Prepared for Presentation at the ASTM D-33 Committee January 2000 Meeting
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Accession No. ML003681313

Containment Protective Coatings Research

Why Needed ?

1. Failed coatings represent an undesirable debris source which could impact PWR sump or BWR ECCS stainer performance.
2. Clear evidence of failure of **qualified** coatings during "design life" plant operating conditions (see GL 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System After a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment," July 14, 1998 and enclosed photos of examples of "qualified" containment coating failure).

3. NRR 6/2/97 user need letter requested:

   "Debris generation testing of coatings that are likely to fail during an accident to determine the timing of the coating failure during an accident (e.g. minutes, hours, days) and the characteristics of the failed coating debris (e.g. chips, large strips, particulate)."

SRTC Research Objectives :

Investigate NPP containment coatings to determine coatings system failure mechanisms, estimated time to failure and coating debris characteristics (e.g. failed material composition, geometry, size and distribution).

SRTC's program is designed to provide insights into post-LOCA **Class I** coatings degradation or failure, mechanisms that could lead to failure and failed coating debris characteristics. The goal is identify Class I coating(s) failure characteristics, and extent thereof, for use in GSI-191, PWR Sump Clogging evaluations.

Presentation Objective(s):

This ASTM D-33 Committee January 2000 meeting provides an opportunity to describe the SRTC program structure, provide results obtained since June 1999, and to describe more recent PIRTs that have been performed.

Background:

Public meetings are held periodically to share results with interested parties and the most recent public meeting was held on November 22, 1999. Much of the findings examples shown can be examined in more detail by accessing the 11/22/99 public meeting presentations through NRC's ADAMS System (Accession No. ML993300361).

In addition, the industry coatings PIRT panel continues to interact with SRTC's research program and provide guidance that the project has found very useful. PIRTs that have been completed are also available through NRC's Public Document Room.

The information to presented at this meeting is primarily related to SRTC's System 5 (PIRT panel identification "D" or [4]). Coating systems identification and cross referencing is shown in the enclosed table.

The major SRTC program elements directed at assessing Class I coatings performance will be discussed and results obtained for the System 5 findings will be presented.

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Examples of Failures of a "Qualified" Coatings System Phenoline Topcoat with CZ11 Primer on Steel Liner

