PALMER ENECON NEWS

MT-029

# PALMER/ENECON CeramAlloy Systems PASS the Most Recent DBA Test Standards per ASTM D 3911-89

*This ASTM test method establishes the most up-to-date procedures for evaluating protective coating systems test specimens under simulated design basis accident (DBA) conditions. Included in this procedure are a description of conditions and apparatus for temperature-pressure testing, conditions for radiation testing, and procedures for preparing, examining, and evaluating the samples.*

*DBA is a generic term for any one of a family of accident conditions which can result from postulated events. These conditions are generally associated with the rupture of high energy piping. The more commonly recognized accident conditions used to evaluate coating systems for primary containment are the LOCA (loss of coolant accident) or main steam pipe break.*

*This test method is designed to provide a uniform test to determine the suitability of coatings used inside of primary containment of light-water nuclear facilities under simulated DBA conditions.*

*This test is intended to demonstrate that under DBA conditions, the coatings will remain intact and not become debris which could compromise engineered safety systems.*

*Working under the guidance and direction of a major power company in the northeast, a total of 32 test specimens (representing 8 different CeramAlloy systems) were prepared in accordance with ANSI N512.*

*They were then sent out to a laboratory for nuclear irradiation and decontamination as per ASTM D 4082 - 89 and D 4256 - 89, respectively, slightly modified at the direction of the nuclear plant's engineers so as to conform to the plant's specific requirements.*

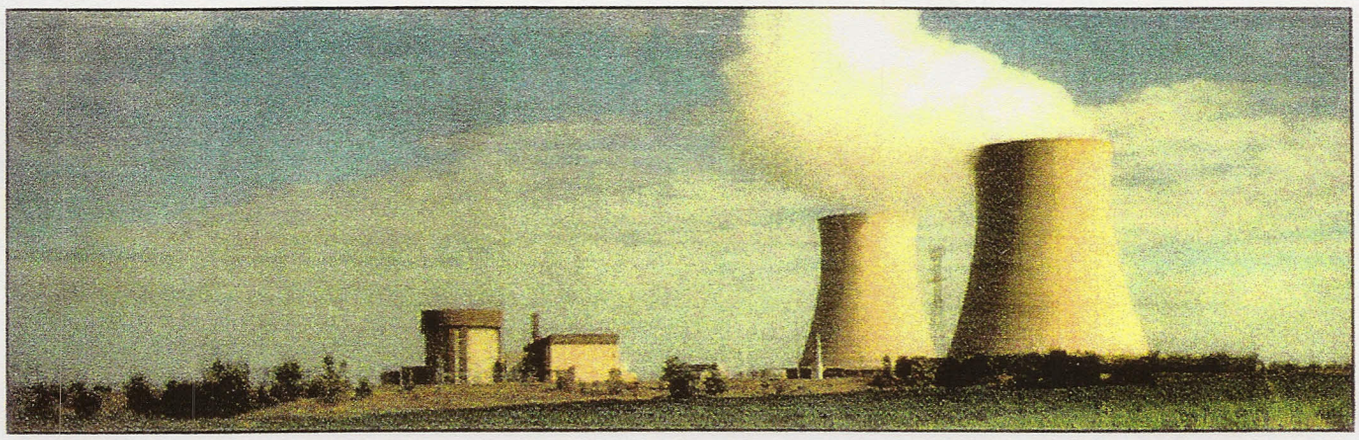
*This DBA test also stipulates specific acceptance criteria, namely:*

***Peeling shall not be permitted.***

***Delamination shall not be permitted.***

***Cracking is not considered a failure unless accompanied by delamination or loss of adhesion.***

***Blisters shall be limited to intact blisters which are completely surrounded by sound coating bonded to the surface.***



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**PALMER® INTERNATIONAL, INC.**

P. O. Box 8, Worcester, PA 19490

TELEPHONE: 215-584-4241 • 800-341-4408

4/7/95

To: Consolidated Edison, Indian Point
RE: Irradiation and DBA Testing on Ceramalloy CL+-CP+-CL+ System of Palmer International

Panels were prepared in accordance to ANSI N512. These panels were made of ASTM A36 type Carbon Steel. Dimensions were 2" x 4" x 1/8" and both corners and edges were rounded. The surface of the panels was grit blasted with #14 angular grit Aluminum Oxide to a 2 mil profile and then solvent cleaned with Acetone. The panels meet SSPC SP10 specification of surface preparation. The panels were coated and cured according to ANSI N512 paragraph 7.4.

Two panels designated as F1 and F2 were irradiated in accordance to ASTM 4082-89. It was decided the panels would be subjected to a total accumulative dose of $2.06 \times 10^8$ rads by Indian Point. Irradiation testing was performed by Sterigenics. It was calculated that the front and back of the panels were exposed to a final dose range of $2.919 \times 10^8$ - $3.324 \times 10^8$ rads. There was some discoloration and blistering of the panels. The blisters were all intact.

Panels designated as F3 and F4 were run along side F1 and F2 for DBA testing (ASTM D3911-89). Carboline performed the DBA on the PWR curve on all 4 panels. The acceptance criteria according to ASTM D3911-39 is: no delamination, peeling or cracking. If any blisters are present they must be intact. All criteria were met.

Fred Lauman

Fred Lauman
Technical Director

SteriGenics
Your Partner in Quality Sterilization

April 6, 1995

Roberta Body
Palmer International
P.O. Box 8
Worcester, PA 19490

Re: Irradiation of Nuclear Panels
Run #PAL 8500001

SteriGenics International irradiated 16 panels according to the ASTM procedure D 4082-89, Standard Test Method for Effects of Gamma Radiation on Coatings for Use in Light-Water Nuclear Power Plants. The only exception to the procedure was that cell temperatures exceeded 140 degrees, but did not exceed 180 degrees during irradiation.

The source used for irradiation was Cobalt-60 while the panels were suspended in air during the irradiation process.

The total accumulated dose requested by the customer was $2.06 \times 10^8$. The materials that were irradiated received the following listed dose:

| | | |
|---|---|---|
| Minimum Dose: | 29.19 kGy | = 291.9 Mrads |
| Maximum Dose: | 33.24 kGy | = 332.4 Mrads |

Sincerely,

Roberta Moss

Roberta Moss
Customer Service Administrator

SteriGenics
Your Partner in Quality Sterilization

March 23, 1995

To: File # PAL 8500001

From: Michael Pollock

Subj: Dosage , Rate and Total

Rate Determination was done by placing Dosimeters on the Front and back of a Plate and a Block (if Applicable). This was read after 30 minutes and the Hourly rate calculated.

