Detroit Edison

REPORT NO. DECO-12-2191
REVISION 4
JUNE 1985

ENRICO FERMI ATOMIC POWER PLANT
UNIT NO. 2
EVALUATION OF
CONTAINMENT COATINGS

MULTIPL DYNAMICS CORPORATION

THE DETROIT EDISON COMPANY

FERMI 2 NUCLEAR POWER PLANT

EVALUATION OF

CONTAINMENT COATINGS

FOR FERMI 2

REPORT NO. DECO-12-2191
REVISION 4

PREPARED BY

MULTIPLE DYNAMICS CORPORATION
29200 SOUTHFIELD, SUITE 103
SOUTHFIELD, MICHIGAN 48076
(313) 557-7766

JUNE 1985

TABLE OF CONTENTS

1.0 INTRODUCTION

An evaluation of the Fermi 2 primary containment coatings was performed in response to comments expressed by the Nuclear Regulatory Commission and Duke Power Company as part of its Construction Assessment Inspection at Fermi 2 in June 1984. The comments raised primarily pertained to the repair and touch-up of damaged coatings, the amount of unqualified coatings and assessment of uncoated surfaces. It was further implied that failure of certain coatings could lead to degraded plant performance in accident conditions.

In response to these comments, Fermi 2 Engineering initiated a review of primary containment coating types and qualifications. This review encompassed the following subjects:

- An analysis of the specific coating substances used for containment surfaces and components, and the rationale for their use

- Original design and current regulatory standards for application and testing of coatings

- Definition of qualified, safety-related coatings

- Proper application of non-qualified coatings

- Confirmation of test results

- Detailed as-built survey and inspection of primary containment coatings and determination of coating parameters and quantities

- Analysis of failure modes of unqualified coatings and evaluation of safety concerns

- Transport of coating debris and potential effects on plant systems performance

- Additional test, surveillance and inspection programs to be implemented by Detroit Edison

- Application of new coatings before and after fuel load

- Responses to additional NRC questions (see Addenda) and supplementary information.

This evaluation determined that the applied containment coatings do not in any way degrade or affect the safe operation of the plant under normal or accident conditions.

The Fermi 2 FSAR and the coating specification will be appropriately revised to reflect the conclusions and as-built conditions discussed herein.

2.0 CONTAINMENT COATINGS

2.1 Drywell Interior

The original containment specification issued in 1969 included a requirement for coating of the interior pressure boundary surfaces in the drywell, with the primary objective being long-term corrosion protection. The industry standard at that time was to apply Carbo-Zinc 11 as manufactured by the Carboline Company in accordance with the manufacturer's recommendations. This type of coating has been successfully applied to most operating BWR's, and has stood up well over the years, even under a variety of adverse conditions. Most of the CZ-11 coating was originally applied to the Fermi 2 surfaces before the issuance of Regulatory Guide 1.54 and ANSI N101.4. However, the Fermi 2 QA Level 1 criteria was applied in the absence of definitive coating criteria.

2.2 Concrete Surfaces

Following erection, pressure testing and coating of the containment drywell, the drywell floor and RPV pedestal were poured to accept the reactor vessel. Erection of the sacrificial shield and drywell primary steel structures followed. The concrete surfaces of the drywell floor, and the exterior and interior of the pedestal, were coated with an Ameron Nu-clad surfacer 110AA and a finish coat of Ameron polyamide epoxy 66. This coating was applied in accordance with ANSI N101.4, and met the pull test requirements (200 psi) per ANSI 5.12, Section 6.2. Required DBA testing was conducted for these coating materials. The prime objective of the concrete coatings is to effectively seal the porous surfaces, to inhibit intrusion of radioactive contaminants and to facilitate easy washdown and decontamination if required.

2.3 Structural Steel

The primary structural steel within the drywell and the exterior steel surface of the sacrificial shield were coated with Carbo-Zinc 11. Surface preparation of these surfaces included blasting or hand power tooling to near-white metal. The purpose of the CZ-11 coating is to provide long-term protection against excessive corrosion and rusting, and to facilitate easy decontamination if required.

As a result of the new Mark 1 Program containment LOCA loads, new Safety Relief Valve discharge loads, and a general containment steel load reevaluation, substantial modifications were required to be implemented in two different phases. The two different time periods resulted in varying degrees of steel surface preparations. Approximately 250 tons of structural steel were added by means of welding to the existing structures. Welding and NDE operations required removal of the existing CZ-11 coating at the tie-in and welded connections. Due to the increased complexity of component placement and shrinking work space, as well as completed installation of much of the mechanical equipment, sandblasting and painting became more and more impractical and time consuming, affecting construction and preoperational testing progress. Therefore, coating of new structural steel and recoating of modified steel components was not routinely completed. The mill scale present on the uncoated and unblasted surfaces of the steel members is discussed in the debris evaluation within Section 6.0 of this report.

2.4 Suppression Chamber

The entire interior of the suppression chamber, including the vent system, ring girders, structures, monorail, piping and supports, is coated with Plasite 7155 manufactured by Wisconsin Protective Coating Company. The coating system is considered safety-related, QA Level 1, and was applied in accordance with Regulatory Guide 1.54 and ANSI N101.4. Some small areas (on the order of 1 inch^2) which were subject to mechanical damage, newly-installed vacuum breaker flanges, some portions of the vent header deflector and two RHR orifice flanges require repair and touch-up. In bays 15 and 16, the Plasite 7155 has been removed in 1 x 2 inch spots to facilitate installation of test instrumentation and strain gauges for the scheduled SRV test. These areas are to be repaired during the first refueling outage, when the instrumentation is removed.

3.0 EQUIPMENT COATINGS

3.1 Galvanized Surfaces

The drywell cooling system ducting and dampers are completely galvanized without any further coatings. At welded joints, the galvanized surface was ground off to clean metal, and in some locations these ground areas were touched up with Galvanox V, a zinc-rich coating similar in properties to CZ-11. In addition, all electrical conduit, terminal boxes, cable trays and supporting unistruts are galvanized. The only exceptions are some large flexible conduits made of stainless steel.

3.2 Hangers and Supports

Hanger and support components, including clamps, rods, spring cans, snubber attachments, pipe whip restraint components and secondary support steel, were originally coated with CZ-11. Significant changes in the hanger and support design resulted in the addition of secondary support steel and change-out of hanger components and welding of attachments. Coating repair and touch up of these areas is scheduled to be accomplished as time permits, to facilitate decontamination and provide long term corrosion protection.