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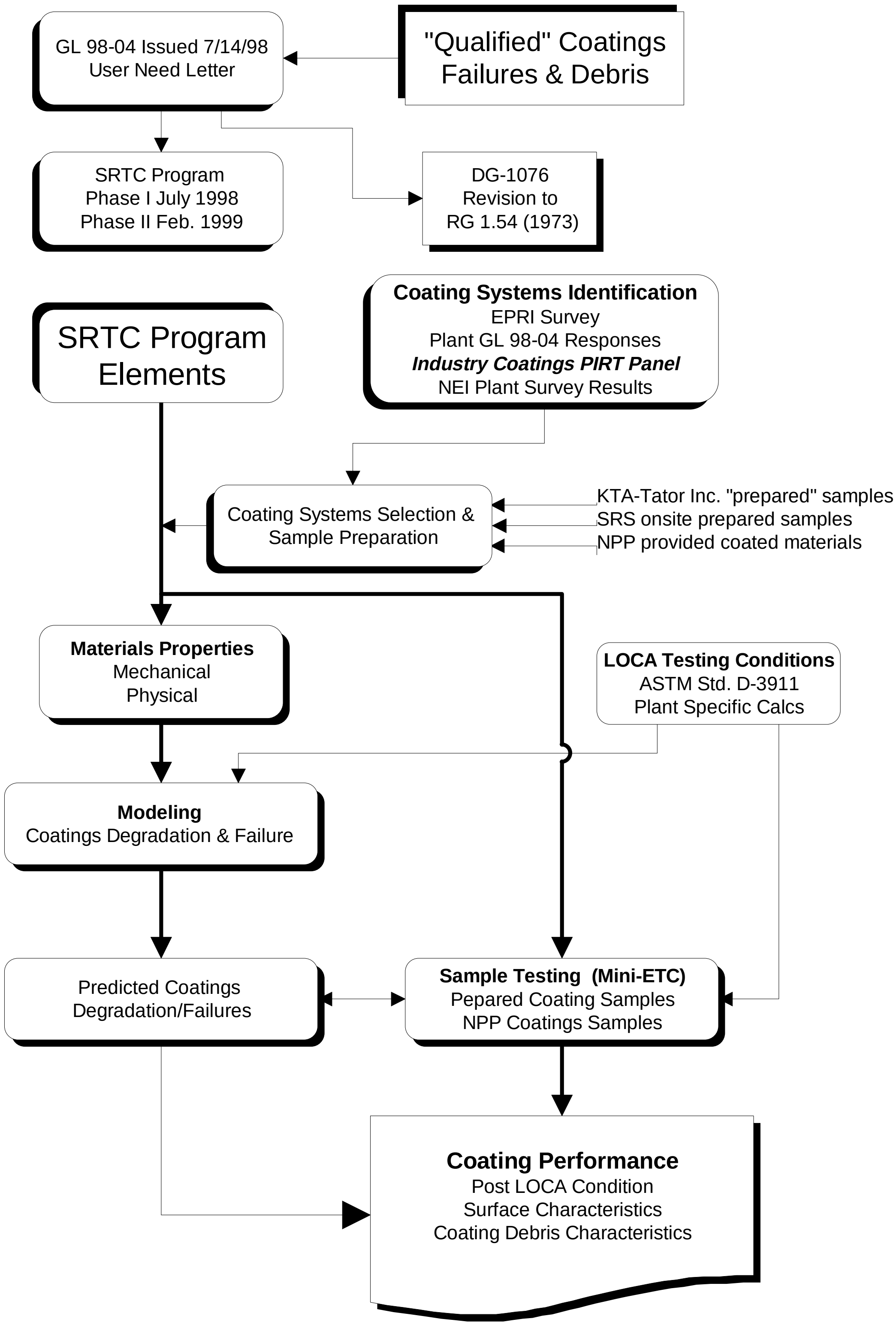
Coating Systems Identification & Cross Reference

Substrate	Generic Description	Coating Products	SRTC System Identification	Industry PIRT Identification	
Steel	Epoxy-phenolic over inorganic zinc	Phenoline over CZ-11	1	**A [1]**	**NRC PDR**
Concrete	Epoxy-phenolic over surfacer	Phenoline over Surfacer	2	E [5]	
Steel	Poly-modified epoxy over inorganic zinc	Amercote 90HS over Dimecote 9	3		
Steel	Poly-modified epoxy over epoxy-poymide	Amercote 90HS over Amercote 370	4		
Steel	**Epoxy-polymide over epoxy-polymide**	**Amercote 370 over Amercote 370**	**5**	**D [4]**	**Draft**
Steel	Inorganic zinc	**Dimecote 9**	**6**		**Draft**
Steel	Epoxy-phenolic over epoxy-phenolic			B [2]	
Steel	Epoxy over inorganic zinc			C [3]	
Concrete	Epoxy over surfacer			F [6]	**NRC PDR**
Concrete	Epoxy-phenolic over epoxy-phenolic			G [7]	
Concrete	Epoxy over epoxy			H [8]	**Draft**



SRTC NPP Protective Coatings Research Program Overview

SRTC Project Alignment with Industry PIRT System D [4]
SRTC System 5: Steel Substrate, Epoxy Primer, Epoxy Topcoat