Dose Rate - Front = 5.67 Mrads/hour
Back = 3.89 Mrads/hour

Time Batch in the Cell

Place = 43 hours

Flip = 22 hours

Total Dose

The total dose is calculated by multiplying the time in the cell prior to turning by both front and back rates plus the time in the cell after turning by the same rates.

Front (side A) (43 * 5.67) = 243.8

Back (side B) (43 * 3.89) = 167.2

Front (side B) (22 * 5.67) = 124.7

Back (side A) (22 * 3.89) = 88.6

Front (side A) + Back (side A) = 332.4 Mrads

Front (side B) + Back (side B) = 291.9 Mrads

Final Dose Range = 291.9 - 332.4 Mrads

# TESTING DEPARTMENT ABSTRACT REPORT

**TESTING PROJECT:** 03184 **DATE:** April 10, 1995

**REPORT #:** One **TIME:** 7 Days **DATE OF GRADING:** 3/24/95; 4/3/95

**TOTAL DESIGN TEST DURATION:** 7 Days **REQUESTED BY:** Roberta Body

**TITLE:** LOCA Testing for Palmer International, Inc.

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**REFERENCE:** Palmer International, Inc.; Roberta Body; Yuly Korobov.

**PURPOSE:** Independent testing for Palmer International, Inc.

**SYSTEMS:** Coated coupons supplied by Palmer International, Inc.
2" x 4" x 1/4" steel panels identified as:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A1-F | B1-F | C1-F | D1-F | E1-F | F1-F | G1-F | H1-F |
| A1-B | B1-B | C1-B | D1-B | E1-B | F1-B | G1-B | H1-B |
| A2-F | B2-F | C2-F | D2-F | E2-F | F2-F | G2-F | H2-F |
| A2-B | B2-B | C2-B | D2-B | E2-B | F2-B | G2-B | H2-B |
| A3-F | B3-F | C3-F | D3-F | E3-F | F3-F | G3-F | H3-F |
| A3-B | B3-B | C3-B | D3-B | E3-B | F3-B | G3-B | H3-B |
| A4-F | B4-F | C4-F | D4-F | E4-F | F4-F | G4-F | H4-F |
| A4-B | B4-B | C4-B | D4-B | E4-B | F4-B | G4-B | H4-B |

**EXPOSURE:** Coupons were irradiated at Sterigenics International (irradiation handled by Palmer International, Inc.)

Coupons were evaluated for the following coating defects (per ASTM D4082-89):

- Chalking
- Checking
- Cracking
- Blistering
- Flaking
- Delamination
- Peeling

From the Carboline Research & Development Laboratory



carboline

EXPOSURE: (Continued)

307°F PWR LOCA Curve.

a. Time - Temperature - Pressure Conditions

| Time * | Temperature, °F* | Pressure, psig* |
|---|---|---|
| 0-10 sec. | 125-307 | 0-60 |
| 10 sec. to 2 hrs. 47 min. | 307 | 60 |
| 2 hrs. 47 min. to 96 hrs. | 250** | 30 |
| 96 hrs. to 7 days | 200 | 10 |

* These are theoretical values. The data for the actual LOCA Curves are taken from the chart recording for this test found on pages 22 and 23, Lab Book 519.

** Solution circulation started at 250°F.

b. Water chemistry

Boric acid (2,000 ppm boron) solution adjusted to pH 8.5 with sodium hydroxide.

LOCA Grading Procedure: Coupons were evaluated per ASTM D3911-89 within 4 hours after removal from the test chamber for the following coating defects:

- Delamination and peeling
- Cracking
- Blistering

Coupons were photographed after irradiation prior to LOCA test, and again after LOCA test by Carboline.

CONCLUSIONS: See Results.

Carl L. Braun
Carl Braun
Senior Testing Technician
Testing/Analytical Department

John Montle
VP-Technology

Yuly Korobov
Yuly Korobov
Manager
Testing/Analytical Department

# GRADING AFTER LOCA TEST

## 307°F LOCA (STEEL PANELS)*

| PANEL IDENTIFICATION | PANEL SIDE | DELAMINATION OR PEELING | BLISTERING | CRACKING | OTHER PERFORMANCE CHARACTERISTICS |
|---|---|---|---|---|---|
| A1-F | Front | None | #8 few intact[1] | None | Coating discoloration |
| A1-B | Back | None | #8 few intact[1] | None | Coating discoloration |
| A2-F | Front | None | None | None | Coating discoloration |
| A2-B | Back | None | #8 few intact[1] | None | Coating discoloration |

Panels were irradiated prior to LOCA test.
Panels were examined and evaluated within four hours after removal from the test chamber.
[1] Panels exhibited blisters after irradiation, prior to LOCA test.

* Panel suspended in the vapor phase.

## 307°F LOCA (STEEL PANELS)*

| PANEL IDENTIFICATION | PANEL SIDE | DELAMINATION OR PEELING | BLISTERING | CRACKING | OTHER PERFORMANCE CHARACTERISTICS |
|---|---|---|---|---|---|
| A3-F | Front | None | None | None | Coating discoloration |
| A3-B | Back | None | #6 few intact | None | Coating discoloration |
| A4-F | Front | None | None | None | Coating discoloration |
| A4-B | Back | None | #6 few intact | None | Coating discoloration |

Panels were examined and evaluated within four hours after removal from the test chamber.

* Panel suspended in the vapor phase.

## 307°F LOCA (Steel Panels)*

| Panel Identification | Panel Side | Delamination or Peeling | Blistering | Cracking | Other Performance Characteristics |
|---|---|---|---|---|---|
| B1-F | Front | None | #2 medium dense intact[1] | None | Coating discoloration; softening |
| B1-B | Back | None | #4 few intact[1] | None | Coating discoloration; softening |
| B2-F | Front | None | #2 medium intact[1] | None | Coating discoloration; softening |
| B2-B | Back | None | #4 medium intact[1] | None | Coating discoloration; softening |

Panels were irradiated prior to LOCA test.
Panels were examined and evaluated within four hours after removal from the test chamber.
[1] Panels exhibited blisters after irradiation, prior to LOCA test.

* Panel suspended in the vaper phase.

