdam.*

OITS #6592

Staff Comment:

In addition to the staff's concerns on debris transport to the containment sumps, the performance characteristics of the passive containment cooling system (PCS) are based on an experimental test program with the coating. No testing is known to exist with either degraded coatings or without coatings. The justification for the mass and heat transfer correlations, the PCS film model and the water coverage model are all based on testing with the coating. In the Large-Scale Test (LST), the coating exists on both the exterior and the interior surface of the vessel. Failure of the coating will impact heat transfer, film formation and water coverage. Westinghouse has not provided any data or experimental evidence as to why deterioration of the containment coatings will not affect the design basis properties of the containment shell and the PCS performance.

Response:

Passive Containment Cooling System (PCS) performance and the design basis properties of the containment shell will not be affected adversely by deterioration of the containment coatings for the following reasons:

1) The containment coating material is procured under the requirements of 10 CFR Part 50, Appendix B quality assurance requirements and will be applied anc' inspected by qualifi.d personnel in accordance with a program prepared by the Combined License applicant for the testing , application, and monitoring of nonsafety-related coatings. (See response to OITS #6590)

2) Testing of the PCS performance has been conducted using the coating specified for the AP600 containment on the PCS test articles and subjected the coating to numerous pressure and temperature cycles over a long period of time without failure of the coating.

3) Periodic inspections of the containment coatings are performed for the AP600 and the coatings are maintained according to manufacturers specifications. Water distribution tests are also performed on the outside of the containment to confirm the wetting characteristics of the outside surface.

The data Westinghouse has provided for the PCS is based on tests performed with new and aged coatings. Testing was performed using the Heated Plate Test, the Small Scale Test Facility, the Large Scale Test Facility and the Water Distribution Test Facility as described in Reference 1. Each of these facilities used the same coating on a carbon steel surface. The coating was applied to each test article according to the manufacturer's application specifications. The coatings were subjected to significant usage through the testing cycles and due to weathering of the test facilities located outdoors.

The previous response to RAI 480.883 in letter NRC/DCP0973 dated August 5, 1997 discusses the application process and aging effects of the coated surfaces for the PCS tests. In each test facility, no noticeable degradation or failure of the surface was observed. The integrity of the coating did not deteriorate over a period of years during which substantial testing was performed. This includes observations of the coating inside the Large Scale Test vessel which was periodically opened over the span of the test program.

A substantial number of tests were performed using the Small Scale and Large Scale Test Facilities over a period of six and two years, respectively. These tests subjected each facility to pressure and temperature cycles. Pressures of up to 100 psig were achieved by injecting steam into the test vessels over a range of flow rates. The test vessels were subjected to temperatures typical of what would be achieved during a design basis event. In addition, these facilities, being outdoors, saw daily and seasonal temperature and humidity cycles. The coating applied to each facility maintained its integrity throughout the testing period. No flaking or peeling was observed, either as a result of the transients applied to the test vessel, or as a result of prolonged exposure to the environment.

A potential failure of the zinc coating due to misapplication will be readily assessable shortly after application as either excessive thickness or as "mud cracking". Mud cracking may be due to either excessive application thickness or excessive thinning. Either problem will be detected shortly after application and corrected prior to plant operation as a part of the Combined License applicants coatings program. Should misapplication not be detected locally, then the results may be disbondment with small amounts of small sized flaking which will not effect either the overall water distribution or drainage of the containment annulus. In this manner localized failure does not prevent the PCS from accomplishing its safety-related function.

The PCS tests were performed using new and aged coatings which simulated conditions that could develop on the inside and outside of the AP600 containment. The tests were performed to determine the heat transfer characteristics of the PCS, with and without water coverage. The coating on the inside and outside of the containment affects the overall heat transfer through the shell and the water coverage. The data obtained from the PCS tests are appropriate for the AP600.

The coating inside and outside the AP600 containment will be periodically inspected and, if necessary, maintained. On the exterior of the shell tests are performed to confirm the water coverage as an ITAAC during the preoperational tests of the Initial Test Program, the first refueling and every ten years thereafter. Inspections of the coating on the inside and the outside of the containment shell are performed periodically and maintained to meet manufacturers' specifications.