High-Ranked Industry PIRT Phenomena/Processes	Time Phase	Related Inputs and Physical Properties from SRTC Factor Table	Related Project Activities
Blistering and Delamination at Substrate-Primer Interface	2,3,4,5	Adhesive Strength, Tensile Strength, Ductility	Adhesion Testing, Free-Film Testing, Mode 1 & 2 Failure Modeling
Oxidation at Substrate-Primer Interface	3,4,5	Corrosion	DBA Testing of Defect 2 Coupons
Environmental Exposure to Primer	1 and 5	Total Radiation Dose, Temperature/Humidity History, Decontamination Chemicals, Corrosion, Erosion, Abrasion	Radiation Aging and Thermal Aging of Laboratory Specimens, Characterization and Testing of Plant Specimens
Mechanical Damage to Primer & Topcoat	1	Adhesive Strength	DBA Testing of Defect 2 Coupons
Minor Coating Anomalies in Primer	5	Surface Cleanliness	Adhesion and DBA Testing with Defect 1 Coupons
Air, Water, & Chemical Intrusion Into Primer Above Pool	5	Water Permeation and Water Chemistry	DBA Testing
Air, Water, & Chemical Intrusion Below Pool	5	Water Permeation and Water Chemistry	DBA Testing
Blistering and Delamination at Primer-Topcoat Interface	1,2,3,4, 5	Adhesive Strength, Tensile Strength, Ductility	Adhesion Testing, Free-Film Testing, Mode 1 & 2 Failure Modeling
Environmental Exposure to Topcoat	1	Total Radiation Dose, Temperature/Humidity History, Decontamination Chemicals, Corrosion, Erosion, Abrasion	Radiation Aging and Thermal Aging of Laboratory Specimens, Characterization and Testing of Plant Specimens

Phase 1: Normal service to 40 years.
Phase 2: 0 to 40 seconds into LOCA.
Phase 3: 40seconds to 30 minutes after LOCA.
Phase 4: 30 minutes to 2 hours after LOCA.
Phase 5: Beyond 2 hours after LOCA.

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Insights Gained & Activities Underway

1. Industry PIRT Panel is an **ASSET .** The panel has identified 11 important coating systems, 5 PIRTs completed; 2 PIRTs are available through the USNRC PDR. The panel interacts with both project staff and industry groups and has assisted in finding and obtaining critical coating formulation materials. PIRT panel involvement will continue.

2. Procurement of coating materials and sample preparation has been a pacing item and therefore alternate coatings systems (i.e. System 5) have been used to gain earlier insights. Initial findings were reported at the 11/ 22/99 public meeting at NRC Hdqs. Examples of sample preparation, property measurements, modeling insights and DBA test results are in the supplemental handout provided.

3. Coating System 5 research activities are nearing completion and the plan is to issue a Status Report in March 2000. This report will be made publically available.

4. System 5 mechanical and physical properties have been measured for both irradiated (10^9 R) and non-irradiated samples, with and without introduced defects. Samples have been subjected to DBA conditions using ASTM D3911 PWR envelope and plant-specific calculations.

5. System 5 (polyamide epoxy top coat & primer on carbon steel substrate) findings show:

    - Non-aged samples - no failure under DBA conditions tested.
    - Aged samples - some blistering and very small amount of potential coating debris evident.

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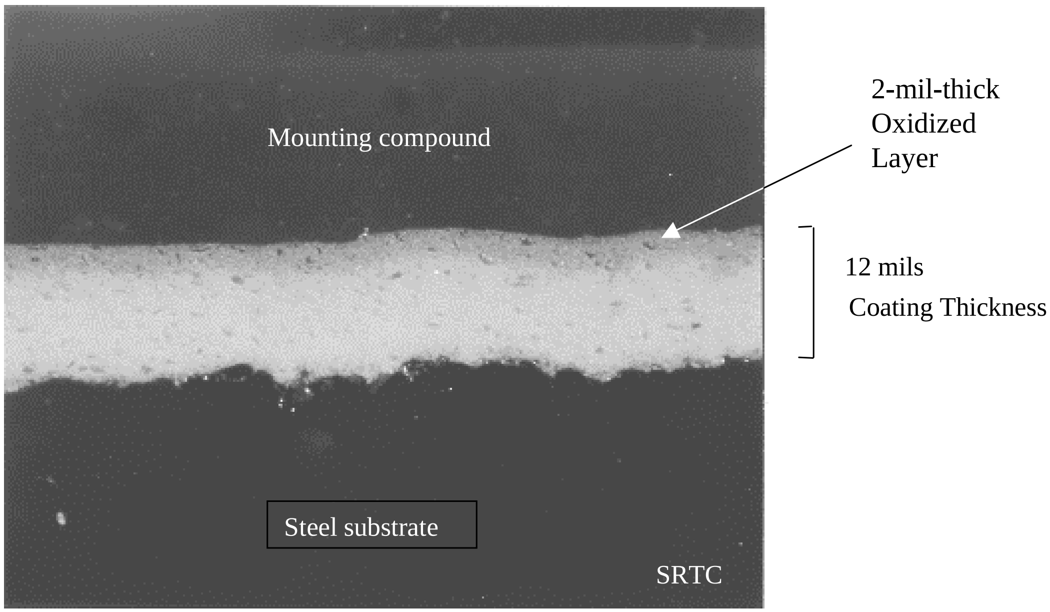
Cross-Section of Irradiated System 5, Pre-DBA Test