## 307°F LOCA (Steel Panels)*

| Panel Identification | Panel Side | Delamination or Peeling | Blistering | Cracking | Other Performance Characteristics |
|---|---|---|---|---|---|
| B3-F | • Front | None | None | None | Coating discoloration |
| B3-B | Back | None | None | None | Coating discoloration |
| B4-F | Front | None | None | None | Coating discoloration |
| B4-B | Back | None | None | None | Coating discoloration |

Panels were examined and evaluated within four hours after removal from the test chamber.

* Panel suspended in the vapor phase.

## 307°F LOCA (STEEL PANELS)*

| PANEL IDENTIFICATION | PANEL SIDE | DELAMINATION OR PEELING | BLISTERING | CRACKING | OTHER PERFORMANCE CHARACTERISTICS |
|---|---|---|---|---|---|
| F1-F | Front | None | (2) > #2 intact; #6 few intact[1] | None | Coating discoloration; cratering |
| F1-B | Back | None | (3) > #2 intact; #6 few intact[1] | None | Coating discoloration; cratering |
| F2-F | Front | None | > #2 dense intact[1] | None | Coating discoloration; cratering |
| F2-B | Back | None | #2 medium intact[1] | None | Coating discoloration; cratering |

Panels were irradiated prior to LOCA test.
Panels were examined and evaluated within four hours after removal from the test chamber.
[1] Panels exhibited blisters after irradiation, prior to LOCA test.

* Panel suspended in the vapor phase.

## 307°F LOCA (STEEL PANELS)*

| PANEL IDENTIFICATION | PANEL SIDE | DELAMINATION OR PEELING | BLISTERING | CRACKING | OTHER PERFORMANCE CHARACTERISTICS |
|---|---|---|---|---|---|
| F3-F | Front | None | None | None | Coating discoloration |
| F3-B | Back | None | None | None | Coating discoloration |
| F4-F | Front | None | None | None | Coating discoloration |
| F4-B | Back | None | None | None | Coating discoloration |

Panels were examined and evaluated within four hours after removal from the test chamber.

* Panel suspended in the vapor phase.

A

PALMER INTERNATIONAL WORCESTER, PA
LABORATORY SPECIMEN PREPARATION SHEET

Date Applied: March 3&4, 1995

Coating System: Ceramalloy CL+3 Primer - Ceramalloy CL+3 Teal

Substrate Type: Carbon Steel A36/A36M Surface Preparation: Grit blasted to 2mil profile — Ace Rins

Sample Testing: Irradiation & DBA Testing (ASTM D4082-89)

1 COATING SYSTEM

Primer: Ceramalloy CL+3 Primer at 10-12 mils DFT

Intermediate: _____ at _____ mils DFT

Finish: Ceramalloy CL+3 Teal at 10-12 mils DFT

Total: 20-24 mils DFT

2 BATCH NUMBERS

| | | Base Lot | | Hardener Lot |
|---|---|---|---|---|
| Primer Ceramalloy CL+3 Primer | Part A | 941007A | Part B | 941010A |
| Intermediate _____ | Part A | _____ | Part B | _____ |
| Finish Ceramalloy CL+3 Teal | Part A | 940404A | Part B | A3235A |

3 APPLICATION CRITERIA

| | Panel # | Method Applied | Temp (F) R.H. (%) | Cure Cycle | Average DFT | |
|---|---|---|---|---|---|---|
| * A1 | 1 | Brush | 73°F, 28%(H) | 150°F | .02084 | in |
| | | | 73°F, 26.4% | 72hrs | | |
| A3 | 2 | | | | .02311 | in |
| A4 | 3 | | | | .01917 | in |
| * A2 | 4 | | | | .01945 | in |

Submitted by: Greg Tzap
Title: Senior Chemist

* Will be irradiated

B

PALMER INTERNATIONAL WORCESTER, PA
LABORATORY SPECIMEN PREPARATION SHEET

Date Applied March 3&4, 1995

Coating System Ceramalloy CL+3 Primer - CP+3 - CL+3 Primer

Substrate Type Carbon Steel A36/A36M Surface Preparation Grit blasted to 2mil prof.le — Aceta Rinsed

Sample Testing Irradiation & DBA Testing (ASTM 4082-89)

1 COATING SYSTEM

| | | | |
|---|---|---|---|
| Primer | Ceramalloy CL+3 Primer | at 10 | mils DFT |
| Intermediate | Ceramalloy CP+3 | at 100 | mils DFT |
| Finish | Ceramalloy CL+3 Primer | at 10 | mils DFT |
| | Total | 120 | mils DFT |

2 BATCH NUMBERS

| | | | Base Lot# | | |
|---|---|---|---|---|---|
| Primer | CL+3 Primer | Part A | 941007A | Part B | 941010A |
| Intermediate | CP+3 | Part A | 940328A | Part B | 940325A |
| Finish | CL+3 Primer | Part A | 941007A | Part B | 941010A |

3 APPLICATION CRITERIA

| | Panel # | Method Applied | Temp (F) R.H. (%) | Cure Cycle | Average DFT /side |
|---|---|---|---|---|---|
| B3 | 5 | Brush | 72F 28RH | 150°F - 72 hrs | .11383 in |
| | | | 73F 26.4 | | |
| B4 | 6 | | | | .11230 in |
| * B1 | 3 | | | | .12282 in |
| * B2 | 8 | | | | .12365 in |

Submitted by Greg Trap
Title : Senior Chemist

* will be irradiated

F

PALMER INTERNATIONAL WORCESTER, PA
LABORATORY SPECIMEN PREPARATION SHEET

Date Applied: March 3 & 4, 1995

Coating System: Ceramalloy CL+Blue - CP+ - CL+Blue

Substrate Type: Carbon Steel A36/A36M  Surface Preparation: Grit Blasted to 2mil profile — Acet Rins

Sample Testing: Irradiation & DBA Testing (ASTM 4082-89)

1 COATING SYSTEM

| | | | |
|---|---|---|---|
| Primer | Ceramalloy CL+Blue | at 15 | mils DFT |
| Intermediate | CP+ | at 100 | mils DFT |
| Finish | CL+Blue | at 15 | mils DFT |
| | Total | 130 | mils DFT |

2 BATCH NUMBERS

| | | Base | | Hardener |
|---|---|---|---|---|
| Primer | CL+Blue | Part A 950117A | Part B | 950124A |
| Intermediate | CP+ | Part A 950104A | Part B | 950105A |
| Finish | CL+Blue | Part A 950117A | Part B | 950124A |