3.3 Piping

Most of the piping within the drywell is insulated with reflective metallic insulation panels (Mirror

Insulation), consisting of removable sections having an outer cover of stainless steel. No fibrous insulation has been used within the containment. Normally cold fluid system piping is not insulated or coated. The uninsulated carbon steel piping was shop coated with a protective varnish. Tight mill scale and some rust is apparent on the piping surfaces. The varnish and mill scale are considered unqualified coatings for the purpose of this evaluation and per Standard Review Plan 6.1.2. The design of the piping pressure boundary included a corrosion allowance of 0.125".

3.4 Miscellaneous Coatings

As part of a detailed coating survey within the containment, miscellaneous unidentified coatings were surveyed. These coatings consist largely of manufacturers' shop coatings and primers such as red lead, aluminum base, enamels, polymer and phenolic paints and yellow safety paint. These coatings are present on valve bodies, yokes and bonnets, motor and air operators, handwheels, handrails, electric motors, etc. Another category consists of identification marking and banding of electrical conduit, terminal boxes and trays. These unidentified coatings have been removed from surfaces where the average coating exceeded 3 mils. Only very small quantities of these coatings (3 mils DFT or less) remain within the drywell as shown on Table 1 and as further discussed in Item 5 of Addendum 1.

TABLE 1

SUMMARY OF PRIMARY CONTAINMENT COATINGS

Type of Coating	Qual. Coatings	Average DFT* (mils)	Total Surface (ft^2)	Approx. Dry Film Density ($\#/ft^3$)	Total Volume (ft^3)	Total Mass (lbs)
Carbo-Zinc 11	No	7	125,000	217	73	15,841
Plasite 7155	Yes	12	67,000	150	66.9	10,035
Ameron 66 and Surfacer	Yes	1/16" plus 10 mills	7,380	125	44.6	5,575
Galvanox V	No	5	775	202	0.36	73
Mill Scale and Varnish	No	3.4	89,000	350	25.22	8,827
Unqualified Paints	No	0.7 to 2.5	972	90 to 150	0.128	15

* DFT (Dry Film Thickness) measurements were taken with a Positector 2000 gauge, Serial #30531, calibrated with NBS shims #22272.

4.0 COATING SURVEY

A detailed coating survey was conducted of all surfaces within the primary containment, to assess type of coating, surface areas, and dry film thickness (DFT). This data was used to calculate total quantities of qualified and unqualified coatings. The results of this survey are summarized in Table 1 and the additional responses to NRC questions (Item No. 5 of Addendum 1 and Item No. 7 of Addendum 2).

5.0 COATING QUALIFICATIONS

The Plasite 7155 and Ameron 66 coatings have been applied in full compliance with the provisions of Regulatory Guide 1.54 and ANSI N101.4 (1972). Pull tests have been performed in accordance with ANSI 5.12, Section 6.2 on the original coatings and the repaired areas. DBA testing was performed by the paint manufacturers as required under ANSI N5.9 and ANSI N101.2. These coatings are therefore considered fully qualified per the regulatory criteria of Standard Review Plan 6.1.2.

The Carbo-Zinc 11 coatings applied to the containment surfaces have also been subjected to extensive DBA testing for a variety of application techniques, and were found to be acceptable for use in BWR environments under LOCA conditions. The test results are contained in Report No. 56878 issued by the Carboline Company (Reference 1).

As discussed earlier, most of the CZ-11 on the containment pressure boundary was applied prior to the issuance of R.G.1.54 and ANSI N101.4. Even though a specific effort was made to document the CZ-11 application in accordance with the Fermi 2 QA Manual, a current inspection of the existing documentation reveals deficiencies when gauged against current criteria. These deficiencies in documentation, however, do not adversely affect the primary function of corrosion protection. The coatings have already successfully withstood more than 10 years of construction environment, wear and tear, and have undergone a substantial degree of thermal cycling, from direct summer sun exposure to near freezing winter conditions, without deleterious effects. For the purpose of this assessment, however, the CZ-11 coatings are evaluated as unqualified coatings.

Those containment surface areas which are severely damaged or worn (visible bare metal) are repaired by touch up, to ensure the continued long-term function of corrosion protection for the pressure boundary and to facilitate potential decontamination. The consequences of failures are evaluated in Section 8.0 of this report. These coatings are maintained under the Fermi 2 QA Level 1 criteria, to assure the long-term corrosion protection for the pressure boundary.

The remaining coatings listed in Table 1 are Galvanox V, Unqualified Paints, Mill Scale and Varnish. All of these coatings are non safety-related, and are considered unqualified by the definition of SRP-6.1.2-III. They are assumed to form solid debris under LOCA conditions for the purpose of this evaluation, though complete failure is not expected.

6.0 FAILURE MODES OF UNQUALIFIED COATINGS

Containment coatings are postulated to fail in one of two modes under extreme environmental conditions. Inorganic metallic type coatings, such as CZ-11, Galvanox V, Keeler and Long #7720 and aluminum based paints, without any top coating, have low tensile strength and are very brittle, such that any sizable flakes, separating from surfaces due to lack of proper adhesion, crumble into small particles. This failure mode has been identified as the most likely by the 4 largest manufacturers of inorganic type zinc coatings (Mobile, Ameron, Carboline and Napko). When directly impinged by steam or water, these coatings separate from the surface in small particles as a result of the scouring action.

Phenolic and polymer based paints when applied in thicknesses of approximately 3 mils and over are likely to separate from the surfaces in the form of peels, blisters, and flakes as a result of chemical breakdown and extreme temperature exposure.

Coatings of less than 3 mils generally are too thin to sustain the strain of peeling or blistering and the adhesion force, and are likely to separate in or disintegrate into small particles, as discussed in Item 8 of Addendum 2.

For the purpose of this evaluation and in estimating the total quantities of paint debris, 100% failure of all the unqualified coatings was conservatively assumed.

The DBA test report No. 56878 issued by Carboline (Reference 1) demonstrated that Carbo-Zinc 11 is not lost in flakes, but rather in particles of a size less than 20 microns. The report further states that the particles do not dissolve in water and do not clog screens. The density of CZ-11 dry film coatings is between 3 to 4 times that of water, and particles are expected to settle to the botto... of the drywell and the suppression pool, concentrating as sludge in low velocity areas. The particle separation mode is a result of continuous scouring action of steam and water spray as simulated in DBA testing programs. In a typical BWR containment, direct scouring occurs only in the immediate vicinity of the postulated pipe break and within a few feet of the containment spray headers (if used). Temperature resistance of CZ-11 up to 750°F is considered excellent by the manufacturer, as described in Reference 2.

The failure mode for Galvanox V is considered similar to that of CZ-11, based on the physical properties provided by the manufacturer (Reference 3). However, no detailed test data exist to quantify the rate of deterioration. The tensile strength of Galvanox V dry film coating is such that if flaking occurs, the flakes will break up into small particles within a turbulent fluid or when subjected to gravity impact. The resulting debris can be classified as solid hydroxide as defined in NUREG-0897, Reference 4, in respect to ECCS pump and strainer performance.