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System 5 DBA Effects

- System 5 (Amercoat 370), Non-Defected, Aged ($1x10^9$ R)
- Abbreviated D3911 Exposure
- Post DBA Results (photo on right)
  - » Blisters
  - » Minor Cracking (Below Water Line)
  - » Debris Source Term from Small Chips


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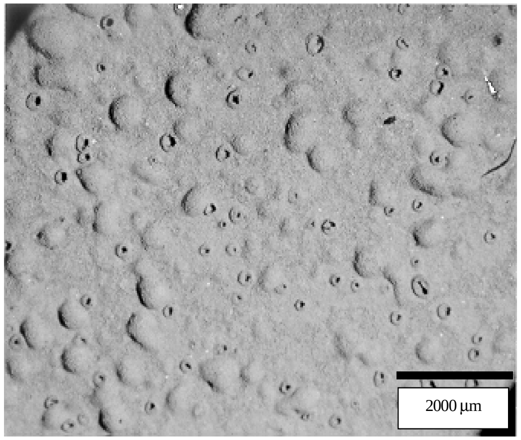
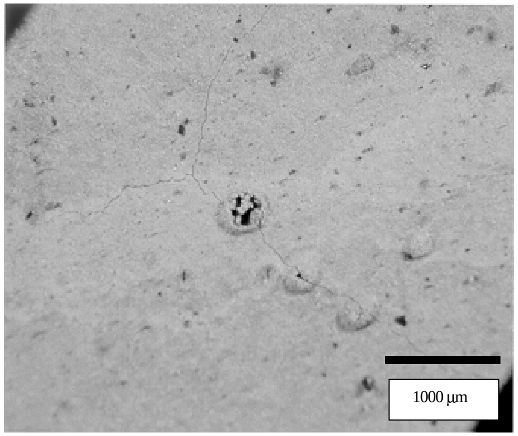
Results System 5 (CONT'D)



Blistering in Vapor



Cracking and Minor Blistering in Water

- Blister Areal Fraction: 22%
- Debris Areal Fraction: 0.8%

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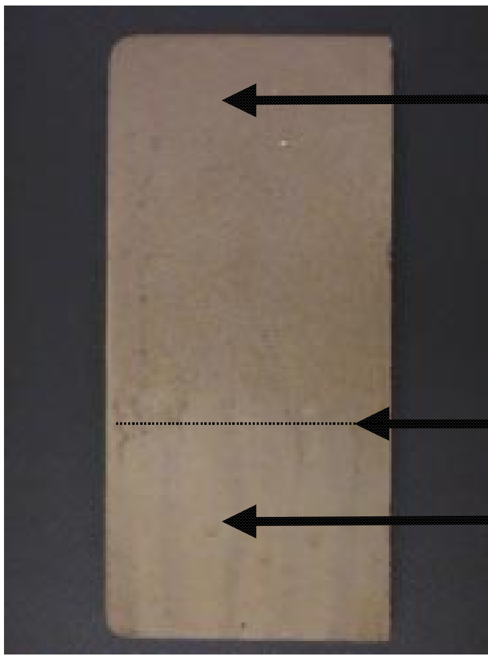
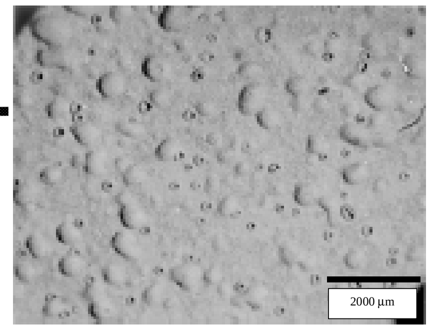
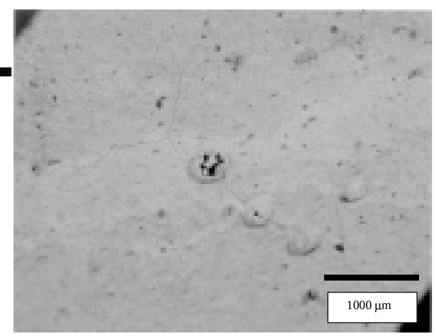
Results System 5 (CONT'D)