3 APPLICATION CRITERIA

| | Panel # | Method Applied | Temp (F) R.H. (%) | Cure Cycle | Average DFT / side |
|---|---|---|---|---|---|
| F3 | 21 | Brush | 72F 28RH | 150°F - 72hrs | .11953 in. |
| | | | 73F 26.4 | | |
| F4 | 22 | | | | .11708 in |
| | | | | | |
| * F1 | 23 | | | | .12605 in |
| | | | | | |
| * F2 | 24 | | | | .12927 in |
| | | | | | |

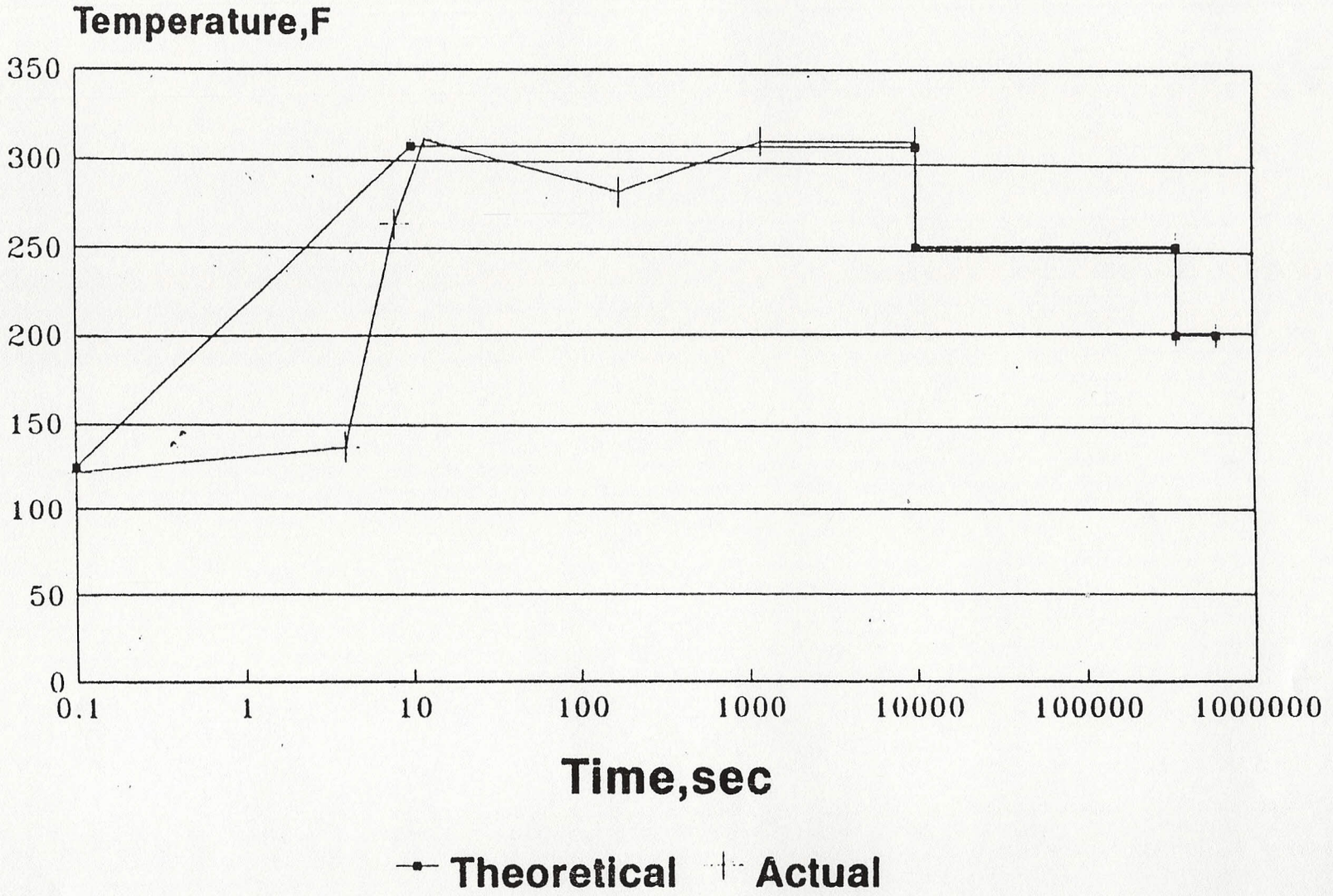
Submitted by: Greg Trap
Title: Senior Chemist