Very small quantities of unqualified miscellaneous paints within the drywell are assumed to fail under LOCA conditions. In the absence of substantiating test data, these paints are assumed to fail in the form of flaking and peeling. The resulting debris is considered similar in behavior to fibrous insulation material with a near neutral buoyancy. The detailed coating survey determined DFT (Dry Film Thickness) measurements between 0.7 and 6.1 mils. Unqualified coatings of 3 mils DFT and thicker have been removed and surfaces recoated with CZ-11. A DFT of less than 3 mils is not expected to result in flaking or peeling, and the coating will disintegrate into small particles as discussed previously.

Even though not considered a coating under standard definition, the mill scale present on some uncoated carbon steel surfaces was included in this evaluation.

Mill scale exists on uncoated structural steel and on uncoated, uninsulated carbon steel piping. The piping has a thin varnish applied over the mill scale. To determine the failure mode under LOCA conditions, short-term simulation tests were conducted by the Engineering Research Department of Detroit Edison. These tests concluded that the mill scale remained adherent to the steel in a hot (210°F) dry nitrogen atmosphere. In a distilled water immersion test in a nitrogen environment, the mill scale spalled off within 72 hours at 210°F. The mill scale particles ranged in size from 4 to 60 microns and settled on the bottom of the test container. In addition, a LOCA simulation test was conducted, simulating the BWR LOCA conditions for an SBA event. The mill scale specimen was subjected to 6 hours of steam atmosphere at 340°F, followed by 40 hours at 250°F. Mill scale did not separate, removal of rust was observed on the surfaces. Particles found in the container were in the form of sludge and water discoloration. Based on these results, it is postulated that some of the mill scale will spall off during postulated LOCA conditions. The density of mill scale is approximately 350 lbs/cu ft, and the scale is expected to settle in the drywell bottom and suppression pool as a sludge. The sludge is classified as hydroxide as defined in NUREG-0897.

Temperature resistance tests were also conducted for the varnish present on uncoated, uninsulated steel piping. Specimens were baked at 340°F in a dry oven, and the varnish was observed to soften but did not run or separate from the surfaces. No other deterioration was identified.

7.0 SAFETY EVALUATION OF COATINGS

The application of primary containment coatings has inherent positive and negative aspects. As discussed earlier, the desired positive qualities of long-term corrosion protection and decontamination must be balanced with the potential negative aspects of hydrogen evolution and debris generation during or following a postulated LOCA. This section, therefore, individually examines these aspects to assure that the applied coatings will not degrade or affect the safe operation of the plant.

7.1 Corrosion Protection

Under normal operation, the Fermi 2 containment is nitrogen inerted and maintained at an operating temperature between 135 and 150°F. The drywell cooling system continuously removes excess moisture from the environment to maintain a dew point near the EECW/RBCCW water temperature (approximately 95°F). The drywell atmosphere is therefore substantially below saturation. Short-term, substantial corrosion during normal operation is therefore not expected, nor has it been observed in operating BWR's. The existing CZ-11 coating on the pressure boundary, together with repair and touch up coating, will adequately protect the containment from corrosion. Long-term effects, if any, will be monitored via visual inspections during refueling outages, and will be repaired in those areas where rusting or discoloration is apparent. Deterioration of the CZ-11 coating is anticipated during a postulated LOCA. Following the LOCA and containment depressurization, the onset of corrosion can be expected and will progress over time at a predictable rate. In the absence of significant concentrations (>25%) of acids and chlorides in the containment following a LOCA, a maximum corrosion rate of 0.02 to 0.05 inch per year is given in the literature, Reference 5. With a minimum shell thickness of 0.75 inch, containment integrity and leak tightness can be assured for years following the LOCA.

7.2 Decontamination

The coatings within the containment also serve as a surface sealer to prevent contaminated fluids and particles from penetrating into porous materials and crevices. Washdown and other physical decontamination methods are made more effective and less time consuming, thereby promoting ALARA personnel exposure considerations. Decontamination itself is not considered a safety-related activity, but more specifically a normal plant maintenance item. It is an objective of Fermi 2 Nuclear Production to coat interior containment surfaces and maintain these coatings during the life of the plant for economic and ALARA reasons. Further discussions regarding ALARA considerations are provided in Item 1 of Addendum 1.

7.3 Hydrogen Evolution

The evolution of hydrogen from the corrosion of aluminum, zinc and zinc-base paints has been previously assessed in the Fermi 2 FSAR Section 6.2.5.3.1. The two hydrogen recombiner systems have been adequately sized to comply with the provisions of Regulatory Guide 1.7.

8.0 EFFECTS OF COATING DEBRIS

To evaluate the effects of coating debris generated by the postulated failure of unqualified coatings, both solid hydroxide type and fibrous debris (paint peels) are assessed separately in respect to their transport mechanisms and affect on ECCS performance. The assumptions used are extremely conservative for the purpose of this analysis as discussed in Item 2 of Addendum 2.