- Blister Areal Fraction: 22%
- Debris Areal Fraction: 0.8%

Water Level



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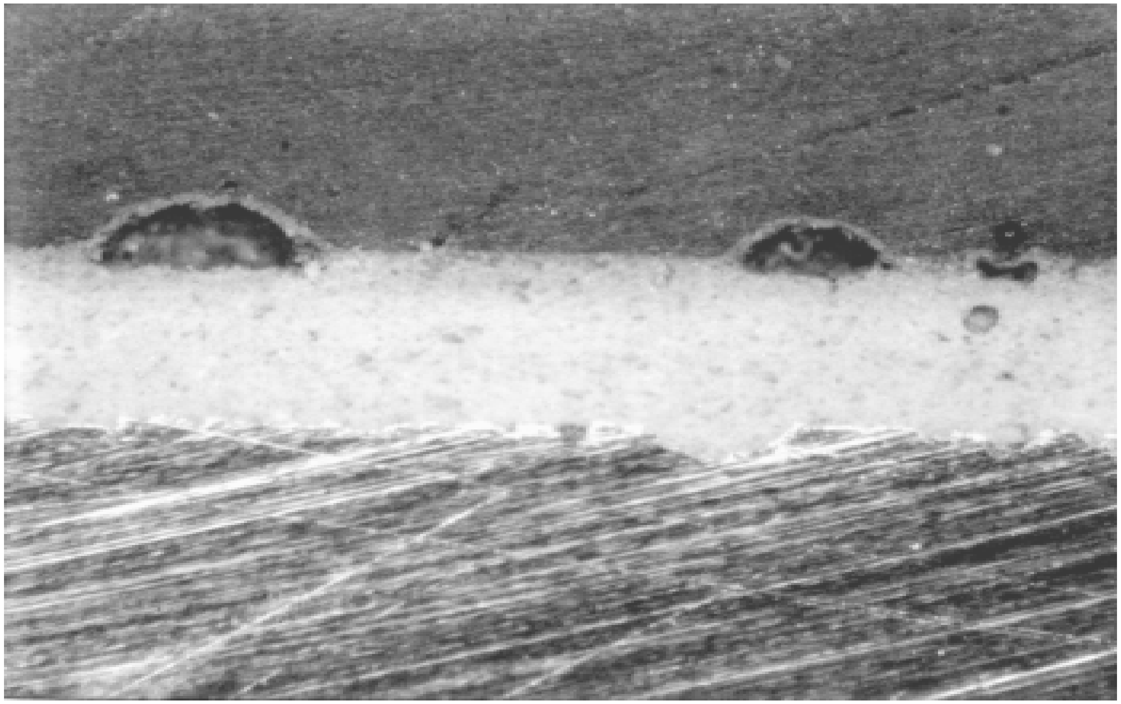
Post-DBA System 5 Sample Cross Section

Mounting Media

Paint Coating

~12 mils

Substrate



Aged Epoxy Polyamide (System 5) with blisters

Original Magnification - 50X