* Will be irradiated

# DBA Test for Palmer International

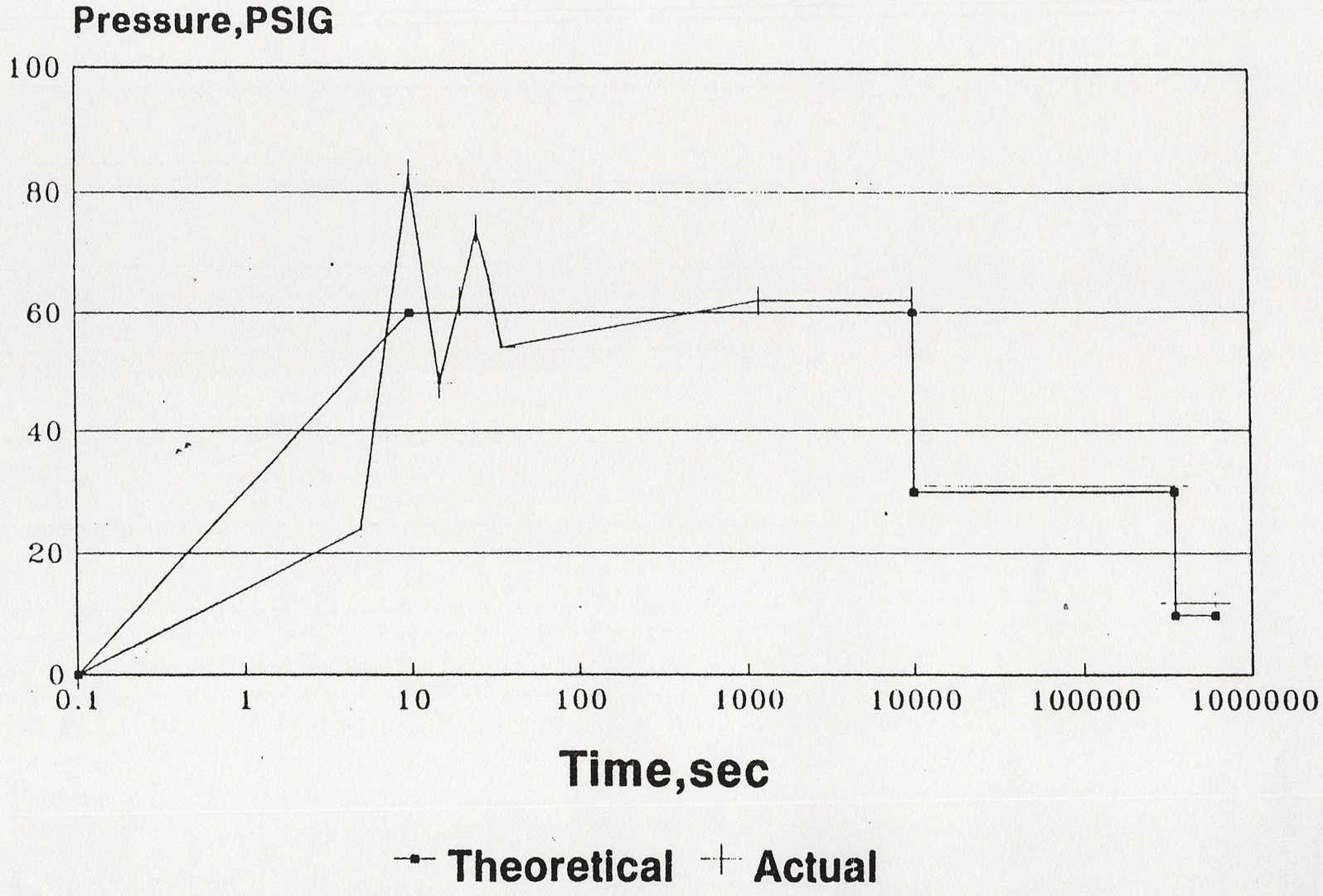
## Temperature



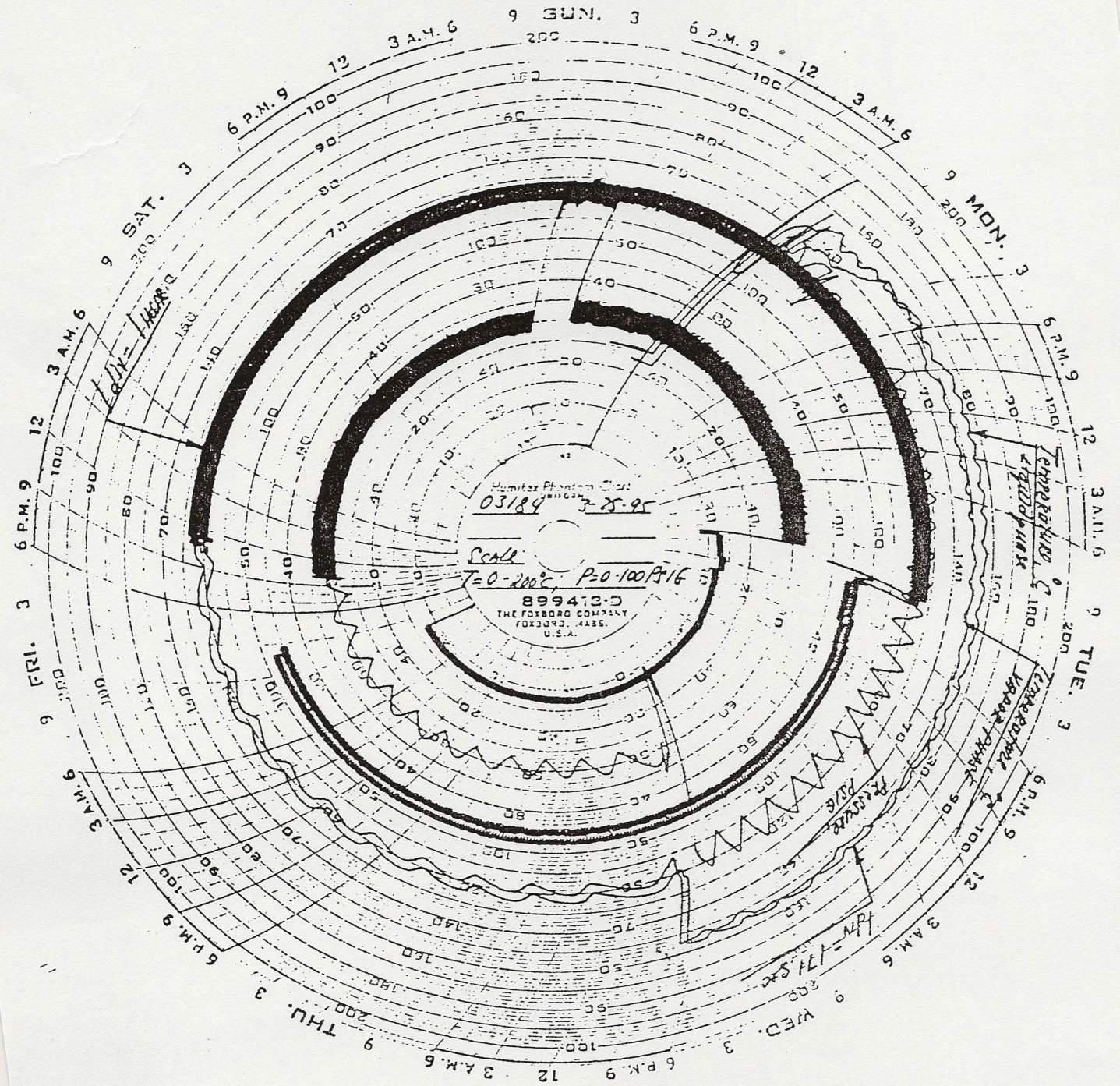


# DBA Test for Palmer International

## Pressure



Testing Project: 03184
Report: One, 7 Days



03184

## LOCA MANUAL RECORDING FORM

| "INITIAL TEMP. & PRESSURE INCREASE" | | | | | "PRESSURE DROPS" | | | |
|---|---|---|---|---|---|---|---|---|
| TIME (SEC.) | TEMPERATURE °F | TEMPERATURE °C | TIME (SEC.) | PRESSURE (PSIG) | TIME (SEC.) | PRESSURE (PSIG) | TIME (SEC.) | PRESSURE + (PSIG) - (IN Hg) |
| 0 | 122 | 50 | 0 | 0 | 0 | 58 | 0 | 25 |
| 4 | 136 | 58 | 5 | 24 | 5 | 36 | 5 | 19 |
| 8 | 263 | 128 | 10 | 83 | 10 | 22 | 10 | 12 |
| 12 | 311 | 155 | 15 | 48 | 15 | 13 | 15 | 9 |
| | | | 20 | 62 | 20 | 17 | 20 | 8 |
| | | | 25 | 74 | 25 | 17 | 25 | 10 |
| | | | 30 | 65 | 30 | 17 | 30 | 10 |
| | | | 35 | 54 | | | | |
| | | | | | | | | |
| | | | | | | | | |