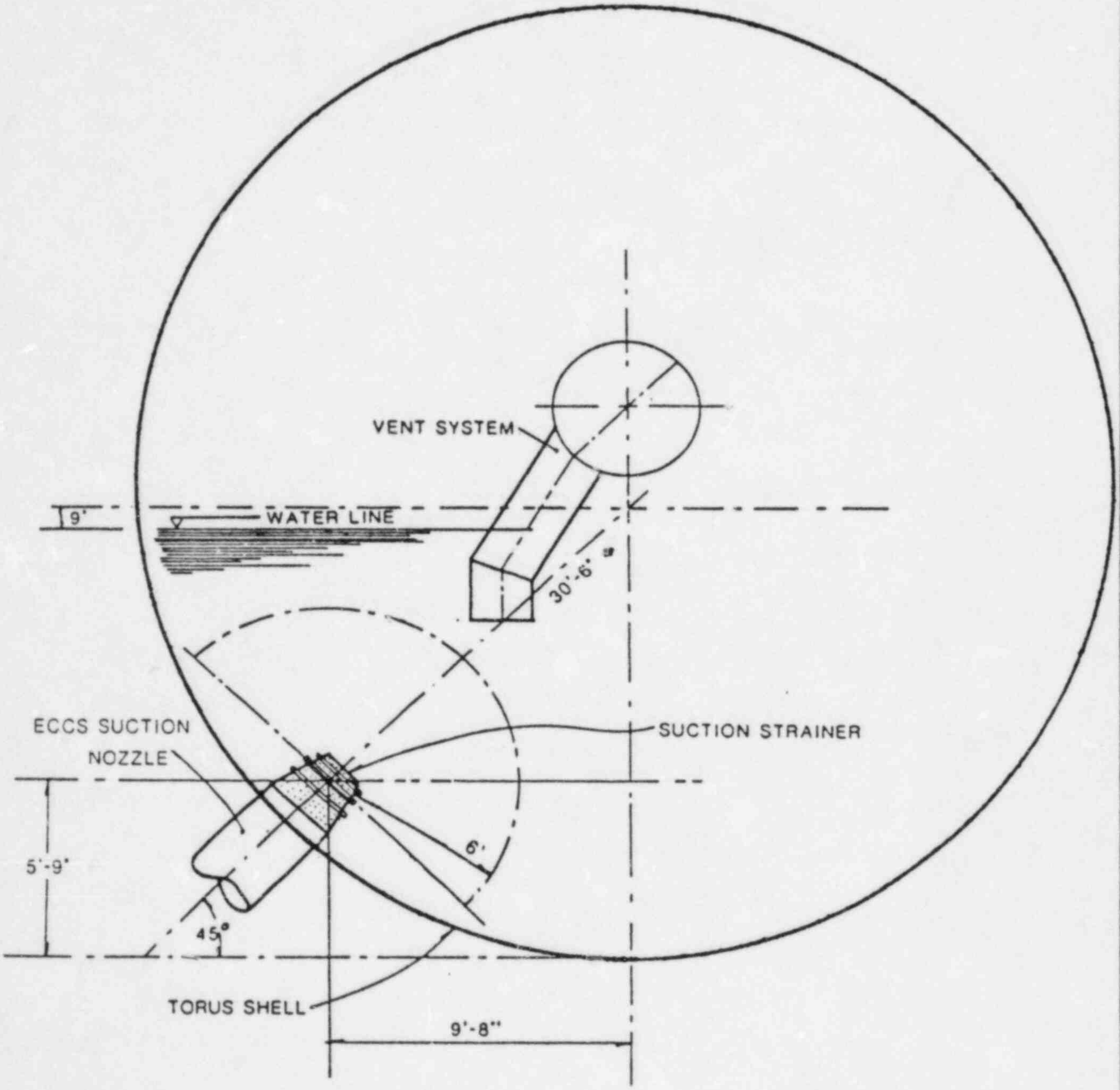
8.1 Debris Transport

The debris generated from the failure of unqualified coatings and mill scale during and following a LOCA will be transported to the suppression pool by the flow of water, steam and noncondensible gases from the drywell. After initial surface separation, the coating particles will tumble to the drywell floor or other horizontal intervening surfaces by gravity. Pipe break flow or containment sprays will then flush most of the debris through the vent system into the suppression pool. High vent system flow velocities occur only during the initial 20 to 40 seconds following the DBA-LOCA while the reactor vessel depressurizes.

Coating debris which remains in the drywell after this initial transient can be transported to the pool by the ECCS flow or containment spray flow. Drywell floor and vent line/header flow velocities are very low and subject to gravity flow only. A pool of approximately 2 feet depth will develop on the drywell floor before excess water spills over to the vent lines into the vent system. Debris particles with densities significantly higher than water (such as CZ-11 and mill scale) will settle out in the drywell floor bottom. Particles which are swept over into the vent system will flow through the vent header and exit the downcomers near the center of the torus.

Average water velocities within the torus following the initial transient are below 0.25 ft/sec, but approach 0.3 ft/sec within a 4 foot hemisphere of the largest suction strainers at maximum RHR pump capacity. Refer to Figure 1 for the dimension and arrangement within the torus. The maximum surface velocity at the strainer surface was calculated to be 2.5 ft/sec. The strainer intakes are located 9'-8" from the center of the torus and 5'-9" above dead bottom. For these pool velocities hydroxide type particles are therefore not postulated to reach the strainers in a realistic situation.

SUBJECT: EVALUATION OF CONTAINMENT COATINGS FOR FERMI 2	DATE ISSUED June 1985	DOC. NO. DECO-12-2191
	REVISION: 4	PAGE 19



ECCS SUCTION STRAINER LOCATION

FIGURE 1

Unqualified paints with DFT's of less than 3 mils that fail in a peeling or flaking mode are expected to float on the pool surface or remain suspended in water, where they could ultimately migrate toward the ECCS suction strainers. The particles of these thin coatings are expected to be small enough to pass through the strainers as discussed in Section 6.0.

8.2 <u>ECCS Performance</u>

To conservatively evaluate the postulated performance of plant systems and equipment, it was assumed that the hydroxide type debris, consisting of CZ-11 and mill scale particles, are completely suspended in the pool water during the early turbulent phase of the LOCA. Under this assumption, the total hydroxide particle concentration in the pool is calculated to be less than 0.17%. In accordance with the conclusions and guidelines given in NUREG-0897, Section 3.2.2.4, a solid hydroxide concentration of less than 1% of mass does not affect pump performance. The solid particles are less than 60 microns in size, and will therefore freely pass through the 1/8" holes in the suction strainers of the RHR, Core Spray and HPCI lines.

The fibrous debris, generated by failure of unqualified thin coat paints, is also transported to and distributed in the pool water volume. The total volume of 0.128 cu ft (15 pounds), as shown on Table 1 (page 8), results in a volumetric concentration of 1.2×10^{-6}%, well below the acceptable limits of 4% given in

NUREG-0897 for fibrous debris. The particles are expected to be small enough to freely pass through the strainers. In addition, the ECCS pumps and system piping has been designed for a worst case assumption of 50% strainer blockage for the Design Basis Accident.

8.3 Containment Sprays

The Fermi 2 containment spray headers are equipped with a 1-1/2-7G25 fog nozzle as manufactured by Spraying Systems Company. The fog nozzle has a fleet passage of 0.125" which is of equal size to the ECCS strainer passage.

Solid and fibrous particles which pass through the strainer are therefore expected to also pass through the fog nozzle, and no clogging or performance degradation occurs.

The plant design basis does not require containment spray operation. This function, however, is desirable to mitigate the consequences of a LOCA.

8.4 RPV Core Spray and Feedwater Spargers

ECCS flow is injected into the reactor vessel directly via the RHR and Recirculation System piping and/or Core Spray piping. No intervening obstructions are located in the RHR flow path. Core spray flow is injected via the core spray spargers located directly above the fuel. The minimum flow passage through the sparger is more than 0.5 inch, which is larger than the strainer flow passage. Similarly, HPCI and RCIC flow is injected into the vessel via the feedwater system piping and spargers. The minimum flow passage in the feedwater spargers is more than 0.5 inch, and no flow blockage or performance degradation will occur.

The potential ultimate depositioning of debris within the reactor vessel was evaluated by General Electric Co., as discussed in Addendum 1 (Item 3).

The recirculation pumps are equipped with a demineralized water seal purge system, thereby preventing particle intrusion into the pump seal and bearing assembly.