The AP600 containment also undergoes periodic pressurizations. An initial hydrostatic test is performed during the preoperational test program to meet ASME requirements. Technical Specifications also require leak rate tests be performed during the preoperational test program and at least every ten years thereafter. This tests will subject the containment vessel to similar pressure transients, although at cold conditions, that the PCS test articles were subjected.

The outside of the AP600 containment is subject to changes in environmental conditions including temperature and humidity through the inlet and outlet of the Shield Building. The Small Scale and Large Scale Tests were subjected to a range of environmental conditions, as these facilities were located outdoors.

On the outside of the AP600 containment, evaporative cooling is the dominant heat transfer mechanism. The coating's primary purpose on the exterior shell is to promote wettability and to provide a surface with a predictable water coverage. PCS heat transfer tests, with new and aged coatings, have been conducted with and without water coverage to develop heat transfer data for the two most diverse water coverage conditions. These tests were performed over the range of pressures and temperatures of both normal operating conditions and a Design Basis Accident, which result in low exterior surface temperatures, thereby reducing the potential for failure of the coating. In addition, the exterior surface conditions during an accident are not significantly different from the exterior surface conditions that the AP600 containment is exposed to during normal weather variations and periodic testing.

On the inside of the AP600 containment, condensation of steam in the water film covering the inside shell surface is the dominant heat transfer mechanism. The coating on the interior of the shell acts as a resistance to heat conduction to the steel shell and improves the wettability of the inside of the surface. This water film is also a resistance to heat transfer. If the coating degrades, the resistance to heat conduction is now less and wettability may deteriorate, allowing rivulets to form. The removal of the water film and the lack of a coating would improve heat transfer from the containment environment to the steel shell. PCS tests have been performed with the coating, new and aged, to obtain data over the most likely range of surface conditions.

SSAR Revision: NONE

References:

1 WCAP-14407, Revision 1, "WGOTHIC Application to AP600," July, 1997, Westinghouse Electric Corporation.

OITS #6593

The evolutionary designs have effectively agreed to a safety-related coating program by committing to implement Reg Guide 1.54 to satisfy the requirements of Appendix B to 10 CFR part 50. Westinghouse needs to demonstrate that protective coatings used in the AP600 are non-safety-related, and clearly substantiate the basis for its current exception (in SSAR Appendix 1A) to RG 1.54 and the endorsed ANSI standards (i.e., explain why the provisions of Appendix B to 10 CFR Part 50 and 10 CFR Part 21 do not apply to protective coatings in the AP600).

Response:

AP600 safety-related coating, including manufacture, application, inspection and maintenance, are subject to a quality assurance program that satisfies the provisions of Appendix B to 10 CFR Part 50. 10 CFR Part 21 also applies to the safety-related coatings. Subsection 6.3.2.2.7.3 outlines the extent of safety-related coatings

Review of the Design Control Document for the ABB/CE System 80+ indicates a commitment to the <u>intent</u> of the recommendations in Regulatory Guide 1.54. Regulatory Guide 1.54 references a standard (ANSI N101.4) for quality assurance for safety-related paint that has been withdrawn. The draft for Revision 3 of Standard Review Plan 6.1.2 provides an alternative. The draft revision of SRP 6.1.2 recommends conformance with the quality assurance standards of ASTM D3842, "Selection of Test Methods for Coatings for Use in Light-Water Nuclear Power Plants," and ASTM D3911, "Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions. The safety-related coatings in the AP600 will conform to these standards.

The use of nonsafety-related paint inside containment and the on exterior of the containment shell is based on the use of selected types of paint and the properties of the paint if it deteriorates. To preclude the use of inappropriate paint, quality assurance requirements that satisfy the provisions of Appendix B to 10 CFR Part 50 will apply to the manufacture, procurement, handling, and storage of the nonsafety-related paint used inside containment on internal structures and on the exterior of the containment shell.

SSAR Revision:

See Response for Open Item 6590 for SSAR changes in subsection 6.1.2 related to quality assurance requirements for safety-related coatings and other containment coatings and changes in Appendix 1A related to conformance with Regulatory Guide 1.54.