PRESSURE DROP RATE TO REACH FINAL PRESSURE: 3.6 PSIG/S | 1.1 PSIG/S

DATE: 3-27-95 | 3-31-95

SIGNATURE: Tully Houston | Tully Houston

Carl L. Braun | Carl L. Braun

TIME TO REACH
( ) 340°F (171°C): _____
(V) 307°F (153°C): 11.7 sec

DATE: 3-27-95

SIGNATURE: Tully Houston
Carl L. Braun

TEST 072683

Designation: D 4082 – 89

# Standard Test Method for Effects of Gamma Radiation on Coatings for Use in Light-Water Nuclear Power Plants[1]

This standard is issued under the fixed designation D 4082; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method covers a standard procedure for evaluating the lifetime radiation tolerance of coatings to be used in nuclear power plants. This test method is applicable to Coating Service Levels I and II.

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 659 Method of Evaluating Degree of Chalking of Exterior Paints[2]

D 660 Test Method for Evaluating Degree of Checking of Exterior Paints[2]

D 661 Test Method for Evaluating Degree of Cracking of Exterior Paints[2]

D 714 Test Method for Evaluating Degree of Blistering of Paints[2]

D 772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints[2]

2.2 *ANSI Standard:*[3]

N512 Protecting Coatings (Paints) for Nuclear Industry

## 3. Significance and Use

3.1 Variations can occur in surface preparation, application, and curing of coating materials. They may affect the performance of a coating system exposed to radiation when considered in conjunction with applicable engineered safety requirements. This test method is designed to provide a uniform test to assess the suitability of coatings, used in nuclear power facilities, under continuous radiation exposure for the projected 40-year lifetime of the facilities, including radiation during a DBA. Specific plant radiation exposure may exceed or be less than the amount specified in 6.2 of this standard. The gamma dose used may exceed the actual anticipated plant gamma dose in order to account for expected beta exposure as well. Coatings in Level II areas (outside primary containment) are expected to be exposed to lower accumulated radiation doses.

## 4. Preparation of Test Samples

4.1 *Steel Panels*—Panels shall be prepared in accordance with ANSI N512.

4.2 *Concrete Blocks*—Blocks shall be prepared in accordance with ANSI N512.

## 5. Sampling

5.1 Prepare and test specimens at least in duplicate, or as otherwise specified by the owner.

## 6. Procedures

6.1 *Irradiation Dose Rate:*

6.1.1 Make the gamma energy field at the position of the test specimen $1 \times 10^6$ rads/h, or greater. It shall be uniform to within 10 % from one position of the specimen to another.

6.1.2 Make provisions so that all areas receive the same average exposure and dose, if the specimen is irradiated by a nonuniform source.

6.1.3 Determine the dose rate by a procedure acceptable to the coating manufacturer or as otherwise specified by the owner.

6.2 *Irradiation Accumulated Dose*—Make the total accumulated dose $1 \times 10^9$ rads, unless otherwise specified by the owner.

6.3 *Radiation Source*—Simulate conditions at a reactor site, closest to the preferred type of gamma source, such as, but not limited to, a fuel assembly.

6.4 *Test Environment:*

6.4.1 Specimens may be in air or in water during exposure to the gamma source, depending on the intended service as prescribed by the owner.

6.4.2 Do not exceed a temperature of 140°F (60°C) for the specimen during irradiation, or as otherwise acceptable to the coating manufacturer or as specified by the owner.

## 7. Examination and Reporting

7.1 Examine and evaluate specimens immediately after irradiation for the following coating defects:

7.1.1 *Chalking* (Method D 659)—Report extent.

7.1.2 *Checking* (Test Method D 660)—Report extent.

7.1.3 *Cracking* (Test Method D 661)—Report extent.

7.1.4 *Blistering* (Test Method D 714)—Report number and extent.

7.1.5 *Flaking* (Test Method D 772)—Report extent.

7.1.6 *Delamination*—Report extent.

7.1.7 *Peeling*—Report extent.

7.1.8 Report any observation of unusual appearance or deterioration.

## 8. Acceptance Criteria

8.1 *Checking, Cracking, Flaking, Delamination, Peeling, and Blistering*—None permitted.

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[1] This test method is under the jurisdiction of ASTM Committee D-33 on Protective Coating and Lining Work for Power Generating Facilities and is the direct responsibility of Subcommittee D33.02 on Service and Material Parameters.

Current edition approved Feb. 24, 1989. Published April 1989. Originally published as D 4082 – 83. Last previous edition D 4082 – 83.

[2] *Annual Book of ASTM Standards*, Vol 06.01.

[3] Available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

## 9. Documentation

9.1 Document the following:

9.1.1 The procedures and conditions relating to the test specimen preparation.

9.1.2 The type of radiation source and the test procedure and environment.

9.1.3 Both the initial dose rate and the total accumulated dose.

## 10. Testing Laboratory

10.1 Testing shall be conducted by an independent laboratory that shall not be affiliated in any manner with the coatings manufacturer unless otherwise specified by the owner.

10.2 The testing laboratory shall be responsible for the documentation and certification of all test results.

10.3 The testing laboratory shall be responsible for meeting the quality assurance requirements of the owner.

## 11. Precision and Accuracy

11.1 The precision and accuracy of this test method is reflected in the precision and certified accuracy of the test instruments used.

Designation: D 3911 – 89

# Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions[1]

This standard is issued under the fixed designation D 3911; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## INTRODUCTION

During a design basis accident (DBA) in nuclear power plants, conditions in the reactor containment will be characterized by elevated temperature and pressure, as well as the presence of a radiation environment. Water sprays, with or without chemical additives, may be used in the primary containment to suppress the consequences of the incident, to scavenge radioactive products, and to return the containment to near-ambient conditions.

## 1. Scope

1.1 This test method establishes procedures for evaluating protective coating systems test specimens under simulated DBA conditions. Included are a description of conditions and apparatus for temperature-pressure testing, conditions for radiation testing, and procedures for preparing, examining, and evaluating the samples.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 714 Test Method of Evaluating Degree of Blistering of Paints[2]

D 1193 Specification for Reagent Water[3]

D 4082 Test Method for Effects of Radiation on Coatings Used in Light-Water Nuclear Power Plants[2]

2.2 *ANSI Standard:*[4]

N512-1974 Protective Coatings (Paints) for the Nuclear Industry.