Further detailed evaluations for the RHR and core spray pumps, RHR heat exchangers and ECCS valves are provided in Item 5 of Addendum 2 and Items 1 through 4 of Addendum 3.

8.5 Normal Operations

During normal plant operations, and as a result of operational vibrations, some coating and mill scale debris is expected to be generated. In the absence of any fluid flow between the drywell and torus, the particles will accumulate on the drywell floor and other horizontal surfaces. Some airborne particles may be transported via the vent system into the torus during purging and inerting operations, where they will settle to the bottom. The Torus Water Management

System (TWMS) is designed to continuously process torus water through a demineralizer system to maintain water quality and to prevent gradual build-up of particles, contamination and sludge. The TWMS takes suction from the bottom of the torus. Normal operations, including ECCS testing, is therefore not impaired.

8.6 Emergency Operations

The Fermi 2 Emergency Operating Procedures (EOP) provide the operators with alternate system core makeup (other than EECS) using alternate water sources, as discussed in detail (in Item 6 of Addendum 3).

9.0 ADDITIONAL CONSIDERATIONS

9.1 Surveillance and Inspection

Following completion of the repair and touch-up of the qualified coatings and the CZ-11 coating on the containment pressure boundary, a thorough visual inspection will be conducted by Detroit Edison Nuclear Quality Assurance. After commercial operation is achieved, these same surfaces will be visually inspected during refueling outages to determine onset of corrosion, blistering or peeling, and coating discoloration. The extent of these inspections will be commensurate with the number of affected areas found. Suspect areas will be cleaned, including manufacturers' recommended surface preparations, and new coatings will be applied in accordance with the original application criteria.

9.2 Additional New Coatings

As discussed earlier in this report, uncoated carbon steel surfaces may be coated in the future as much as practical to reduce corrosion and facilitate decontamination, if necessary. Surfaces will be prepared with hand power tool cleaning, and CZ-11 coatings will be applied in accordance with manufacturers' recommendations. These coatings will be applied on a schedule not interfering with the critical path. As time permits, coating activities will continue during refueling outages, when the containment is accessible.

Unqualified coatings with DFT's over 3 mils (excluding inorganic zinc primers) will be removed from equipment surfaces and recoated with CZ-11 where appropriate.

10.0 CONCLUSION

After detailed evaluation of the coating qualities, quantities and potential failure modes, it is concluded that the Fermi 2 coatings currently applied within the primary containment do not adversely affect the safety of the plant, and will not impair normal or abnormal operation. The coatings are therefore classified as follows:

Suppression Pool	-	Plasite 7155, qualified and safety related
Drywell	-	Carbo-Zinc 11, unqualified, safety related, see Section 5.0, page 9

Concrete Surfaces - Ameron 66, qualified and safety related

Structural Steel and Equipment - Carbo-Zinc 11, unqualified, not safety related*

- Mill scale, unqualified, not safety related*

Ducting - Galvanox V, unqualified, not safety related

Carbon Steel Pipe - Mill scale/varnish, unqualified, not safety related*

Misc. Coatings - Various, unqualified (DFT of 3 mils or less), not safety related*

* Surfaces to be coated and/or repaired per manufacturers' recommendations as time permits.

The Fermi 2 FSAR and applicable specifications will be revised to reflect the conclusions of this assessment.

11.0 REFERENCES

1. The Carboline Company, Report No. 56878, "Carboline/ORNL Round Robin DBA Testing - Test II"

2. The Carboline Company, Carbo-Zinc 11 Product Data Sheet of February 1981

3. The Carboline Company, SUBOX Division, Product Bulletin No. 29 of June 1979, Galvanox Type V

4. NUREG-0897, Revision 1 Draft, USNRC, "Containment Emergency Sump Performance"

5. Perry's Chemical Engineers Handbook, Table 23-3, 4th Edition

6. Detroit Edison Letter EF2-72,045 dated 1/10/85 (W. H. Jens to B. J. Youngblood), "Transmittal of Responses to 6 NRC Staff Questions"

7. Detroit Edison Letter NE-85-0048, dated 1/24/85 (W. H. Jens to B. J. Youngblood), "Primary Containment Coatings - Additional Information"

12.0 <u>ADDITIONAL INFORMATION</u>

Additional information and responses to NRC questions have been provided as follows:

1. Additional information requested during the Detroit Edison-NRC meeting of September 14, 1984, is contained in Addendum 1 to this report.

2. Responses to 6 NRC staff questions were originally provided via Detroit Edison letter EF2-72,045 (Reference 6). These Questions and Responses are contained in Addendum 2 to this report for completeness.

3. Supplementary information and responses to NRC follow-up questions were provided via Detroit Edison letter NE-85-0048 (Reference 7). This information is contained in Addendum 3 of this report.

ADDENDUM 1

1. ALARA Considerations (Reg. Guide 8.8)

The NRC requested that Detroit Edison provide additional information describing the primary containment radiation protection provisions which will ensure that occupational radiation exposure will be as low as reasonably achievable (ALARA).

The following provides a discussion of the plant operating and administrative procedures, the design provisions and surface coating considerations which, in combination, ensure that occupational exposure will be maintained ALARA.

(a) The primary containment is classified as a restricted area with limited access. Access will normally only be required when the plant is in cold shutdown and refueling. Health Physics will conduct detailed surveys to map area radiation levels and sources, identify minimum protective measures, and strictly control personnel access and the duration of access. Because the drywell is a highly congested area, work packages and inspections will be thoroughly planned and the personnel indoctrinated and trained to skillfully perform their required activities so as to minimize the time spent in the drywell and the radiation exposure levels.

(b) The drywell equipment drains systems is designed to collect the leakages from all anticipated leakage sources, such as valve stem packings and recirculation pump seal leak-offs. The leakages are collected in a piping system and routed to the drywell equipment drain sump. Leakages from unidentified sources are collected in the drywell floor drains sump. The floor drains sump level instrumentation will detect, and alarm in the main control room, leakages greater than one (1) gallon per minute. As such, with the drywell equipment and floor drain systems, significant surface contamination buildup due to primary pressure boundary leakages is very unlikely. Operating BWR's are equipped with very similar drywell drain collection and leakage detection systems. Historically, significant surface contamination at operating BWR's has not been a problem and decontamination procedures to control radiation exposure from general surface contamination have not been required.

(c) The surface coatings which have been applied in the primary containment complement the procedural methods and plant design features for radiation protection by further minimizing locations where contaminated fluids and particles could accumulate. The major surface areas in

1. (Cont'd)

the primary containment, including the porous concrete surfaces, major portions of the structural steel and piping, and equipment and component surfaces, have been coated and sealed to prevent any accumulation of contaminated substances and subsequent higher radiation exposure levels.