## 3. Terminology

3.1 *Definitions:*

3.1.1 *blistering*—the formation of bubbles in a coating (paint) film.

3.1.2 *boiling water reactor (BWR)*—a reactor in which the water moderator-coolant is boiled directly within the reactor core. The pressure in the reactor vessel is only slightly greater than the steam turbine pressure.

3.1.3 *chemical spray*—a solution of chemicals, such as those contained in Table 1, which could be used during a loss of coolant accident (LOCA) to suppress the incident, to scavenge fission products, and to return the facility to near-ambient conditions.

3.1.4 *coating (paint) system*—a polymeric protective film consisting of one or more coats applied in a predetermined order by prescribed methods to a defined substrate.

3.1.5 *cracking*—a break or a split in the coating (paint) system extending through the film or to the substrate.

3.1.6 *curing*—the transformation of a coating or other material into a solid phase or film.

3.1.7 *DBA*—a generic term for any one of a family of accident conditions which can result from postulated events. These conditions are generally associated with the rupture of high energy piping. The more commonly recognized accident conditions used to evaluate coating systems for primary containment are the LOCA or main steam pipe break.

3.1.8 *deionized water*—water prepared by an ion exchange process meeting the requirements of Specification D 1193, Types II and III.

3.1.9 *delamination*—separation of one coat or layer from another coat or layer, or from the substrate.

3.1.10 *engineered safety system*—a system designed to mitigate the effects of a design basis accident.

3.1.11 *irradiation*—exposure to ionizing radiation.

3.1.12 *light-water nuclear reactor*—an apparatus, using light water as a moderator, in which fissionable material is arrayed so that controlled nuclear fission may be sustained in a self-supporting chain reaction.

3.1.13 *LOCA*—the specific conditions anticipated fol-

TABLE 1 Typical Spray Solutions

| Composition | Chemical Compound | Concentration (in Deionized Water) |
|---|---|---|
| A | Sodium borate | 2000 to 4000 ppm boron |
| | Sodium hydroxide | adjust solution to pH 9.0 to 10.0 |
| B | Boric acid | 2000 to 4000 ppm boron |
| | Hydrazine | 50 ppm unreacted excess |
| | Sodium phosphate, dibasic | adjust solution pH to 6.8 to 10.0 |

[1] This method is under the jurisdiction of ASTM Committee D-33 on Protective Coating and Lining Work for Power Generation Facilities and is the direct responsibility of Subcommittee D33.02 on Service and Material Parameters.

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[2] *Annual Book of ASTM Standards*, Vol 06.01.

[3] *Annual Book of ASTM Standards*, Vols 06.03 and 11.01.

[4] Available from the American National Standards Institute, 1430 Broadway, New York, N Y 10018.

lowing a loss of coolant accident that would expose the coated surface of the containments of a light-water nuclear power facility to the temperature-pressure environmental parameters described.

3.1.14 *peeling*—separation of one or more coats or layers of a coating from the substrate.

3.1.15 *pressurized-water reactor (PWR)*—a nuclear power reactor design utilizing liquid water under high pressure as moderator-coolant.

3.1.16 *quality assurance*—the verification of the conformance of materials and methods of application to the governing specifications, in order to achieve the desired result.

3.1.17 *reactor containment (containment)*—the enclosure provided to protect the environment from the consequences of a nuclear incident.

## 4. Significance and Use

4.1 This test method is designed to provide a uniform test to determine the suitability of coatings used inside primary containment of light-water nuclear facilities under simulated DBA conditions. Variations in actual surface preparation and in application and curing of the coating materials may require additional testing as deemed necessary by the specifying or qualifying agency, or both, if it is anticipated that the variations may adversely affect the performance of the coating system during a DBA. This test method is intended only to demonstrate that under DBA conditions, the coatings will remain intact and not become debris which could compromise engineered safety systems.

## 5. Apparatus

5.1 *Environmental Test Chamber*, constructed of materials that are corrosion-resistant to the test solutions.

5.2 The equipment shall be capable of reproducing and continuously recording the temperature and pressure profiles of the DBA conditions.

5.3 A sufficient number of thermocouples shall be located in the test chamber to assure conformity to the test curve, and so that both the temperature of the vapor phase and of the liquid phase (if present) can be recorded.

## 6. Preparation of Test Specimens

6.1 Determine the appearance of the test panels prior to testing by photo documentation or equivalent methods in order to provide a basis for post-test comparison. The testing requirements should indicate if this assessment will be done prior to shipping to the test facility.

6.2 Unless otherwise specified, a minimum of four samples shall be required to establish conformance of a given coating system on a given substrate, with two of the four samples being irradiated prior to testing in accordance with Test Method D 4082. Typical laboratory test panels are 2 by 4 by ⅛ in. for steel panels and 2 by 2 by 4 in. for concrete panels.

6.2.1 *Steel Panels*—Prepare in accordance with ANSI N512 or as necessary to duplicate actual conditions.

6.2.2 *Concrete Blocks*—Prepare in accordance with ANSI N512 or as necessary to duplicate actual conditions.

## 7. Procedure

7.1 *Test Parameters:*

7.1.1 Test coatings using the applicable curves from the latest Safety Analysis Report (SAR) identified by the owner for the specific containment. Illustrations of time-temperature-pressure test curves that simulate primary containment atmospheres during a DBA are shown in Figs. 1 and 2.

7.1.2 The curves depicted in Figs. 1 or 2 may be used if they represent conditions equal to or more severe than those DBA conditions anticipated.

7.1.3 The parameters of the curves may be simulated during testing as continuous functions or as an enveloping stepwise function.