(d) It is Detroit Edison's objective to properly coat surfaces in the primary containment and to maintain these coatings during the life of the plant. Problems with surface coatings can lead to new sources of contaminated particles, increased decontamination problems and higher exposure levels. Radiation exposures associated with inspection and maintenance of coating systems must also be properly considered in determining the need to apply coating to the remaining uncoated surfaces. Detroit Edison will evaluate the radiation sources and levels inside the primary containment during each outage and apply additional surface coatings, as appropriate, to ensure that occupational exposures are as far below the limits specified in 10CFR20 as is reasonably achievable.

2. <u>SRP Review Regarding Coating Requirements</u>

Detroit Edison was requested to review all applicable provisions of the SRP in respect to primary containment coating criteria and acceptance provisions.

A general review of the SRP was conducted to identify guidance provided by the NRC in regard to the application of coating systems in the primary containment. Section 6.1.2 of the SRP provides specific regulatory criteria concerning this subject. Supplemental criteria is included in Section 3.8.2. No other sections in the SRP were found to discuss the application of coating systems.

The specific criteria of Section 6.1.2 and the supplemental criteria of Section 3.8.2 has been considered in the Fermi 2 coating evaluation report. Therefore, this evaluation, which considered the qualified coatings, unqualified coatings and the uncoated surfaces has addressed all the acceptance provisions of the SRP.

3. <u>Evaluation of the Effects of Hydroxide Debris in the Reactor Vessel</u>

The question was raised whether the effects of the hydroxide type debris given in Table 1 (page 8) of Report No. DECO-12-2191 were evaluated in respect to the reactor vessel.

3. (Cont'd)

The debris, consisting of CZ-11 and mill scale amounts to less than 100 cu ft, in the form of small particles that readily traverse the ECCS suction strainers.

Even though the probability of the postulated amount of hydroxide debris reaching the RPV is extremely remote, we requested the General Electric Company to evaluate the potential concern.

The effect of up to 100 cu ft of hydroxide debris (20-60 microns in diameter) being deposited in the RPV by the ECC systems during post LOCA cooling is expected to be negligible. All critical flow paths inside the vessel (jet pump nozzle, core spray nozzle, top and bottom of fuel bundles) are larger than the strainer flow passage. As a result, most of the debris will be deposited in the lower plenum where it does not affect the ability of the ECC system to provide adequate core cooling.

Each fuel channel forms an essentially independent flow path connecting the upper and lower plenum in the core bypass region. In order to maintain adequate cooling, less than one gallon per minute must be provided to each assembly. Each fuel assembly has 3 independent inlet flow paths, the top and bottom of the fuel bundles, and the flow paths between the bundle and the bypass. Calculations have been performed which show that all 3 flow paths have to be greater than 99% blocked before any fuel damage will result. It is highly unlikely that debris of 20-60 microns in size could produce this amount of blockage in any channel under the flow conditions present in the vessel following a LOCA. Thus, depositing hydroxide debris from paint inside the RPV will not impair the ability of the ECC systems to maintain adequate core cooling.

4. Purge Valve Operability

Confirmation was requested that inlet screens to the purge valves have been provided and that the valves will be capable of operating with potential paint debris passing the screens.

The two 24-inch drywell purge inlet and outlet valves (VR3-3012 and 3023) are protected from potential paint debris by stainless steel screens. The screens are made of perforated plate with 1/8" diameter holes, 33 holes per square inch. The maximum particle size that could traverse the screens is therefore 1/8 inch in size with a thickness of less than 15 mils. The purge valves are normally closed and are opened for only short periods during normal operation to control containment pressure and just prior to and following

4. (Cont'd)

refueling when inerting or deinerting is performed. In the extremely unlikely event that a LOCA coincides with purging operation, the valves are capable of closing in less than 2 seconds.

While the valves are closing, during the initial stage of the LOCA, flow velocities across the valve seat can be in excess of 600 ft/sec, particularly during the latter phase of closing when critical orifice flow is approached. It is therefore highly improbable that small paint particles can be trapped between the seats. Only very small quantities of paint debris are expected to be generated within the short time and transported to the screens.

We therefore conclude that the operability of the purge isolation valves is assured.

5. <u>Evaluation of Potential Strainer Blockage from Unqualified Coatings</u>

A more detailed evaluation was requested, to substantiate that the unqualified coatings will not excessively block the ECCS suction strainers and that ECCS flow is not degraded.

The total surface area of the ECCS suction strainers is calculated to be 92.1 ft^2. Unqualified coatings within the primary containment constitute a total of 1,785 ft^2 as shown in Table 1 of Report No. DECO-12-2191. This quantity was derived from the following:

37 Valves (yokes, bonnets, bodies)	- 460 ft^2
Valve Operators (M.O., A.O.)	- 90 ft^2
Recirc. Pump Motor Flanges (2)	- 220 ft^2
MSIV Top Works (4)	- 100 ft^2
2790 ft of Conduit Labeling	- 350 ft^2
Miscellaneous	- 500 ft^2
62 Terminal Box Labelling	- 62 ft^2

In an effort to further quantify the surface areas, a more detailed survey was conducted, including additional dimensional verification and DFT measurements. Based on this updated survey, the unqualified coatings were categorized into:

A. Coatings with average DFT of 3 mils or less
B. Coatings consisting of zinc primers
C. Coatings thicker than 3 mils DFT

5. (Cont'd)

The coatings with DFTs of 3 mils or less do not produce flakes or peels capable of blocking the strainers, as discussed in Section 6.0 of Report No. DECO-12-2191.

Coatings consisting of inorganic zinc primers, such as Keeler & Long #7720 on the Recirc. Pump Motor Flanges, are categorized as hydroxide debris together with Carbo-Zinc 11 and Galvanox V. These coatings do not produce debris capable of blocking the strainers as discussed in Section 6.0 of this report.

The remaining thicker coatings are identified and tabulated as follows:

25 Valve Operators (3/4" to 28" valves)	- 142 ft^2
Recirc. Pump Motor Hoist	- 18 ft^2
Recirc. Pump Motors (2)	- 440 ft^2
Ventilation Fan Housing (14)	- 256 ft^2

These unidentified coatings will be removed prior to fuel load and the surfaces will be recoated with Carbo-Zinc 11. This action will effectively remove the potential generation of fibrous debris from unqualified coatings, such as flakes and peels, capable of plugging the ECCS strainers.

ADDENDUM 2

ATTACHMENT NO. 1 TO LETTER EF2-72045

RESPONSES TO NRC QUESTIONS
"PRIMARY CONTAINMENT COATINGS EVALUATIONS"

1. Provide the data, or your analysis, which you used to reach your conclusion on Page 12 of your Report No. DECO-12-2191, "Enrico Fermi Atomic Power Plant Unit No. 2, Evaluation of Containment Coatings", Revision 3, dated October 1984, that "The total affected surface area due to steam and water scouring is less than 10% of the CZ-11 coated area."