7.1.4 Steam is used initially to achieve the desired thermal shock and to raise the test chamber and its environment to the prescribed test conditions. After equilibrium is achieved, the temperature of the test chamber is maintained by means

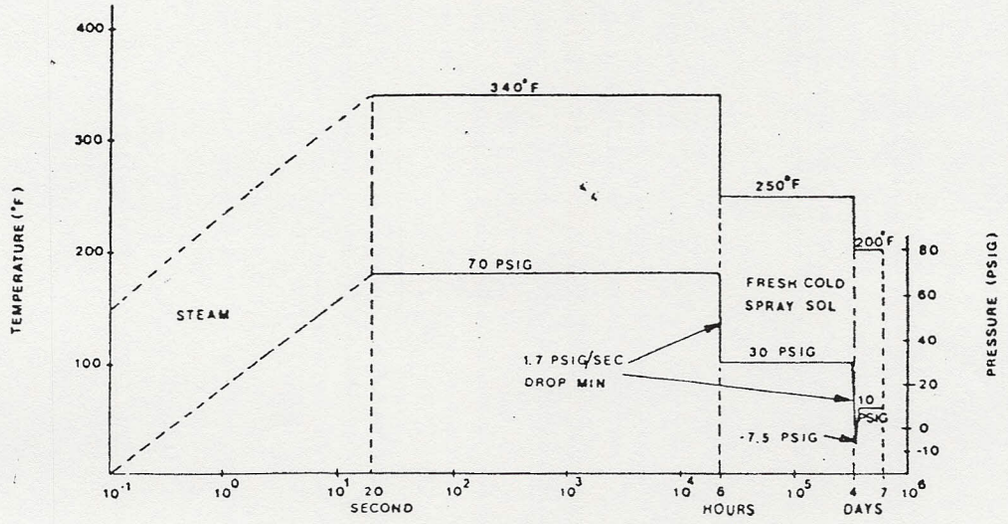


FIG. 1 Typical Design Basis Accident (DBA) Testing Parameters (Temperature-Time-Pressure)—BWR Drywell

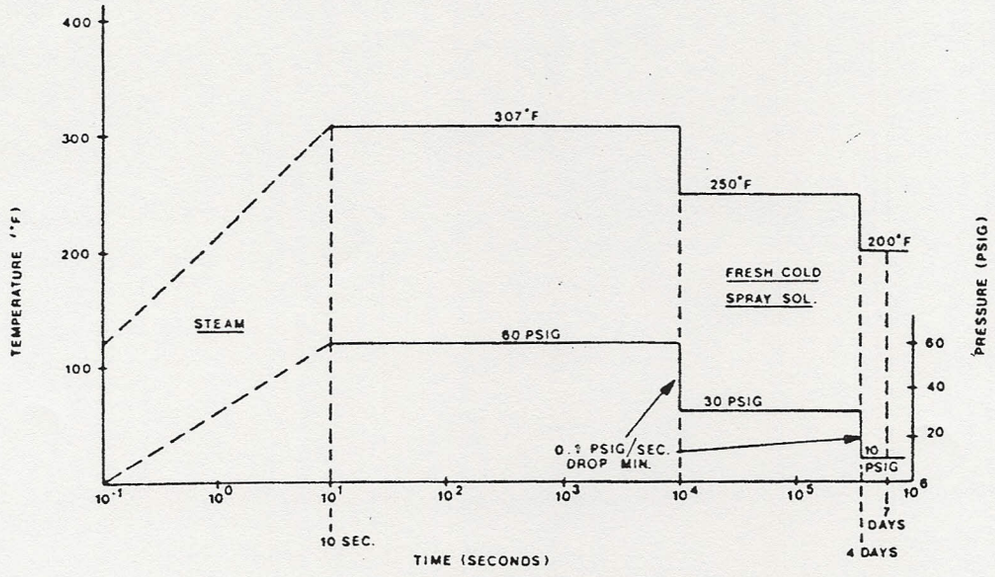


**FIG. 2 Typical Design Basis (DBA) Testing Parameters (Temperature-Time-Pressure)—PWR Containment**

of internal or external resistance, or both, heating elements, or other suitable means. The duration of steam injection should be minimized, as much as feasible, and the duration shall be recorded. Where inlet steam temperatures exceed 370°F, initial steam injection shall be no longer then 15 min.

7.2 *Spray Solution:*

7.2.1 Unless otherwise specified, use deionized water when testing under simulated DBA conditions.

7.2.2 Record the chemical composition of the spray solution before each test.

## 8. Examination and Report

8.1 *Examination:*

8.1.1 Examine and evaluate test specimens within 4 h and again after 14 days following removal from the test chamber for the following coating defects:

8.1.1.1 Delamination and peeling.

8.1.1.2 Cracking.

8.1.1.3 Blistering in accordance with Test Method D 714.

8.1.2 Unless otherwise instructed, disregard the condition of the edges and plane areas within ¼ in. (6.4 mm) from the edges of the steel or concrete test surfaces, and the top and bottom ends of the concrete surfaces.

8.2 *Report*—Report the following information:

8.2.1 The results of the evaluation of each test specimen. Report for all sides of concrete blocks and front and back of steel panels.

8.2.2 The extent of each defect from 8.1. Report "none" if no defects are present.

8.2.3 Any observations of unusual appearances.

## 9. Acceptance Criteria

9.1 Peeling shall not be permitted.

9.2 Delamination shall not be permitted.

9.3 Cracking is not considered a failure unless accompanied by delamination or loss of adhesion.

9.4 Blisters shall be limited to intact blisters which are completely surrounded by sound coating bonded to the surface.

9.5 An owner may establish acceptance criteria more stringent than above. The above criteria are meant to establish minimum standards only.

## 10. Documentation

10.1 *Testing Procedures*—Document each of the following:

10.1.1 A description of the test apparatus, temperature and pressure profiles, spray solution composition including pH, duration, frequency, and rate of spray solutions, and any other pertinent test conditions.

10.2 *Test Agency:*

10.2.1 The testing agency shall be responsible for the documenting, reporting, and certifying of all tests.

10.2.2 The testing agency shall be responsible for meeting applicable quality assurance requirements.

10.2.3 The testing agency shall be responsible for providing color photographic documentation of the test surfaces as required.

10.2.3.1 Photographs shall reflect the actual size as close as possible of the test specimens.

## 11. Repairability

11.1 Test repair coatings applied to significant areas within Service Level I in accordance with the requirements for radiation and DBA conditions.

11.2 The test shall include evaluation of the repair coating applied in accordance with the repair procedure over the intended surface preparation or the original qualified coating system, or both.

11.3 Significant areas shall be determined by the specifying or qualifying agency. Nonsignificant areas have been determined as being less than 2 $ft^2$ in an approximate 2000 $ft^2$ area; larger areas require a decision regarding significance.

## 12. Precision

12.1 Test equipment must be demonstrated to have the capability to reproduce the design time/temperature parameters within ±10 s and ±5° F and the design pressure within ±3 psig. In any test where the test equipment imposes variances in the pressure/temperature parameters that are outside this range, an analysis of the validity of these test results should accompany the test data.