   RESPONSE: The statement will be deleted from the report as shown on the enclosed marked-up pages 12 and 20 of the report.

   The discussion was meant to provide a quantitative margin of conservatism used in the safety evaluation. No credit was taken in the analysis for this mitigating effect, as stated in Section 8.2 of the report. The mitigating effect was evaluated on the basis of the large break design jet model, computing actual surface areas exposed to the jet. For the Fermi 2 containment, the largest break exposes a total of 3315 ft^2 to the steam/water jet which translates to 1.55% of the total CZ-11 and mill scale surfaces within the drywell.

2. State the calculated velocities you assume to support your statement on Page 17 of your report that "Drywell floor and vent line/header velocities are very low..." Provide the calculations used to arrive at such velocities and identify the time frame following a postulated loss-of-coolant accident (LOCA) that such velocities exist (e.g., immediately after the postulated break, during long-term recirculation or the depressurization period when the operators are bringing the reactor to cold shutdown).

   RESPONSE: Question Nos. 2, 3 and 4 are directed toward the discussions provided for the debris transport mechanism in the report Section 8.1. As in our response to Question No. 1, the discussions were provided to illustrate the degree of conservatism and the mitigating effects associated with the debris transport path. In the safety evaluation, none of these mitigating effects were used. To clarify this aspect, the assumptions used are summarized as follows:

   (a) All CZ-11 and mill scale coatings as given in Table 1 (page 8 of the report) were assumed to fail and separate from their surfaces during a LOCA.

(b) All unqualified coatings (3 mils DFT and less, Galvanox V) are assumed to fail during the LOCA.

(c) All hydroxide and fibrous debris generated from the failure of CZ-11, mill scale, unqualified paints and Galvanox V are assumed to be transported from the drywell to the torus during the initial stages of the LOCA (RPV depressurization).

(d) All debris deposited in the torus is evenly distributed within the suppression pool water volume and held in suspension to produce the concentrations of hydroxide and fibrous debris as given in Section 8.2 of the report (0.35% and 4.1×10^{-4}%, respectively).

(e) The debris concentrations are ingested into the ECCS flow and are circulated through the ECCS flow path.

3. Provide the data, or your analysis, which you used to arrive at the following statement on Page 18 "... average water velocities within the torus following the initial transient are below 0.25 ft/sec, but approach 0.3 ft/sec within a 4 foot hemisphere..."

RESPONSE: See response to Question 2 above.

4. Indicate what the velocities would be in the torus pool following the initial transient if the safety relief valves were to discharge or the automatic depressurization system were to be activated. State the effect that such a valve discharge would do to paint particulates into the emergency core cooling system (ECCS) recirculation trains would occur. Provide your calculations or data, to support your conclusions on this matter.

RESPONSE: See response to Question 2 above.

5. Indicate the effect of ingesting paint particulates into the ECCS recirculation loops on the equipment needed to bring the plant down to cold shutdown following a postulated LOCA.

RESPONSE: The cold shutdown path for the Fermi 2 reactor, following a LOCA, consists of the RHR system operating in the shutdown mode or LPCI mode. Equipment needed to operate with circulating cooling water containing coating debris, consists of the RHR pumps, heat exchangers and valves. In the initial stages of the LOCA and subsequent core flooding and cooling, the core spray pumps and associated valves may also be required to operate.

The effect of coating particulates circulating through the cooling loops has been evaluated as follows:

(a) RHR and Core Spray Pumps

These pumps are vertical, centrifugal pumps, equipped with mechanical seals. Experience with this type of pump and seals in fossil power applications has shown very satisfactory operation under long-term continuous duty conditions, for example, pumping general service water (such as lake and river water) which contains silt, organics and corrosion particles. Special design features were incorporated into the Fermi 2 ECCS pumps to further assure long-term operability. These features include a recirculating seal cooling loop which contains a cyclonic separator to extract any solids from the seal cooling loop before reaching the seal. The solids are continuously recirculated to the pump suction stream to mix with the main flow. The pump seals thus are adequately protected from the effects of circulating coating debris particulates. Potential seal leakage and ultimate failure has previously been addressed as documented in the Fermi 2 SER (NUREG-0798) pages 6-21 and 15-15.

(b) RHR Heat Exchanger

The heat exchanger is a vertical vessel, 4.5 feet in diameter and 24 feet long. The RHR primary fluid is pumped through the shell side with top entry and near bottom exit. Flow velocities in the shell are between 6 and 10 ft/sec, far in excess of settling velocities of the particulates. Due to the near bottom exit flow, any particulates that could accumulate in low velocity fields, would be swept out of the heat exchanger and remain in suspension in the ECCS flow. The U-tubes are arranged vertically with the U-bend exposed to the top entry RHR flow. Particle build-up on the tubes, therefore, is not considered feasible and the heat transfer capacity of the heat exchanger would not be affected.

(c) Valves

The valves used in the ECCS flow path of the RHR and core spray loops consist of large wedge-type OSY gate valves with electric motor operators. These type of valves are standard in nuclear and fossil power plants for fluid shutoff where pressure exceeds the service rating of butterfly valves (usually about 150 psig). The seating surfaces are perpendicular to the flow stream, thus avoiding a build-up of particulates. During the closing of the valve, the fluid velocity across the seat increases nearly proportional to the decrease of available flow area across the seat, thus promoting a self-cleaning action. Particulates entrained within the flow stream would not affect the operability of the valve, in either the closing or opening phase. The seating surfaces (body seat rings and wedge surfaces) are hard-surfaced with stellite No. 6 to prevent seat erosion. Such gate valves are indeed well suited for the intended service, including slurries with particulate concentrations far above those postulated to result from coating debris.

(d) Reactor Vessel

The behavior and affects of particulate concentrations within the reactor vessel have been previously evaluated by General Electric Co., as discussed in Response No. 3 of the Addendum to Report No. DECO-12-2191, Rev. 3.

6. Provide the breakdown of the total surface area of mill scale and varnish in the drywell and in the torus. Provide the range of particle sizes and the distribution of the 25.22 cubic feet of mill scale indicated in Table 1 on Page 8.

RESPONSE: There is no mill scale and varnish within the torus. Some minor items previously identified in Section 2.4 of the report will remain uncoated until the first refueling outage. Though no mill scale is present, the surfaces are oxidized (rusted). These surfaces represent about 150 ft^2.

Within the drywell, the mill scale and varish is generally evenly distributed as part of the structural steel and a few piping sections. Structural steel consists mainly of hanger attachments, brackets, reinforcing gussets and similar small items which are difficult to clean and coat. These uncoated surfaces are also present on the inside of rectangular structural tubing, not generally accessible to spray guns, brushes or wire wheels. From a series of tests conducted at the Detroit Edison Research Department, it was determined that the measurable mill scale particle sizes ranged from approximately 4 to 60 microns. As stated in the response to Question 2, all the mill scale and varnish are assumed to separate from their surfaces and be transported to the torus.

Response to two additional questions was requested during the teleconference on December 20, 1984.

7. The amounts of unqualified coatings shown on Table 1 (page 8 of the report) are not consistent with the responses provided in the Addendum.

   RESPONSE: The unqualified coatings shown on Table 1 have been reduced in quantity due to the removal of unqualified coatings thicker than 3 mils DFT and due to recategorizing unqualified inorganic zinc primers. The remaining unqualified coatings consist of:

Valve yoke, bonnets, bodies	- 460 ft^2 at 0.7 mils=0.027 ft^3
MSIV top works	- 100 ft^2 at 2.1 mils=0.018 ft^3
Conduit labelling	- 350 ft^2 at 2.5 mils=0.073 ft^3
Terminal box labelling	- 62 ft^2 at 2.0 mils=0.010 ft^3
Total	- 972 ft^2

   Table 1 will be revised accordingly as marked on the attached copy.

8. Provide documentation regarding failure modes of unqualified coatings with DFT of 3 mils or less as stated on page 11 of the report.

   RESPONSE: The mode of failure of unqualified thin film coatings under accident conditions involving steam exposure at 340°F can be postulated based on an examination of test panels following exposures. Coating manufacturers and utilities have conducted many tests at Oakridge National Labs, which included coatings unsuitable for nuclear service. The failure of cured thermoset type films is normally in the form of blistering. Preradiation at $1x10^9$ rad causes some disintegration of non-radiation resistant films. Nominally blisters average less than 1/4 inch in size.

   Blisters form due to the reaction of the steel substrate with steam to form hydrogen. The film is soft at 340°F and blisters which form, cause the film to be reduced to a fraction of the original thickness. If any cracking or removal occurs, there is insufficient film tensile strength in the resulting 1 to 2 mil film to maintain any film integrity, and the resulting debris is present as a fine sludge. However, in most cases the blister formation relieves the hydrogen pressure and this results in no further force acting to cause film removal, except in areas where steam may directly impinge the surface.

   Discussions with coating experts associated with nuclear coating manufacturers indicate that tensile strength measurements would be of little value unless measurements could be made on film heated in the 200° to 3)° range. There is no conventional equipment or test method known to perform such a test in a reliable manner. At the temperatures predicted, unqualified coatings at 1 to 2 mils thickness such as alkyds are too fragile to be mounted for test.

ADDENDUM 3

1. Are the Byron Jackson ECCS pumps multistage?

   Response:

   The RHR and core spray pumps are single stage, vertical, double suction, centrifugal pumps with a single stainless steel impeller.

2. If so, do they have interstage bushings lubricated by the pump fluid? The debris may cause bearing damage. Provide any test data from the pump vendor.

   Response:

   Response to Question No. 1 indicates the pumps are not multistage.

   Edison does not believe that there is a significant potential for bearing damage due to debris. The Fermi 2 ECCS pump bearings are protected with mechanical seals. During initial checkout and operation, and during system flushing, the Fermi 2 pumps had been subjected to operation with debris, with the pumps being protected only via suction side startup strainer to prevent pump damage from larger objects. Post-operation inspection of the pump and the seal cyclones did not detect any particle or debris accumulation. The pumps performed in accordance with their acceptance criteria.

3. With respect to the cyclone separator, what particle size can it block?

   Response:

   Core Spray and RHR pumps are equipped with 1/8-inch size suction strainers at the suppression pool. The strainers are provided to prevent particulates from entering and potentially plugging the pump seal cyclone separator orifice. The orifices for both the CS pumps and the RHR pumps have a diameter of 0.140 inches. Since the cyclone separator orifice is of a larger diameter than the strainer mesh, particulates which pass through the mesh will pass through the orifice. Therefore, the cyclone separator prevents potential seal degradation by effectively removing from the mechanical seal cavity, those particles which pass through the suction strainer.

4. Indicate any instrumentation in the control room which would indicate blockage in the cyclone separator.

Response:

Fermi 2 has no instrumentation in the control room directly indicating blockage of the cyclone separator. Due to the fact that the cyclone separator orifice is larger than the mesh of the suction strainers, blockage is not anticipated. Degradation or impairment of pump performance, however, can be observed by the operator in the control room via the following information:

(a) Pump seal failures are detected via the floor drain sump level indicators within the ECCS pump rooms, with alarms in the control room.

(b) ECCS pump discharge flow rate is monitored and recorded in the control room.

5. With respect to the core spray pumps, do they take suction from the condensate storage tank?

Response:

The normal ECCS mode for the core spray system is to take suction from the suppression pool. However, under the Emergency Operating Procedures, the operator may align the valves to take suction from the condensate storage tank and inject either into the reactor vessel or the suppression pool depending upon the need of core cooling, flooding or torus level restoration.

6. Describe the provisions of your EOPs for alternate system core makeup, other than ECCS.

Response:

The RPV level control guide of the EOPs for Fermi 2 provides the operator with the following options for core cooling and level control:

(a) Normal feedwater through use of the electric driven condensate and heater feed pumps taking suction from the condenser hotwell and injecting into a depressurized reactor vessel.

(b) Continued operation of the control rod drive water pump, injecting condensate into the RPV via the control rod drives.

(c) Aligning the Standby Liquid Control (SLC) System in the test mode and injecting condensate from the SLC test tank into the RPV.

(d) Aligning the Core Spray System to take suction from the condensate storage tank and injecting into the RPV.

(e) Utilizing the RHR to RHR service cross tie and injecting water from the RHR reservoir into the reactor vessel via the RHR service water pump. (Note that this is a last resort due to the "dirty" water from the reservoir.) This option may also be used for containment flooding via the drywell and torus spray headers to avoid direct injection into the RPV.

In addition to those cooling mechanisms discussed above, two additional options are available to the operators to assist core cooling.

(f) Use of the Standby Feedwater System, utilizing the dedicated electric driven pumps, and injecting into the reactor vessel.

(g) The fuel pool cooling (FPC) system pumps aligned with the RHR pumps and heat exchangers. In this mode, the FPC pumps take suction from the fuel pool skimmer tanks (with makeup provided via fire hose stations) and return the water via the RHR pumps and heat exchangers into the depressurized RPV or into the containment as desired.

As can be seen from the above description, the operators have great latitude in utilizing all available water sources onsite, including the hotwell, condensate storage tanks, RHR reservoir and fuel pool.